A Study on the Tail Behaviour of the Stock Prices of Nifty 50 Stocks Using Extreme Value Theory (EVT)

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Preface

Research Center for Management Studies (RCMS) at SDMIMD has endeavoured to promote research in the field of management education in the Institute, in various ways. The Research Centre has encouraged faculty and students to actively take part in research activities jointly, collate and disseminate findings of the research activities through various types of projects to contribute to the body of knowledge to the academic fraternity in general, and management education in particular.

In this direction, keeping in line with the philosophy of promoting active research in the field of management to capture live situations and issues, the Research Center has taken a unique initiative to sponsor and encourage faculty members to carry out Applied Research Projects in various areas of management.

The duration of these projects is typically between four to twelve months. After completion of each project, after peer review, a publication is taken out, by the institute. The projects help the faculty members, and the students, who work under the supervision of the faculty members for these projects, to identify issues of current importance in the field of management in various sectors. Data is collected mostly through primary research, through interviews and field study.

The institute takes into account the time and resources required by a faculty member to carry out such projects, and, fully sponsors them to cover the various costs of the project work (for data collection, travel, etc), thereby providing a unique opportunity to the two most important institutional stakeholders (faculty and students) to enrich their knowledge by extending their academic activities, outside the classroom learning situation, in the real world.

From the academic viewpoint, these projects provide a unique opportunity to the faculty and the engaging students to get a first-hand experience in knowing problems of targeted organizations or sectors on a face to face basis, thereby, helping in knowledge creation and its transfer, adding to the overall process of learning in a practical manner, with application of knowledge, as the focus of learning pedagogy, which is vital in management education.

Dr. Mousumi Sengupta
Chairperson, SDM RCMS

Acknowledgement

I thank SDME trust for providing required funding and encouragement for taking up the project and completing the project.

I thank Dr. N.R. Parasuraman, Director, SDMIMD, for giving necessary support and encouragement for completing the project.

I thank Dr. H. Gayathri, Deputy Director, SDMIMD, for motivating me to take up the project and supporting in completing the project.

I thank Prof Sridhar and his team for providing necessary help in completing this project.

I thank the staff for helping me with necessary support for completing the project. I also thank faculty colleagues for their encouraging discussions during the conduct of the project.

I thank my family members for providing necessary support and cooperation for successfully completing the project.

Dr. Srilakshminarayana.G

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Executive Summary

Studying the behaviour of the stock prices using appropriate probability model, is an age-old problem. Under this, one looks for a model that best fits the movements of the prices and use the properties of the distribution for drawing inferences on the stock's behaviour. Also, the probability distribution is used while building a predictive model. For example, while using a regression model, it is a usual practice to assume a normal model. For several years, normal distribution is an obvious choice till researchers have proved that it is not a right choice, due to high kurtosis. Later, researchers have started searching for other models that can be adopted as alternative models to a normal model. Student-t, log-normal, stable pareto etc., are commonly used alternative probability distributions. None of the models always best fits the model, due to high volatility of the stock prices and it is a continuous attempt to search for the best model. One of the important reasons for this is, the news generated on the stocks. The news can be related to the market or the stock or a government's policy or global news etc. This news can be called as events around the stock and one may be interested in studying the impact of these events on the stock prices. Among the events, market crashes or financial crisis are expected to affect the stock prices the most. Hence, it is very important to observe the behaviour of the stock prices during these periods. Observing the behaviour will help one to note the that stocks that does not lose their fundamental behaviour and note the rate at which they regain their fundamental behaviour. For example, a stock may have a normal or any other behaviour before the crisis and one may invest looking at this. During the crisis it may lose its basic structure and one has to identify the structure. Note that, structure we are mentioning is the probability structure. One can classify the stocks as stable stocks if they retain the same probability structure (parameter values may be different) and unstable if the probability structure changes frequently. Another important aspect is, if none of the probability models best fits the stock prices, then one has to study the thickness of the tail of the stock price distribution. If the thickness is high, then none of the known probability distributions may fit the stock price random variable. Hence, it is suggested to study the thickness of the tail before drawing any conclusions on the stocks. Next aspect one can consider is, the distribution of the extreme stock price random variables. For example, maximum and minimum stock prices. Note that, these extreme random variables can be studied using extreme value distributions. As per the literature, we have three types of extreme value distributions-Gumbel, Weibull, and Fréchet. Based on the extremal index, one can identify the domain the extreme random variables belong to. For this, one can use generalized extreme value distribution. Based on the type of the distribution, one can calculate the respective probabilities and other risk measures. In order to check the stability of the stock price random variable, one can also use the total stock price random variable. If the market crashes have affected the stock price random variable, then it can be captured using the total price random variable. It is very well-known fact that the total random variable gets effected by the presence of the extreme values. The original structure will get affected if the extremes affect the structure to the large extent. If not, then the original structure may be restored at least approximately. Hence, one has to investigate these three aspects, before drawing any conclusions about the stock prices. The current study has been considered to study the three aspects with respect to the NSE listed 50 stocks. We consider each of the stocks and study the three aspects mentioned and this form the objectives of the study.

We use descriptive research design to achieve the objectives of the study and consider the daily stock prices of the 50 listed stocks. We consider the data from the year 2007 to 2020. We divide the years into six blocks, based on the market crashes. The first block has the daily prices between the years 2007-2009, second block has the daily prices for the year 2010, the third block has the daily prices between the years 2011 and 2014, the fourth block has the daily prices between the years 2015 and 2016, the fifth block has the daily prices between the years 2017 and 2019, and the last block has the daily prices for the year 2020. Daily prices for each block are analysed and conclusions are drawn appropriately. We have used EasyFit 5.6 and R as tools for analysing the data. Tail index for each of the stock price random variable is estimated using Weight least squares method (WLS). Based on the index value we study the behaviour of the stock price random variable. To identify the extreme value distribution, we have fit the generalized extreme value distribution and based on the index value we have identified the distributions. To estimate the index value for the total price random variable, we have used Koutrouveils (1980) method. Based on the index value we classify the total stock price random variable to either normal or stable. Frequent change of domain to stable makes the stock highly unstable.

For each stock and each block, we have fit all possible distributions (listed in table 8) and the best possible distribution is found. We have used EasyFit 5.6. as a tool to fit the distributions and tables 9 to 50 gives the details of the distributions that were fit. But not all distributions were best fit to the stock prices. In such cases, we have observed the thick ness of the tail and based on the thickness of the tail appropriate conclusions are drawn. From our analysis we found that, apart from other traditional distributions Johnson SB, Cauchy, Beta, Pert, Weibull, Log-logistic (3P), Fatigue (3P), Frechet, Kumaraswamy, Error, Nakagami, Gen Gamma (4P), Burr, Dagum (4P), Pearson 6 etc. best fits the stock prices. We also found that the tail thickness is high in cases where the distributions failed to fit the stock price random variable. Another interesting point is the distributions and the tail thickness have changed with change in the events. Finally, we conclude that the stock prices have changed with change in the events and the market crashes have significant in few cases and not significant in other cases. Table-A gives the stocks that have got affected and that are not affected by the market crashes. Based on the number of times the stock's tail index value falls below the value 3, we have classified the stocks into highly riskier, medium riskier, and low riskier. As per the theory, if the index value lies below 1, then the stock is considered as the one with thick tail and the variance will be very high. Sometimes the structure will be unknown and the known probability models may not fit the data. Also, mean and variance may not exist. If the index value is more than 3, then the distribution may exist or at least, the mean and variance may exist. Part-1 of the data analysis section gives the results of the analysis.

In the second part of the data analysis, we have studied the behaviour of the extreme price random variables- maximum and minimum. From the analysis we have found that, Weibull and Gumbel domains form the frequent domains for the maximum and minimum stock price random variables. Few cases have Fréchet distribution of the domain.

In the third part of the data analysis, we have studied the behaviour of the total price random variable. From the analysis we have found that, in majority of the cases the normal behaviour for the total price random variable is preserved. In other cases, the behaviour is stable distribution is appropriate. In these cases, we conclude that, the stock price random variable has got affected by the market crashes. Table-B gives the details of the stocks whose domain got changed to stable with change in the events. Based on the number of times the domain is stable, we have classified as highly affected, moderately affected and low affected due to the market crashes.

Our study can be considered by the researchers and practitioners who are interested to understand the behaviour of the individual stocks. Also, to get the details of the stocks that are affected by the market crashes or financial crisis.

We conclude the study with few limitations and future work.

1. Introduction

In this section we present the introduction to NSE, extreme value theory, tail behaviour and importance of studying the same in stock market analysis, purpose of doing the current project, and, organization of the other sections in the project etc.

1.1. Introduction

A stock market is an aggregation of buyers and sellers of stocks. It is a network of economic transactions and not a physical facility. These stocks or shares represent the ownership claims on businesses. They include securities listed on a public stock exchange, stocks traded privately, sold to investors. Investments in stock market is usually done though stockbrokerages and electronic trading platforms. A stock exchange is a place where stockbrokers and traders can buy and sell the shares of a stock, bonds and securities. Companies who wish to sell their shares uses these platforms and they get listed in for trade. Trade in a stock exchange means, transfer of a stock or security from a seller to a trader. Small individual stock investors to large investors trade in a stock exchange. They also include banks, insurance companies, etc. A stock exchange trader buys or sells on their behalf. While few stock exchanges are physical locations, other are network of computers where trades are made electronically. A buyer bids a specific price and the seller asks a specific price for the same stock. When the bid and ask prices match, a sale takes place, on a first-come, first-served basis. A stock exchange facilitates the exchange of securities between buyers and sellers, provide real-time trading information on the listed securities and facilitates price discovery. Market participants include individual retail investors, institutional investors, and publicly traded corporations. Stock market is an important way for the companies to raise funds for businesses. This allows them to trade publicly, raise additional funds for expansion by selling shares of ownership of the company. Exchanges usually affords liquidity that enables their holders to quickly and easily sell securities. According to the history, price of stocks and other assets are an important part of economic activity and can acts as an indicator of social mood. An economy is considered as an up-and-coming economy, if the stock market is on rise. It is also considered as the primary indicator of a nation's economic strength and development. If the prices of the share price are increasing, then there is a tendency to associate this with the increased business investment. Movements in the share prices also affect wealth of households and their consumption pattern. This is one of the reasons why the central banks tend to control and behaviour of the stock market. Stock exchanges act as the clearinghouse for the transactions. That is, they collect and deliver the shares, and takes care of payment to the seller of a security. When all the activities are smooth, it will help for the economic growth and also increases employment. Sometimes, there can be some disturbances like stock market crash. But they again come back to the normal state after a point of time. The movements in the prices are monitored by price indices called as stock market indices. For example, BSE SENSEX, NSE Nifty, S&P etc. Based on the movements of these indices, one can judge the behaviour of the stock market or a sector. In India, two stock exchanges take the control over the entire market. The first one is the Bombay Stock Exchange (BSE) and the second one is National Stock Exchange (NSE). Due to the returns one gets by investing in the stock market, there is a need for the traders to predict the behaviour of the stock market, before selling or buying. There are several methods used to predict the behaviour.

One frequent question one ask is, can the behaviour be predicted using the events related to the individual stocks or the events related to the market or events related to government decisions or other events. In this regard, an important hypothesis, called as Efficient Market Hypothesis was proposed by researchers (Bachelier (1900), Savage (1950), Fama (1970)). According to this, stock prices are seen as a function of the information and rational expectations. Also, that the new revealed information is almost immediately reflected in the current stock price. This means that all the publicly known information about a stock is already reflected in the current price. This implies that the stock prices cannot be predicted accurately by looking at the price history. Malkiel (1973) argued that stock prices are described by a statistical process called a random walk, meaning each day's fluctuations from the mean value are random and unpredictable. This argument attracted huge criticism and among others, Warren Buffet rebutted EMH in 1984 during his speech in Columbia University.

Another approach used to understand the behaviour of the stock market is Intrinsic value approach. Under this, the intrinsic value or the true value of a company is calculated, including tangible and intangible factors. One uses fundamental analysis to arrive at the intrinsic value. Another name for this is the fundamental value. It is usually used for comparison with the company's market value and find if the company is undervalued or not. An investor looks at both the qualitative and quantitative aspects of the business. Other prediction methods include fundamental analysis, technical analysis and technological methods.

Apart from these aspects, researchers are interested to study and identify the probability structure of the stock price movements or changes. This is because of the uncertainty that prevails over the movements in the stock prices. This helps one to predict the probabilities of stock prices and use the same in decision making. Also, this helps the investors in understanding the fluctuations in the stock prices and estimate the level of deviations from the average values. Sometimes the stock prices movement may be so complex that one cannot model them using simple structures and also it leads to higher levels of uncertainty. In such cases, it is very important to fit a probability structure and estimate the characteristics of the stock prices. For example, expected risk, volatility modelling, building the predictive models etc. In all the cases, one assumes a probability structure to the price movements and then studies the behaviour to make appropriate estimations. These models are also used to build the investment strategies. One such distribution that is frequently used is the normal distribution.

Stock market modelling is an age-old problem and for many years, researchers have modelled the stock price returns using normal distribution. In the later years, studies have shown that normal distribution is not the appropriate model (Mandelbrot (1963), Fama (1965)) and attempts have been made to find the alternative models. For example, log-normal distribution, Cauchy, Pareto models have been used as alternative models to normal distribution. But, as the time changes or the market conditions change, the models turned to be wrong and each time there have been attempts to build the modified models. One of the important reasons for the failure of the models is, the change in the tail behaviour of the stock price random variable. The tail index value of the stock price random variable decides the thickness of the tail and based on the same, one can judge on the validity of the model. For example, if the index value of the stock price random variable is 2, then we conclude the that tails are normal. Normal tails are symmetric and gives the researcher flexibility in calculation of the respective probabilities. Also, one can utilize the properties of normal model to compute complex probabilities. Another important aspect is, if one wish to build a predictive model, then the first choice for the errors is a normal model. For example, while building a regression model, one uses a normal model for the errors and ultimately the same is used for the response variable. Even if one wishes to test a statistical hypothesis, a normal model is the obvious choice. In many such aspects, a normal model is assumed and used for drawing appropriate inferences. The three sigma limits can be used to clean the data before adopting any statistical method for analysis. Fama (1963) uses a stable pareto model to study the behaviour of the stock prices and later many have used other models. The studies of Officer (1972), Akgiray and Goeffrey Booth (1988), Hing lau et.al. (1990) argue that stable models also may not sometimes fit the market returns appropriately.

The tail behaviour of a normal model is given by

$$P(Y > x) = \int_x^\infty f(x)dx \cong \frac{1}{x\sqrt{2\pi}} e^{-\frac{x^2}{2}} \qquad (1)$$

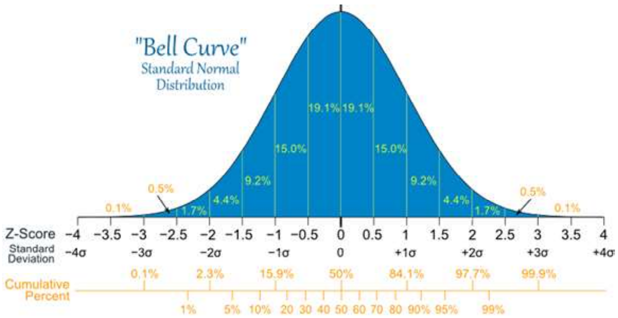
One can note that the tail structure is valid in situations where the volatility is less.

Figure- below gives the structure of a normal distribution. One can note that the tails of a normal law is are lighter than a stable law and becomes fatter as variance increases.

Figure-1

Normal distribution tails and sigma limits

Source: www.mathsisfun.com



1.The presence of extreme values increases the variance, and high variance leads to high skewness and a normal model fails.

2.The presence of high frequency values increases the kurtosis and leads to the failure of a normal model.

3.Presence of heavy tails also leads to failure of a normal model. A heavy tail implies that there is a large probability of getting very large values. A particular class of distributions that are heavy are power laws. Based on the tail index value, one can observe the thickness of the tail. Note that the thickness of the tail is decided by the index value.

When a normal model fails, it is a regular practice to adopt a log-normal model or a Pareto model. Fama (1963) shows that a stable pareto model fits the stock price changes. Tails other than normal tails can be classified as heavy tails, fat tails, thin tails, etc.

Heavy tailed distributions are those probability distributions whose tails are not exponentially bounded. That is, they are heavier than the exponential distribution. In few cases the right tail may be heavy, in some cases left tail may be heavy and in other cases both the tails may be heavy. There are three important classes of heavy tailed distributions: the fat-tailed distributions, the long-tailed distributions and the sub-exponential distributions. Examples of heavy tailed distributions include Pareto, log-normal, Levy distribution, Burr distribution, log-logistic distribution, log-gamma distribution, Fréchet distribution etc. In section 1.3, we present more details about the tail behaviour of a random variable and its importance.

Market crashes details

We present the important market crashes from the year 2007 to 2020.

Technically, a random variable's behaviour gets affected due to the presence of extreme values or

Table-1 : Market Crash details

Financial crisis of 2007–08	16 Sep 2008	On September 16, 2008, failures of large financial institutions in the United States, due primarily to exposure of securities of packaged subprime loans and credit default swaps issued to insure these loans and their issuers, rapidly devolved into a global crisis resulting in a number of bank failures in Europe and sharp reductions in the value of equities (stock) and commodities worldwide. The failure of banks in Iceland resulted in a devaluation of the Icelandic króna and threatened the government with bankruptcy. Iceland was able to secure an emergency loan from the IMF in November. Later on, U.S. President George W. Bush signs the Emergency Economic Stabilization Act into law, creating a Troubled Asset Relief Program (TARP) to purchase failing bank assets. Had disastrous effects on the world economy along with world trade.
2009 Dubai debt standstill	27 Nov 2009	Dubai requested a debt deferment following its massive renovation and development projects, as well as the Great Recession. The announcement caused global stock markets to drop.
European sovereign debt crisis	27 Apr 2010	Standard & Poor's downgraded Greece's sovereign credit rating to junk four days after the activation of a €45-billion EU–IMF bailout, triggering the decline of stock markets worldwide and of the Euro's value, and furthering a European sovereign debt crisis.
2010 flash crash	6 May 2010	The Dow Jones Industrial Average suffered its worst intra-day point loss, dropping nearly 1,000 points before partially recovering.
August 2011 stock markets fall	1 Aug 2011	S&P 500 entered a short-lived bear market between 2 May 2011 (intraday high: 1,370.58) and 04 October 2011 (intraday low: 1,074.77), a decline of 21.58%. The stock market rebounded thereafter and ended the year flat.
2015–16 Chinese stock market crash	12 Jun 2015	China stock market crash started in June and continues into July and August. In January 2016, Chinese stock market experienced a steep sell-off which set off a global rout.
2015–16 stock market selloff	18 Aug 2015	The Dow Jones fell 588 points during a two-day period, 1,300 points from August 18–21. On Monday, August 24, world stock markets were down substantially, wiping out all gains made in 2015, with interlinked drops in commodities such as oil, which hit a six-year price low, copper, and most of Asian currencies, but the Japanese yen, losing value against the United States dollar. With this plunge, an estimated ten trillion dollars had been wiped off the books on global markets since June 3.
2018 Global Stock Market Downturn	20 Sep 2018	The S&P 500 index peaked at 2930 on its September 20 close and dropped 19.73% to 2351 by Christmas Eve. The DJIA falls 18.78% during roughly the same period. Shanghai Composite dropped to a four-year low, escalating their economic downturn since the 2015 recession.
2020 stock market crash	24 Feb 2020	The COVID-19 outbreak caused supply disruptions, leading to the fastest U.S. stock market plunge from record highs into a correction (and subsequently a new bear market). Stock markets around the world fell simultaneously amid the turmoil.

Source: Retrieved from https://en.wikipedia.org/wiki/List_of_stock_market_crashes_and_bear_markets as on 08.04.2020 outliers. This is because, the presence of extremes increases the variance and affects the symmetric behaviour of the random variable. Also, the kurtosis of the random variable increases with the presence of high frequency data. Hence, the normal behaviour of a random variable gets affected due to the presence of extreme values. Hence, one has to note this and carefully identify a probability model that can explain the behaviour of the random variable properly. Note that, a random variable will always have a probability structure and, one has to identify and adopt the probability model, before analysing the data on the random variable. Using this probability model, one can calculate the respective probabilities and also use the properties of the model to understand the behaviour of the random variable better. The presence of extreme values will increase the variance and also increases the skewness of the random variable. Note that, the data on the random variable is collected from a population or a source and there is every possibility of collecting extreme values on the random variables. Each data point collected, is a reaction of the respondent or the process generating the data. Extremes can arise only of the reaction is extreme. Another reason could be sudden change in the respondent due to his experience or extreme changes in the data generating process. Hence, it is not possible to get normal data always and one has to look for alternative models as the behaviour of the data changes. This is one of the reasons for having several probability models for the same situation and one has to choose appropriate model, based on the behaviour of the data. Data decides the distribution to be used and the model has to best fit the data. Appropriate test has to be used to test the significance of the model fit. The similar behaviour can be seen in the stock market prices.

Stock market prices fluctuate at faster rate as compared to other data. They keep changing with the change in the events related to them. The news can be related to individual stock or that related to market. Either case, the stock prices keep changing and sometimes fall drastically or sometimes increase to high values. That is, change in the events changes the levels of the stock prices. For example, market crash in the year 2007 had changed the stock prices of majority of the stocks to low values. Similarly, COVID-19 has changed the stock prices of the stocks. Taking these examples, one can expect that the stock price random variable changes its behaviour as the events change, and the corresponding probability model needs to be identified, using the data. Hence, we an attempt to identify the probability model for each of the stock considered. Also, note the changes in the probability models with change in the events. We consider the time points where the major market crashes have happened and study the behaviour of the stock prices during these time periods.

Another important change that one can expect due to change in the events is, the change in the tail behaviour of the stock price random variable. In a normal scenario the tails will be symmetric, and one can easily study the behaviour of the stock price random variable. When the tails become heavy, one has to estimate the thickness of the tail and accordingly choose the model. Sometimes, the tails become so heavy that none of the probability models can best fit the stock prices. This situation can arise only if the events are severe are change the stock prices drastically. Hence, we try to estimate the tail index value for each of the stocks and study the behaviour of the stock price random variable. This forms one of the objectives of the current study. We consider major market crashes as the events and study the tail behaviour of each of the 50 stocks listed in NSE. Note that, tail behaviour of a random variable is directly linked to the properties of the random variable. For example, expected value is or mean is linked to the tail behaviour of the random variable. If the tail is heavy, then mean do not exist and variance will be close to infinity. In such cases, an investor has to be very careful in investing in that stock. If a stock has heavy tails, then it has high risk and investing in such stock may be riskier for an investor. Also note that, a predictive model can be built only if the probability model is identified appropriately. If a probability mode cannot be identified, then one has to look for alternative predictive approaches. In the current study, we fit all possible probability models for each of the stocks and then choose the best one. Also, estimate the tail index for each stock and categorize the stock price behaviour. We do this process for each of the stocks at all the time points and note the changes in the behaviour.

When studying the behaviour of the stock prices, one may be interested in extreme stock prices. For example, maximum stock price or minimum stock price. Hence, it is important to study and identify the probability model that best fits the maximum or minimum stock price random variable. This will help one to measure the risk associated with the maximum or minimum stock price. In the current study, we make an attempt to identify the probability model for each of the stocks. We use generalized extreme value distribution to identify the distribution for extremes. We continue this process for each of the stocks at all the time points considered and note the changes in the behaviour.

The next important property of the stock price is the total stock price. Note that, each stock price is an information generated on the stock and the level of the stock price indicates the importance of that stock. An investor chooses that stock which has high stock price. Sometimes, one may look at the aggregate of the stock price and this will help on to know the behaviour of the total stock price random variable. Total stock price can be considered if one cannot understand the behaviour of the individual stock prices or when the stock prices are too volatile, or stock prices are not sufficient to come to a conclusion on the stock. The total stock price provides adequate information to the investor on a selected stock and also helps one to take appropriate decision on the stock. A normal model is an obvious choice to model the total stock price random variable. But, not always. When the tails are heavy or extremes dominate the total or the variance is infinite, normal model fails, and even central limit theorem fails. In such cases, one has to make use of stable models. The stable index or the exponent decides the model that one has to adopt. In the current study, we make an attempt to identify the model that best fits the total stock price random variable for each of the stocks. We also note the changes in the stable index for each of the stocks at the time points considered.

Taking the above three aspects-tail behaviour or the probability distribution, extreme value distribution of the extreme stock prices, and, the probability model for the total stock price random variable, we construct the objectives and select appropriate methodology for the current study.

We now present few research studies that look at the effect of market crash on the market returns. Also, how the news effect the market returns. These studies act as motivating factors for the current study.

Fauzi and Wahyudi (2016) studies the effect of market crash on the characteristics of stocks and firms. The study uses data for three major stock market crashes that have occurred in 1997, 2000, and 2008. Multiple regression analysis was used, and the results show that stocks with high betas, larger capitalization, more return volatility, higher debt ratios, lower levels of liquid assets, and lower asset profitability tend to lose more value on crash day. Nikkinen and Peltomäki (2019) studies the complex relation between information supply and demand using newspaper articles and web searches that reflect investors' crash fears. They inform that more web searchers led to more news and more news does not have effect on web search in the future. They also show that web searches have an immediate effect on stock market returns and VIX implied volatility. Also, the effect of news articles lasts longer up to 11 weeks. The results suggest collectively that the web searches related to market crashes lead both the printed news stories about market crashes. Studies have focused on causes of crashes and the co-movement and volatility of stock market during and after crashes. But, the role of stock, firm, and industry characteristics in explaining the impact of crashes on individual stock returns has not received attention. Wang et.al. studies this issue and finds that stocks with higher beta, larger capitalization, lower levels of illiquidity, and more return volatility one-year to the event date lose more value on crash days. Also finds that stocks of companies with higher debt ratios, higher levels of liquid assets, lower cash flow per share, and lower asset profitability tend to lose more value on the crash day. They find a positive momentum effect for the cumulative stock returns earned one-week prior to the crash date and a negative reversal effect for the cumulative stock returns earned three months and three years prior to the crash date in most stock market crashes. This motivate us to consider the total stock price behaviour.

We present the literature on tail behaviour, extreme value theory and total stock price in the literature review section.

In the following sections, we introduce the extreme value distributions, stable distributions and present the discussion on tail behaviour of a random variable. We also present the details of NSE in brief.

1.2. Introduction to NSE

National stock exchange (NSE) is the leading stock exchange in India, located in Mumbai. It was established in 1992 and was the first dematerialized electronic exchange in the country. It was the first exchange in the country to provide modern, fully automated screen-based electronic trading system. Mr Vikram Limaye is the Managing Director & Chief Executive officer of NSE.

NSE has a total market capitalization of more than US$2.27 trillion and is the 11th largest stock exchange as on April 2018. NIFTY 50, the 50-stock index if the flagship index of NSE and used extensively by the investors in India and abroad. This index was launched in the year 1996 and acts as a barometer of the Indian capital markets. In India, stock trading in BSE and NSE account for 4% of the economy and the major portion is derived from the unorganized sector and households. Corporate sector in India account for 12-14% of the national GDP and 7,800 companies are listed, out of which 4000 trade on BSE and NSE. According to economic times news on April 2018, 60 million retail investors have invested in stocks in India. These investors invest either through direct purchases of equities or through mutual funds. In USA 27% of the population had invested in the stock market, in China it is 10%, and in India it is 1.3%.

NSE was setup in the year 1990 to bring transparency in the markets and has given an opportunity to all those, with basic qualification and, met the minimum financial requirements, to trade. NSE was ahead of its times when it separated the ownership and management, under SEBI's supervision. Price information could be accessed by anyone from any place and electronic-based accounts settlement and trade is an important development. The robust risk management system was setup, which guarantees protection to the investors against broker defaults.

NSE was setup by a group of leading Indian financial institutions at the behest of the government of India such that, transparency can be brought to the Indian capital market. Based on the recommendations of the Pherwani committee, NSE has been established with a diversified shareholding comprising domestic and global investors. Life insurance corporation of India, State Bank of India, IFCI limited, IDFC limited and Stock Holding Corporation of India limited are the key domestic investors. Gagil FDI Limited, GS Strategic Investments Limited, SAIF II SE Investments Mauritius Limited, Aranda Investments (Mauritius) Pte Limited and PI Opportunities Fund I are the global investors.

In 1992, the exchange was incorporated as a tax-paying company and in 1993 it was recognized as a stock exchange under the Securities Contracts (Regulation) Act, 1956, when P. V. Narasimha Rao was the Prime Minister of India and Manmohan Singh was the Finance Minister. In June 1994, it has commenced its operations in the Wholesale Debt Market (WDM) segment and in November 1994 it has commenced its capital market (equities) segment. In June 2000 it has started its operations in the derivatives segment. It currently offers trading, clearing and settlement services in equity, equity derivatives, debt, commodity derivatives, and currency derivatives segments. It has 2500 VSATs and 3000 leased lines spread over more than 2000 cities across India. It was instrumental in creating the National Securities Depository Limited (NSDL), which allows investors to securely hold and transfer their shares and bonds electronically. It also allows investors to hold and trade in as few as one share or bond. This not only made holding financial instruments convenient but more importantly, eliminated the need for paper certificates and greatly reduced the incidents of forged or fake certificates and fraudulent transactions that had plagued the Indian stock market. The NSDL's security, combined with the transparency, lower transaction prices and efficiency that NSE offered, greatly increased the attractiveness of the Indian stock market to domestic and international investors.

NSE offers trading and investment Equity, derivatives, and debt segments. Trading on equity segment takes place on all days of the week, except Saturdays, Sundays and holidays declared by the exchange in advance). The market timings of the equity segment are

(1) Pre-open session:

•Order entry & modification Open: 09:00 hrs

•Order entry & modification Close: 09:08 hrs*

•with random closure in last one minute. Pre-open order matching starts immediately after the close of pre-open order entry.

(2) Regular trading session

•Normal/Retail Debt/Limited Physical Market Open: 09.15 hrs

•Normal/Retail Debt/Limited Physical Market Close: 15:30 hrs.

NSE's trading systems is a state-of-the-art application. It has an uptime record of 99.99% and processes more than a billion messages every day with the sub-millisecond response time.

NSE has taken huge strides in technology in these 20 years. In 1994, when trading started, NSE technology was handling 2 orders a second. This increased to 60 orders a second in 2001. Today NSE can handle 1,60,000 orders/messages per second, with infinite ability to scale up at short notice on demand, NSE has continuously worked towards ensuring that the settlement cycle comes down. Settlements have always been handled smoothly. The settlement cycle has been reduced from T+3 to T+2/T+1.

(The information on NSE is taken from https://en.wikipedia.org/wiki/National_Stock_Exchange_of_India extracted as on 07.04.2020)

1.3. Introduction to Tail Behaviour of a random variable and its importance

We now present the discussion on tail behaviour of a random variable and its importance. We only present the details in brief and avoid mathematical expressions or equations. Note that, the behaviour of a random variable can be explained based on the tail behaviour of its probability distribution. If the tails are non-normal, then one has to carefully study and identify the distribution that best suits the behaviour of the random variable. It is very important to know the tail behaviour before drawing any inferences related to the random variable. For example, if the tail behaviour is skewed then one cannot use those methods that assume a normal model. Similarly, while modelling the stock market prices, one has to estimate the tail thickness and accordingly model the prices. The presence of extremes or outliers can make the tail of a random variable non-normal. Non-normal or skewed tails can be classified as heavy tails, fat tails or sub-exponential tails. The expected value or mean of a random variable is directly related to the tail of the probability distribution of the random variable. In some cases, the mean or other moments do not exist, because of heavy tails. Tail probabilities are usually calculated using the distribution function of a random variable.

A distribution function of a random variable is given by

$$F(x) = P(X \leq x),\ x \text{ real}$$

The tail probability is given by

$$1\text{-}f(x) = P(X \geq x)\ 1\text{-}f(x) = P(X \geq x)$$

The relation between the tail probability and the expected value is given by

$$E(X) = \int_{o}^{\infty} P(X > x)dx$$

One can note that if the tail is heavy, then the expected value or the mean value gets affected. For example, expected value doesn't exist for a Cauchy random variable. There exist few inequalities that act as lower or upper bounds for the expected values. They also get affected if the tails are heavy. For example, Markov inequality, Chebyshev inequality etc.

We now present the tails of few probability distributions:

1. Normal distribution:

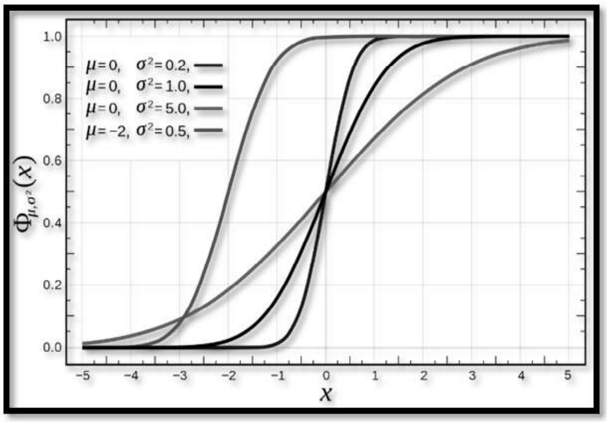
$$P(X < -m) = P(x > m) \sim \frac{1}{1\sqrt{\pi\sigma m}} e^{-m2/14\sigma 21}$$

Figure-2 : CDF of a Normal random variable

Source: Extracted from Wikipedia as on 11.04.2020

2. Pareto distribution:

Here x_m is the minimum possible value of X, and ? is a

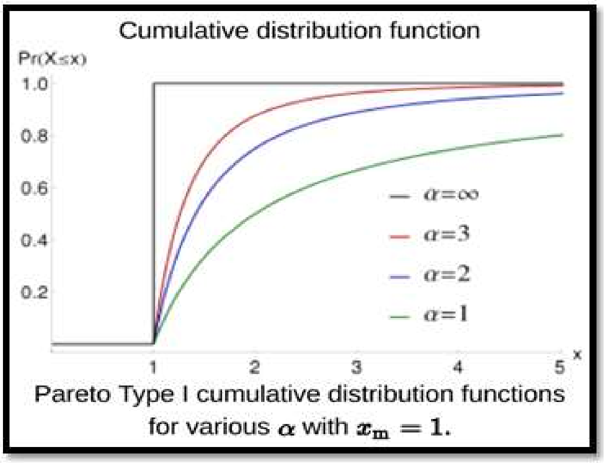


positive parameter. ? called as tail index or Pareto index. Pareto distribution is used frequently in the study of stock markets and in finance, as a wealth distribution.

Figure-3 :CDF of a Pareto random variable

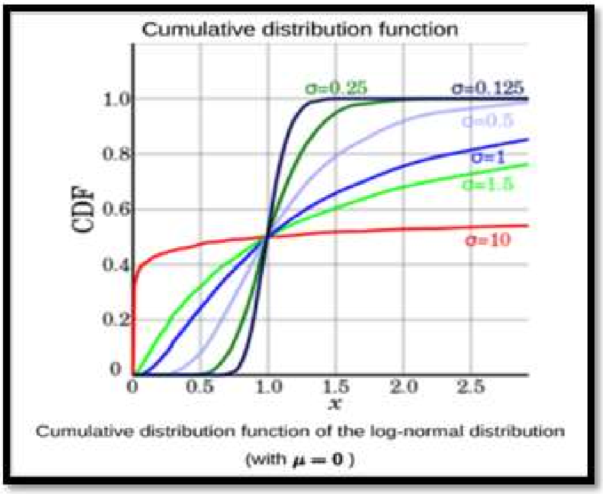
Source: Extracted from Wikipedia as on 11.04.2020

1. Log-Normal distribution:



$$P(X > x) = 1 - \Phi\left(\frac{(Inx) - \mu}{\sigma}\right), x > 0$$

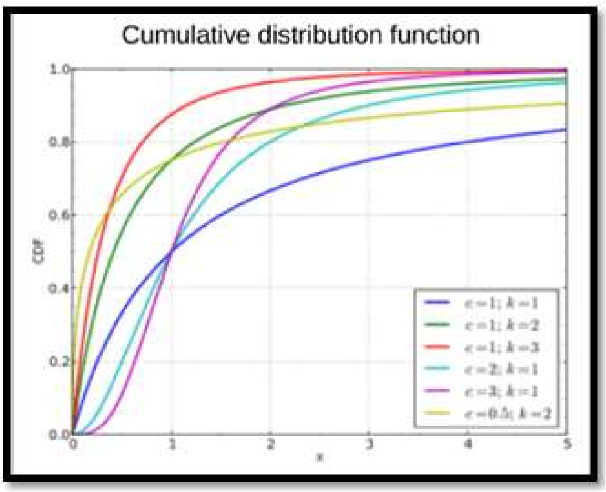
Figure-4 : CDF of a log-normal random variable



Source: Extracted from Wikipedia as on 11.04.2020

2. Burr distribution: P(X>x)=?(1+x^{c})$^{-k,}$ x>0.

Figure-5 : CDF of a Burr random variable

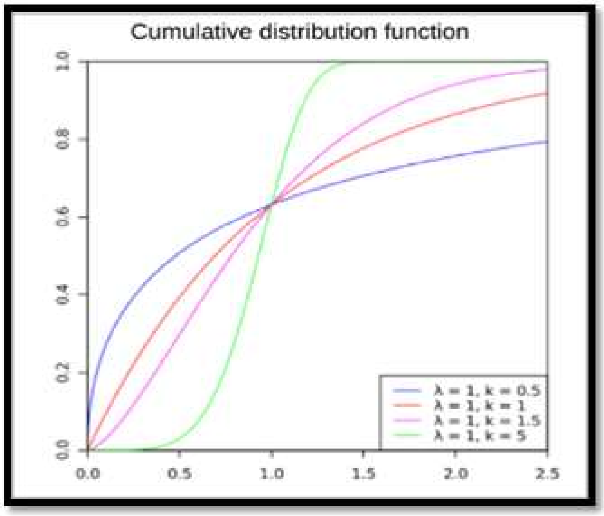


Source: Extracted from Wikipedia as on 11.04.2020

1. Weibull distribution:

$$P(X > x) = e - \left(\frac{x}{m}\right)^{k}, x \geq 0$$

Figure-6 : CDF of a Weibull random variable

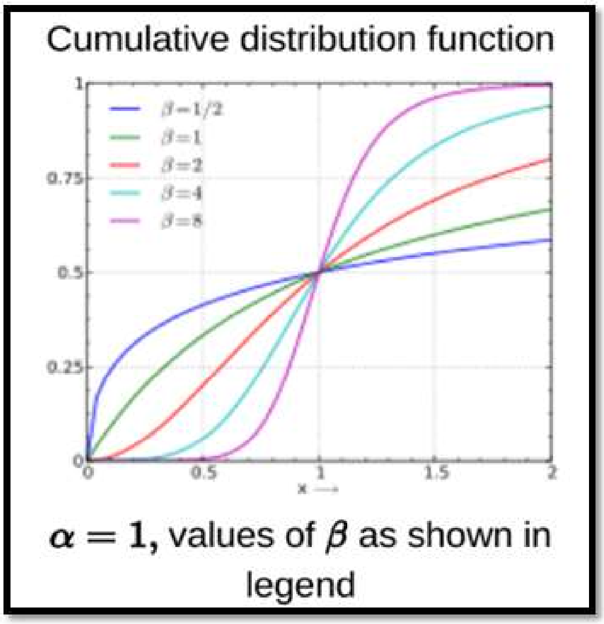


Source: Extracted from Wikipedia as on 11.04.2020

2. Log-Logistic distribution:

$$P(X > x) = \frac{x^{\beta}}{a^{\beta} + x^{\beta}}, x > 0, a > o, \beta > 0$$

Figure-7 : CDF of a log-logistic random



variable

Source: Extracted from Wikipedia as on 11.04.2020

1. Fréchet distribution: P(X>x)=1-e^(-(? (x-m)/s)?^(-?)

x>m.) $P(X > x) = 1 - e - \left(\frac{x-m}{s} \right)^{-a} \quad x > m$

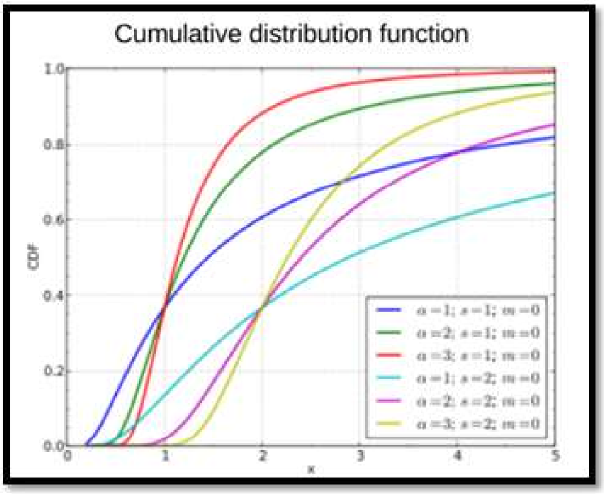


Figure-8 : CDF of a Fréchet random variable

Source: Extracted from Wikipedia as on 11.04.2020

These are some of the distributions that are frequently used, when the tails are non-normal or heavy. The above discussion gives the information on, how the tails are related to the expected or mean value. We now present some details related to heavy tails, fat tails etc.

Heavy tailed distribution:

The distribution of a random variable X with distribution function F is said to have a heavy (right) tail if the moment generating function of X, MX(t), is infinite for all t > 0. That means

$$\int_{-\infty}^{\infty} e^{tx}\, dF(x) = \infty \quad \text{for all } t > 0.$$

The same can be written in terms of the tail distribution function

$$\overline{F}(x) \equiv \Pr[X > x]$$

$$\lim_{x \to \infty} e^{tx}\overline{F}(x) = \infty \quad \text{for all } t > 0.$$

When discussing how much mass is in the tail of a probability density function, it is convenient to use the exponential distribution as a reference. The PDF of the exponential distribution approaches zero exponentially fast. That is, the PDF looks like exp(-?x) for large values of x. Thus, you can divide distributions into two categories according to the behaviour of their PDFs for large values of |x|.

- Probability distribution functions that decay faster than an exponential, are called thin-tailed distributions. Example for a thin-tailed distribution is the normal distribution, whose PDF decreases like exp(-x2/2) for large values of |x|. A thin-tailed distribution does not have much mass in the tail, so it serves as a model for situations in which extreme events are unlikely to occur.

- Probability distribution functions that decay slower than an exponential, are called heavy-tailed distributions. Example for a heavy-tailed distribution is the t distribution. The tails of many heavy-tailed distributions follow a power law (like |x|-?) for large values of |x|. A heavy-tailed distribution has substantial mass in the tail, so it serves as a model for situations in which extreme events occur somewhat frequently.

Table-2 : Regularly varying distribution functions

Distribution	$\overline{F}(x)$ or $f(x)$	Index of regular variation
Pareto	$\overline{F}(x) = x^{-\alpha}$	$-\alpha$
Burr	$\overline{F}(x) = \left(\frac{1}{x^{\tau}+1}\right)^{\alpha}$	$-\tau\alpha$
Log-Gamma	$f(x) = \frac{\alpha^{\beta}}{\Gamma(\beta)} (\ln(x))^{\beta-1} x^{-\alpha-1}$	$-\alpha$

Source: Extracted from the monograph of Cook and Nieboer (2011)

Fat-tailed distributions

A fat-tailed distribution is a probability distribution that exhibits a large skewness or kurtosis, in comparison to either a normal distribution or an exponential distribution. Fat-tailed distributions include those whose tails decay like a power law.

$$\Pr[X > x] \sim x^{-\alpha} \text{ as } x \to \infty, \qquad \alpha > 0.$$

Here, ? is small. For example, ?<3 the variance and skewness of the tail is mathematically undefined and hence larger than normal or exponential distribution.

From a modelling perspective, fat-tailed distributions are important when extreme events must be part of the model. For example, models of claims in the home insurance industry have to account for an intense category 5 hurricane hitting the Miami area, or Superstorm Sandy flooding the New York area. Although the probability of these extreme events is small, the size of the pay-out is so large that these events are vital to models of insurance claims.

From a mathematical perspective, the most fascinating aspect of fat-tailed distributions is that the mean, variance, and other measures that describe the shape of the distribution might not be defined. You might wonder how this can be. For the symmetric Cauchy distribution, pictured at the left, it looks like the mean should be at zero. After all, the function is symmetric. However, although the Cauchy distribution has a well-defined median and mode at 0, the mean is not defined.

Long-tailed distribution

The distribution of a random variable X with a distribution function F is said to have a long tail if for all t>0,

$$\lim_{x\to\infty} \Pr[X > x + t \mid X > x] = 1,$$

or equivalently

$$\overline{F}(x+t) \sim \overline{F}(x) \quad \text{as } x \to \infty.$$

Note that, all long-tailed distributions are heavy-tailed, but the converse is not true.

Sub-exponential distributions

A distribution function F with support (0,?) is a sub-exponential distribution, if for all n?2

$$\lim_{x\to\infty} \frac{\overline{F^{n*}}(x)}{\overline{F}(x)} = n.$$

Table-3 : Distributions with sub-exponential tails

Distribution	Tail $\overline{F}$ or density f	Parameters
Lognormal	$f(x) = \frac{1}{\sqrt{2\pi}\sigma x} e^{\frac{-(\ln(x)-\mu)^2}{2\sigma^2}}$	$\mu \in \mathbb{R},\ \sigma > 0$
Benktander-type-I	$\overline{F}(x) = \left(1 + 2\frac{\beta}{\alpha}\ln(x)\right) e^{-\beta(\ln(x))^2-(\alpha+1)\ln(x)}$	$\alpha,\ \kappa > 0$
Benktander-type-II	$\overline{F}(x) = e^{\frac{\alpha}{\beta}} x^{-(1-\beta)} e^{-\alpha\frac{x^\beta}{\beta}}$	$\alpha > 0,\ 0 < \beta < 1$
Weibull	$\overline{F}(x) = e^{-cx^\tau}$	$c > 0,\ 0 < \tau < 1$

Source: Extracted from the monograph of Cook and Nieboer (2011)

Tail behaviour for the generalized extreme value distribution

We now present the tail behaviour of the extreme value distributions.

The tail of the generalized extreme value distribution is given by $P(X > x) = 1 - G_{(x;\mu,\sigma,\xi)}$

$$P(X > x) = \exp\left\{-\left[1+\xi\left(\frac{x-\mu}{\sigma}\right)\right]^{\frac{-1}{\xi}}\right\}, \text{for } 1+\xi\left(\frac{x-\mu}{\sigma}\right) > 0 \text{ and } \xi \neq 0$$

Based on the value of ? we get the respective tail behaviour of the three extreme type distributions.

Tail Behaviour of stable distributions

We now present few details related to sums of random variables or the total stock price random variable.

Note that, the tail of the distribution of the sum of random variables is decided based on the tail index or stable index value. If the value is equal to 2, then we get a normal model and the tail is discussed earlier. When the value is less than 2, the tail probabilities behave like x^(-?).

The tail of a stable random variable with index between 0<?<2 is given by

where $$\begin{cases} \lim_{\lambda\to\infty} \lambda^{\alpha} P\{X > \lambda\} & = C_{\alpha} \frac{1+\beta}{2} \sigma^{\alpha}, \\ \lim_{\lambda\to\infty} \lambda^{\alpha} P\{X < -\lambda\} & = C_{\alpha} \frac{1-\beta}{2} \sigma^{\alpha}, \end{cases}$$

$$C_{\alpha} = \left(\int_0^{\infty} x^{-\alpha} \sin x dx\right)^{-1} = \begin{cases} \frac{1-\alpha}{\Gamma(2-\alpha)\cos(\pi\alpha/2)} & \text{if } \alpha \neq 1, \\ 2/\pi & \text{if } \alpha = 1. \end{cases}$$

In the current study, we focus on three aspects. The first one is related to identifying the probability distribution of stock prices and estimating the tail index of each of the 50 stock considered, the second one is related to identifying the extreme value distribution of the extreme stock prices (maximum and minimum), the third one is related to total stock price random variable. In all the three cases, we divide the daily stock prices at different time points, where the market crashes have occurred. We observe and note the changes in the distributions and index values with the change in the time points. These form the main objectives of the study.

Based on the classification of tail index given in the following point, we present the analysis.

- $1 < \alpha \leq 2$, all moments diverge, i.e., $\mathsf{E}[X] = \infty$;
- $2 < \alpha \leq 3$, all second and higher-order moments diverge, i.e., $\mathsf{E}[X^2] = \infty$;
- $3 < \alpha \leq m+1$, all m and higher-order moments diverge, i.e., $\mathsf{E}[X^m] = \infty$.

If the tail index has a value less than 1 or between 1 and 2, then it is classified as heavy tailed and moments of any order does not exist.

If the tail index has a value between 2 and 3, then it is classified as heavy tailed and only mean exists.

If the tail index has a value between 3 and m+1, then it is classified as heavy tailed and mean and variance both exists.

We now present few details related to extreme value theory and stable distributions.

1.1 Introduction to Extreme Value Theory

In this section, we present the discussion on extreme value distributions and their classification based on the tail index value.

Suppose that we have a sequence of random variables (X1, X2,.........., Xn) and let Mn be the maximum of all the random variables. Now, the interest is in studying the behaviour of the maximum random variable. Note that, X1, X2, ... Xn are the stock prices of a stock at different time points and Mn is the maximum stock price. One may be interested in predicting the maximum stock price and this leads to the study of the underlying probability model that best fits the maximum random variable. Note that, if one is interested to make predictions, then it is a regular practice to assume a probability model, to handle the uncertainty that gets induced into the prediction model. In such cases, one has to first identify a probability model that best fits the stock prices and then proceed to build a predictive model. For example, a normal probability model is assumed before a regression model is built for predicting the stock prices. Here, the interest is to make predictions on the maximum stock price. Hence, one has to identify the suitable probability model that best fits the maximum random variable. Similarly, one may be interested in the minimum stock price or the kth extreme value. Extreme value distributions have been identified as the appropriate probability models that best fit the extreme values, properly normalized. Note that, the extreme random variables have to be properly normalized before one proceeds to construct a probability model. For normalizing, one has to identify appropriate location and scale quantities. The probability models obtained through this process, form the set of extreme value distributions. We now present the discussion on these distributions and also classification based on the extremal index value.

Extreme value distributions arise as limit distributions of the maximum or minimum on 'n' independent and identically distributed random variables. The commonly used distributions are Gumbel (type-1), Fréchet (type-2), and Weibull (type-3). The type of the distribution is decided based on the extremal index value. The discussion on these limiting distributions dates to papers by Frechet (1927), Fisher and Tippet (1928), von Mises (1936), and Gnedenko (1943). de Haan (1970) proposes the domains of attraction of the extreme, usually called as max-stable or min-stable laws. Any type has three parameters- location, scale and shape. Also, each type has support and the corresponding characteristics. Note that, each type has other distributions getting attracted and the set of distributions form the domain of attraction of th

at type. Also, that irrespective of the original distribution, one can study the behaviour of the extreme random variables. We now present details of each type separately.

The following gives the three types of the extreme value distributions.

Type-1: Gumbel type or domain

The following is the distribution function of a Gumbel law.

$F(x;\mu\ \sigma,0)=e^{-e(x-\mu)/\sigma}$, for $x \in R$

Note that, the first type has the extremal index value ? is at level zero and one can classify the distribution of the extremes as Gumbel if the index value is close to zero. The index value can be estimated using one of the methods like Hill estimator or Pickand's estimator etc (refer to section- for further details). The following distributions form the domain of attraction of a Gumbel law.

- EXP(1): $F(x) = 1 - \exp(-x), x > 0;$
- Weibull for minima: $F(x) = 1 - \exp(-\lambda x^{\tau}), x > 0;\ \lambda, \tau > 0;$
- Logistic: $F(x) = 1 - \frac{1}{1+\exp(x)}, x \in \mathbb{R};$
- Gumbel: $\Lambda(x) = \exp(-\exp(-x)), x \in \mathbb{R};$
- Normal: $\int_{-\infty}^{x} \frac{1}{\sqrt{2\pi}} \exp(-t^2/2)dt, x \in \mathbb{R};$
- Lognormal: The r.v. X has a lognormal distribution if $\log\ X$ is a normal random variable;
- Gamma(α, β): $F(x) = \int_0^x \frac{\alpha^\beta}{\Gamma(\alpha)}(\log\ t)^{\beta-1} t^{-\alpha-1}\ dt$
- Fréchet *for minima*: $\Phi_\alpha^*(x) = 1 - \Phi_\alpha(-x) = 1 - \exp(-(-x)^{-\alpha}), x < 0;$ $\alpha > 0.$

Table-4 : Tail behaviour of the distributions for Gumbel law

Distribution	$1 - F(x)$
Weibull	$\exp(-\lambda x^{\tau}), \quad x > 0;\ \lambda, \tau > 0$
Exponential	$\exp(-\lambda x), \quad x > 0;\ \lambda > 0$
Gamma	$\frac{\lambda^m}{\Gamma(m)} \int_x^\infty u^{m-1} \exp(-\lambda u) du, \quad x > 0;\ \alpha, m > 0$
Logistic	$1/(1+\exp(x)), \quad x \in \mathbb{R}$
Normal	$\int_x^\infty \frac{1}{\sqrt{2\pi\sigma^2}} \exp\left(-\frac{(x-\mu)^2}{2\sigma^2}\right), \quad x \in \mathbb{R};\ \sigma > 0, \mu \in \mathbb{R}$
Log-normal	$\int_x^\infty \frac{1}{\sqrt{2\pi\sigma^2} u} \exp\left(-\frac{1}{2\sigma^2}(\log u - \mu)^2\right) du, \quad x > 0;\ \mu \in \mathbb{R}, \sigma > 0$

Source: Extracted from the monograph of Cook and Nieboer

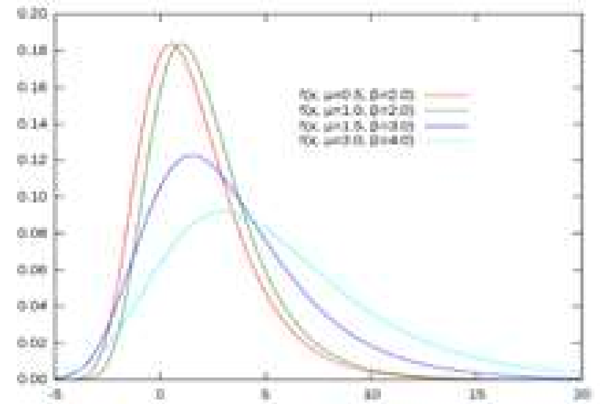
The above gives the tail behaviour of the distributions that belong to the domain of attraction of a Gumbel law.

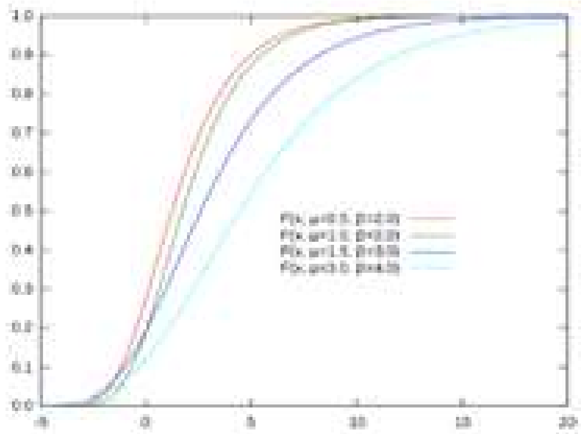
In the current study, we make an attempt to identify the stocks that are under the domain of attraction of a Gumbel law. For this, we estimate the index value for each of the stocks and, those stocks that have the index value close to zero will be classified as the under the domain of a Gumbel law.

The following are the characteristics of a Gumbel law

Figure-9

Graph of probability density functionGraph of cumulative distribution function





Source: From Wikipedia as on 07.04.2020

Parameters	μ, location (real) $\beta > 0$, scale (real)
Support	$x \in \mathbb{R}$
PDF	$\frac{1}{\beta} e^{-(z+e^{-z})}$ where $z = \frac{x-\mu}{\beta}$
CDF	$e^{-e^{-(x-\mu)/\beta}}$
Mean	$\mu + \beta\gamma$ where γ is the Euler–Mascheroni constant
Median	$\mu - \beta \ln(\ln 2)$

Mode	μ
Variance	$\frac{\pi^2}{6}\beta^2$
Skewness	$\frac{12\sqrt{6}\,\zeta(3)}{\pi^3} \approx 1.14$
Ex. kurtosis	$\frac{12}{5}$
Entropy	$\ln(\beta) + \gamma + 1$
MGF	$\Gamma(1-\beta t)e^{\mu t}$
CF	$\Gamma(1-i\beta t)e^{i\mu t}$

Source: From Wikipedia as on 07.04.2020

Type-2: Fréchet law of domain

The following is the distribution function of a Fréchet law.

$F(x;\mu, \sigma, \xi) = e^{-y^{-a}}$, $y \geq 0$

Here $\xi = \frac{1}{a} > 0$ and $y=1+\xi(x-\mu)/\sigma$. If $\xi>0$, then we classify the corresponding distribution under Fréchet law. Using the data collected on the original random variable, we estimate the index and based on the value we classify the distribution of the maximum random variable. The following are the distributions that fall under the domain.

- Pareto Pa(α): $F(x) = 1 - x^{-\alpha}, x > 1, \alpha > 0$; EVI: $\xi = \frac{1}{\alpha}$;
- Generalized Pareto GP(σ, ξ): $F(x) = 1 - \left(1 + \xi\frac{x}{\sigma}\right)^{-\frac{1}{\xi}}, x > 0;\ \sigma, \xi > 0$, EVI: ξ
- Burr(η, τ, λ): $F(x) = 1 - \left(\frac{\eta}{\eta + x^\tau}\right)^\lambda, x > 0;\ \eta, \tau, \lambda > 0$, EVI: $\xi = \frac{1}{\lambda\tau}$;
- Fréchet(α): $F(x) = \exp(-x^{-\alpha}), x > 0;\ \alpha > 0$, EVI: $\xi = \frac{1}{\alpha}$;
- t-student with ν degrees of freedom: EVI: $\xi = \frac{1}{\nu}$;
- Cauchy: $F(x) = \frac{1}{2} + \frac{1}{\pi}\arctan x, x \in \mathbb{R}$, EVI: $\xi = 1$;
- Log-gamma(α, λ): $F(x) = \int_1^x \frac{\lambda^\alpha}{\Gamma(\alpha)}(\log\ t)^{\alpha-1} t^{-\lambda-1}\ dt$, EVI: $\xi = \frac{1}{\lambda}$.

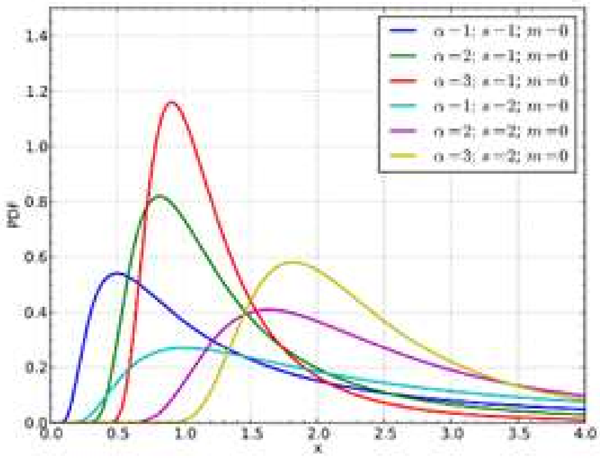
Table-5 : Tail behaviour of the distributions belonging to Fréchet law

Distribution	$1-F(x)$	Extreme value index
Pareto	$\sim Kx^{-\alpha}, K, \alpha > 0$	$\frac{1}{\alpha}$
$F(m,n)$	$\int_x^\infty \frac{\Gamma(\frac{m+n}{2})}{\Gamma(\frac{m}{2})\Gamma(\frac{n}{2})}\omega^{\frac{m}{2}-1}\left(1+\frac{m}{n}\omega\right)^{-\frac{m+n}{2}} d\omega$ $x > 0;\ m, n > 0$	$\frac{2}{n}$
Fréchet	$1-\exp(-x^{-\alpha})$ $x > 0; \alpha > 0$	$\frac{1}{\alpha}$
T_n	$\int_x^\infty \frac{2\Gamma(\frac{n+1}{2})}{\sqrt{n\pi}\Gamma(\frac{n}{2})}\left(1+\frac{\omega^2}{n}\right)^{-\frac{n+1}{2}} d\omega$ $x > 0; m, n > 0$	$\frac{1}{n}$

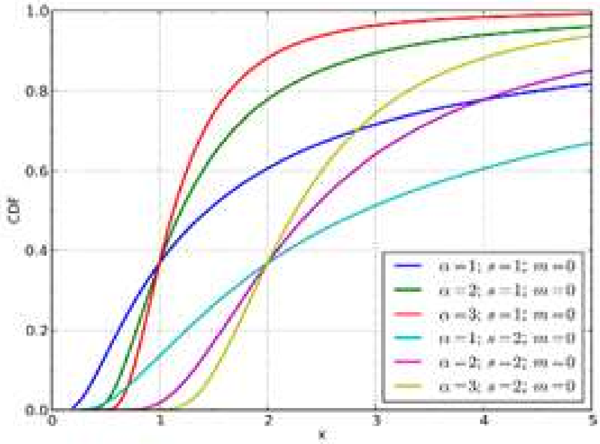
Source: Extracted from the monograph of Cook and Nieboer

The following are the characteristics of a Fréchet law.*Figure-10 :*

Graph of probability density function



Graph of cumulative distribution function



Source: From Wikipedia as on 07.04.2020

Parameters	$\alpha \in (0, \infty)$ shape. (Optionally, two more parameters) $s \in (0, \infty)$ scale (default: $s = 1$) $m \in (-\infty, \infty)$ location of minimum (default: $m = 0$)
Support	$x > m$
PDF	$\frac{\alpha}{s}\left(\frac{x-m}{s}\right)^{-1-\alpha} e^{-\left(\frac{x-m}{s}\right)^{-\alpha}}$
CDF	$e^{-\left(\frac{x-m}{s}\right)^{-\alpha}}$
Mean	$\begin{cases} m + s\Gamma\left(1-\frac{1}{\alpha}\right) & \text{for } \alpha > 1 \\ \infty & \text{otherwise} \end{cases}$
Median	$m + \frac{s}{\sqrt[\alpha]{\log_e(2)}}$

Mode	$m + s\left(\frac{\alpha}{1+\alpha}\right)^{1/\alpha}$
Variance	$\begin{cases} s^2\left(\Gamma\left(1-\frac{2}{\alpha}\right) - \left(\Gamma\left(1-\frac{1}{\alpha}\right)\right)^2\right) & \text{for } \alpha > 2 \\ \infty & \text{otherwise} \end{cases}$
Skewness	$\begin{cases} \frac{\Gamma\left(1-\frac{3}{\alpha}\right) - 3\Gamma\left(1-\frac{2}{\alpha}\right)\Gamma\left(1-\frac{1}{\alpha}\right) + 2\Gamma^3\left(1-\frac{1}{\alpha}\right)}{\sqrt{\left(\Gamma\left(1-\frac{2}{\alpha}\right) - \Gamma^2\left(1-\frac{1}{\alpha}\right)\right)^3}} & \text{for } \alpha > 3 \\ \infty & \text{otherwise} \end{cases}$
Ex. kurtosis	$\begin{cases} -6 + \frac{\Gamma\left(1-\frac{4}{\alpha}\right) - 4\Gamma\left(1-\frac{3}{\alpha}\right)\Gamma\left(1-\frac{1}{\alpha}\right) + 3\Gamma^2\left(1-\frac{2}{\alpha}\right)}{\left[\Gamma\left(1-\frac{2}{\alpha}\right) - \Gamma^2\left(1-\frac{1}{\alpha}\right)\right]^2} & \text{for } \alpha > 4 \\ \infty & \text{otherwise} \end{cases}$
Entropy	$1 + \frac{\gamma}{\alpha} + \gamma + \ln\left(\frac{s}{\alpha}\right)$, where γ is the Euler–Mascheroni constant.
MGF	[1] Note: Moment k exists if $\alpha > k$
CF	[1]

Source: From Wikipedia as on 07.04.2020

Type-3: Weibull law of domain

The following is the distribution function of the Weibull law.

$F(x;\mu, \sigma, \xi) = e^{-y^{-a}}$, $y < 0$ and -1, $y \geq 0$

Here $\xi = \frac{1}{a} < 0$ and $y = -1+\xi(x-\mu)/\sigma$. If $\xi>0$, then we classify the corresponding distribution under a Weibull law.

- Uniform $\mathcal{U}(0, 1)$: $F(x) = x, 0 < x < 1$; EVI: $\xi = -1$;
- Beta(a, b): $F(x) = \int_0^x \frac{\Gamma(a+b)}{\Gamma(a)\Gamma(b)} u^{a-1}(1-u)^{b-1}\, du, x < 1, a, b > 0$; EVI: $\xi = \frac{-1}{q}$
- Reversed Burr(β, τ, λ): $F(x) = 1 - \left(\frac{\beta}{\beta+(-x)^{-\tau}}\right)^{\lambda}$, $x < 0$; $\beta, \tau, \lambda > 0$; EVI: $\xi = \frac{-1}{\lambda\tau}$;
- Weibull *for maxima*: $F(x) = 1 - \exp(-x^{-\alpha}), x > 0$; $\alpha > 0$; EVI: $\xi = \frac{-1}{\alpha}$.

Table-6 : Tail behaviour of distributions belonging to Weibull law

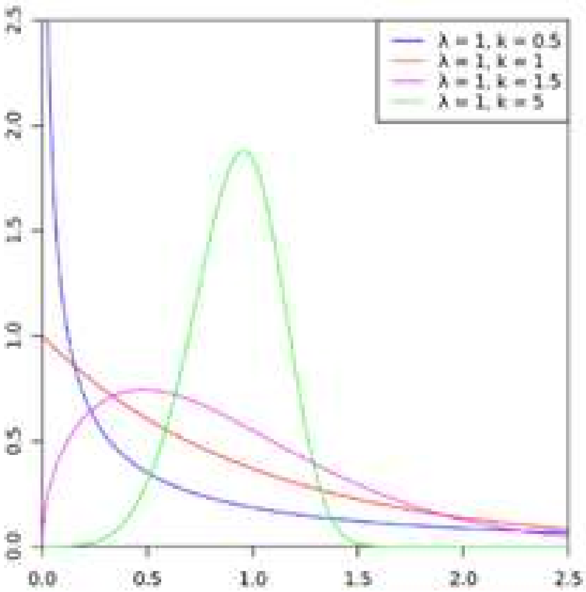
Distribution	$1 - F\left(\omega(F) - \frac{1}{x}\right)$	Extreme value index
Uniform	$\frac{1}{x}$ $x > 1$	-1
Beta(p,q)	$\int_{1-\frac{1}{x}}^{1} \frac{\Gamma(p+q)}{\Gamma(p)\Gamma(q)} u^{p-1}(1-u)^{q-1}du$ $x > 1;\ p,q > 0$	$-\frac{1}{q}$
Reversed Weibull	$1 - \exp(-x^{-\alpha})$ $x > 0;\ \alpha > 0$	$-\frac{1}{\alpha}$

Source: Extracted from the monograph of Cook and Nieboer

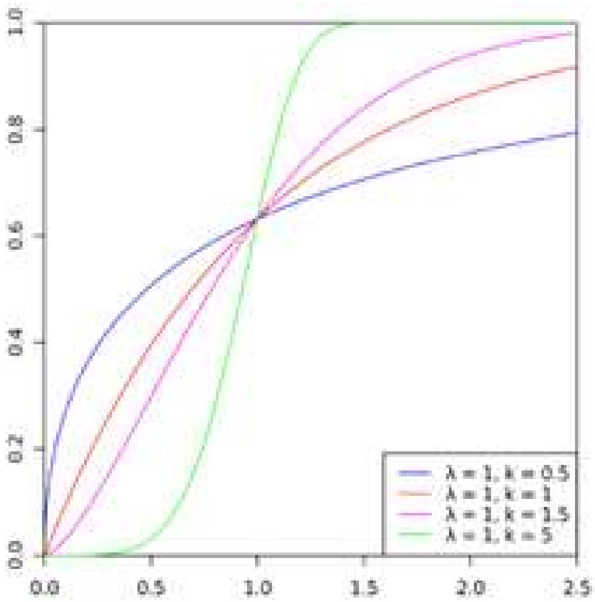
The following are the characteristics of a Weibull law.

Figure-11

Graph of probability density function



Graph of cumulative distribution function



Source: From Wikipedia as on 07.04.2020

Parameters	$\lambda \in (0, +\infty)$ scale $k \in (0, +\infty)$ shape
Support	$x \in [0, +\infty)$
PDF	$f(x) = \begin{cases} \frac{k}{\lambda}\left(\frac{x}{\lambda}\right)^{k-1} e^{-(x/\lambda)^k} & x \geq 0 \\ 0 & x < 0 \end{cases}$
CDF	$\begin{cases} 1 - e^{-(x/\lambda)^k} & x \geq 0 \\ 0 & x < 0 \end{cases}$
Mean	$\lambda \Gamma(1 + 1/k)$
Median	$\lambda(\ln 2)^{1/k}$

Mode	$\begin{cases} \lambda\left(\frac{k-1}{k}\right)^{1/k} & k > 1 \\ 0 & k \leq 1 \end{cases}$
Variance	$\lambda^2\left[\Gamma\left(1+\frac{2}{k}\right) - \left(\Gamma\left(1+\frac{1}{k}\right)\right)^2\right]$
Skewness	$\frac{\Gamma(1+3/k)\lambda^3 - 3\mu\sigma^2 - \mu^3}{\sigma^3}$
Ex. kurtosis	(see text)
Entropy	$\gamma(1 - 1/k) + \ln(\lambda/k) + 1$
MGF	$\sum_{n=0}^{\infty} \frac{t^n \lambda^n}{n!} \Gamma(1 + n/k),\ k \geq 1$
CF	$\sum_{n=0}^{\infty} \frac{(it)^n \lambda^n}{n!} \Gamma(1 + n/k)$

Source: From Wikipedia as on 07.04.2020

Generalized Extreme Value Distribution

The three types of the distributions can be represented using generalized extreme value (GEV) distribution. The following is the distribution function of the GEV

$$F(s;\xi) = \begin{cases} \exp(-(1+\xi s)^{-1/\xi}) & \xi \neq 0 \\ \exp(-\exp(-s)) & \xi = 0 \end{cases}$$

where $\xi \in R$ is the shape parameter, $s=(x-\mu)/\sigma$, where $\mu \in R$ is the location parameter, and $\sigma > 0$ is the scale parameter.

The characteristics of the GEV

Notation	$\mathrm{GEV}(\mu, \sigma, \xi)$
Parameters	$\mu \in \mathbf{R}$ — location, $\sigma > 0$ — scale, $\xi \in \mathbf{R}$ — shape.
Support	$x \in [\mu - \sigma/\xi, +\infty)$ when $\xi > 0$, $x \in (-\infty, +\infty)$ when $\xi = 0$, $x \in (-\infty, \mu - \sigma/\xi]$ when $\xi < 0$.
PDF	$\frac{1}{\sigma} t(x)^{\xi+1} e^{-t(x)}$, where $t(x) = \begin{cases} \left(1+\xi\left(\frac{x-\mu}{\sigma}\right)\right)^{-1/\xi} & \text{if } \xi \neq 0 \\ e^{-(x-\mu)/\sigma} & \text{if } \xi = 0 \end{cases}$
CDF	$e^{-t(x)}$, for $x \in$ support
Mean	$\begin{cases} \mu + \sigma(g_1 - 1)/\xi & \text{if } \xi \neq 0, \xi < 1, \\ \mu + \sigma\gamma & \text{if } \xi = 0, \\ \infty & \text{if } \xi \geq 1, \end{cases}$ where $g_k = \Gamma(1 - k\xi)$, and γ is Euler's constant.

Median	$\begin{cases} \mu + \sigma\frac{(\ln 2)^{-\xi} - 1}{\xi} & \text{if } \xi \neq 0, \\ \mu - \sigma \ln\ln 2 & \text{if } \xi = 0. \end{cases}$
Mode	$\begin{cases} \mu + \sigma\frac{(1+\xi)^{-\xi} - 1}{\xi} & \text{if } \xi \neq 0, \\ \mu & \text{if } \xi = 0. \end{cases}$
Variance	$\begin{cases} \sigma^2 (g_2 - g_1^2)/\xi^2 & \text{if } \xi \neq 0, \xi < \frac{1}{2}, \\ \sigma^2 \frac{\pi^2}{6} & \text{if } \xi = 0, \\ \infty & \text{if } \xi \geq \frac{1}{2}. \end{cases}$
Skewness	$\begin{cases} \operatorname{sgn}(\xi)\frac{g_3 - 3g_2g_1 + 2g_1^3}{(g_2 - g_1^2)^{3/2}} & \text{if } \xi \neq 0, \xi < \frac{1}{3}, \\ \frac{12\sqrt{6}\,\zeta(3)}{\pi^3} & \text{if } \xi = 0. \end{cases}$ where $\operatorname{sgn}(x)$ is the sign function and $\zeta(x)$ is the Riemann zeta function
Ex. kurtosis	$\begin{cases} \frac{g_4 - 4g_3g_1 - 3g_2^2 + 12g_2g_1^2 - 6g_1^4}{(g_2 - g_1^2)^2} & \text{if } \xi \neq 0, \xi < \frac{1}{4}, \\ \frac{12}{5} & \text{if } \xi = 0. \end{cases}$

Source: From Wikipedia as on 07.04.2020

Based on the value of the shape parameter, the three types of extreme value distributions can be represented. If the value of ?=0, then one gets a Gumbel law. If the value of ?>0, then one gets a Fréchet law. If the value of ?<0, then one gets a Weibull law.

In the current study, we compute the value of ? for each stock and based on the value of ? the distribution of the maximum stock price random variable will be classified. Note that, the distribution of minimum is obtained by considering the negative of the random variable considered. That is, -X is substituted in the place of X to obtain the distribution of minimum stock price random variable. The role of extreme value theory in the stock market behaviour will be presented in the literature review section.

Introduction to Stable distributions

In this section, we introduce stable distributions and present the details in brief.

Stable distributions arise as limiting distributions of sums of random variables. In the current study, we are interested to study the behaviour of the total stock price random variable for each of the stocks considered.

In practice, there will be two situations while handling the random variables. The first one is the case where the variance of the random variable is finite and in the second case, the random variable has infinite variance. In both the cases, one can study the behaviour of the random variable using appropriate probability model. Hence, one has to determine whether the random variable has finite variance or infinite variance, before getting into analysis. That is, the type of random variable has to be decided before starting the analysis. This is very important if one is interested in studying the behaviour of the total random variable. While dealing with the total or sums, one adds sequence of random variables and the aggregate of all may lead to infinite variance. That is, when bits and pieces of information is aggregated, sometimes, we may add few pieces of information which are very large and this makes the deviation of other information from the average information, very large. This leads to infinite variance. Hence, one has to use appropriate probability models to handle such random variables. Among other distributions, stable distributions play an important role, when the random variable has infinite variance. A normal model is used if the variance is finite. Other distributions that can handle the finite variance also exist. But when dealing with sums, stable and normal models are frequently used. In order to decide whether to use normal or stable, one has to estimate the tail index. If the tail index value is equal to 2, then one has to adopt a normal model. If the index value less than 2, then

one has to adopt a stable model. If the index value is equal to 1, then the underlying distribution will be Cauchy. If the value is 0.5, then the corresponding distribution is Levy. One can note here that, larger variance implies heavy tails.

Stable distributions are characterized by four parameters- tail index or exponent (??(0,2]), skewness parameter (??[-1,1]), scale parameter (?>0), and location parameter (??R). The tail index decides the rate at which the tails of the distribution taper off. When ?=2, the resulting distribution is normal. When ?<2, the resulting distribution has variance as high as infinity and the tails are asymptotically equivalent to a Pareto law. When ?>2, stable distributions exhibit a crossover from a power decay to the true tail with exponent ?. When ?>1, then mean of the distribution exist and equal to ?. The moments do not exist if ?<1. If ?>0, then the distribution if positively skewed (the right tail is thicker) and negatively skewed if ?<0. When ?=0, one gets a symmetric stable distribution. As ? approaches 2, ? looses its effect and the resulting distribution is a Gaussian distribution. The other two parameters ? and ? are respectively the location and the scale parameters. While ? determines the width, ? determines the shift of the mode. When ?=0 and ?=1, one gets a standard stable distribution. A stable distribution is denoted by . Except for a normal distribution and few other distributions, density functions are not known in a compact form for stable distributions. Most of the time they are dealt with their respective characteristic function. The following gives the characteristic function of a stable distribution.

$$\ln \phi(t) = \begin{cases} -\sigma^{\alpha}|t|^{\alpha}\{1 - i\beta \operatorname{sign}(t) \tan \frac{\pi\alpha}{2}\} + i\mu t, & \alpha \neq 1, \\ \\ -\sigma|t|\{1 + i\beta \operatorname{sign}(t) \frac{2}{\pi} \ln|t|\} + i\mu t, & \alpha = 1. \end{cases}$$

A modified version that suits the numerical purposes was proposed by Nolan (1997) and the following gives the same.

$$\ln \phi_0(t) = \begin{cases} -\sigma^\alpha |t|^\alpha \{1 + i\beta \operatorname{sign}(t) \tan \frac{\pi\alpha}{2} [(\sigma|t|)^{1-\alpha} - 1]\} + i\mu_0 t, & \alpha \neq 1, \\ -\sigma|t|\{1 + i\beta \operatorname{sign}(t) \frac{2}{\pi} \ln(\sigma|t|)\} + i\mu_0 t, & \alpha = 1. \end{cases}$$

The tail of a stable random variable where ?<2 is given by

$$\begin{cases} \lim_{x\to\infty} x^\alpha \mathrm{P}(X > x) = C_\alpha(1+\beta)\sigma^\alpha, \\ \lim_{x\to\infty} x^\alpha \mathrm{P}(X < -x) = C_\alpha(1+\beta)\sigma^\alpha, \end{cases}$$

where

$$C_\alpha = \left(2\int_0^\infty x^{-\alpha} \sin(x)dx\right)^{-1} = \frac{1}{\pi}\Gamma(\alpha)\sin\frac{\pi\alpha}{2}.$$

We do not present more mathematical equations related to these distributions. One can refer to the book of Samorodnitsky and Taqqu (2000) for further details.

In the current study, we estimate the tail index for each of the stocks and based on index value, we classify the distribution of the total stock price random variable. The literature related to the application of stable distributions in stock market is given in the literature review section.

Importance of studying the sums or total stock prices

Studying the total prices will help one to understand the impact of the extreme prices or outliers, on the behaviour of the stock prices. It is a well-known fact that extremes affect the sums or total. If there are extremes in the data set, then they either increase or decrease the value of the sums and exclusion of the same improves the performance of the sums. The same can be sometimes used to test the behaviour of the stock prices. We propose this process through the current study.

For each of the stocks considered, we try to identify the distribution of the total stock price random variable. From the early discussion presented, we recall that the total price random variable can belong either to the domain of normal or to the domain of stable law. This process will be applied for every time period considered and the same will be recorded. If any time period has extremes and affect the stock, then the domain will be stable. If not, then the domain will be normal. Domain is stable, implies that the variance of the random variable is infinite, and the tails are heavier. This implies that the market crashes have affected the stock prices and the domain of the total stock price changes from normal to stable. We apply this process for each of the stocks considered and note the frequency of the change in the domain. If a stock has more changes, then we classify that stock as a high volatile stock. That is, it has got affected by the market crashes or the financial crisis, frequently. Based on the analysis, we classify present the stocks in a table and the same can be used for further decision making.

The decision on the domain will be made based on the value of the stable exponent or tail index. If the value is equal to 2, then we consider a normal domain. If the value is less than 2, then we consider a stable domain.

If the domain is normal, we conclude that the marker crashes have not affected the behaviour of the stock price random variable much. Note that the mean, variance and other moment's might have got affected. But the probability structure of the total stock price random variable might not have got affected. That is, the extremes generated by the market crashes, didn't affect the behaviour of the total stock price random variable. In practical terms one can say that, the cumulative stock price behaviour didn't get affected and hence the basic structure of the stock price random variable is not affected. For example, let us consider stock A. Assume that its behaviour is normal, and a market crash has happened. One can expect that the stock prices have got affected and answer may be yes. But, the original structure of normality might not have got affected. This can be checked by studying the behaviour of the total stock price random variable. The stock prices can be seen as the sequence of random variables and the total stock price if the sum of the sequence of random variables. If there are extremes, then the sum gets affected. Assume that the market crash has occurred, and the stock prices got affected. Then, the values of the stock price random variable may be low or high or lower than the expected values. Individually the values may be high or low. But when taken the aggregate of all the values, the high and low values get adjusted and the total will have a normal behaviour. This can be taken as a test for the influence of the market crashes or the financial crisis, on the stock prices. For each of the stocks considered, we propose to check this and draw conclusions. If the domain is stable, then we conclude that the market crashes have significant effect on the stock prices. They increase the variance or thickness of the tails so that, a normal model cannot be used.

We adopt this process to classify the stocks and check if the market crashes or financial crisis have affected them. Note that, this process can be used to check if the normal behaviour of the stock prices is affected or not.

Organization of the project report

The study is mainly conducted to achieve three main goals. The first one is related to the probability distribution of the stock prices, under which we make an attempt to find other probability distributions that can best fit the stock price behaviour and estimate the tail index for each of the stock considered. Sometimes, no distribution can best fit the stock price random variable. In such cases, the estimate of the tail index will help one to know the thickness of the tails and

, based on this one can conclude on the behaviour of the stock price random variable. The second goal is to find the extreme value distribution for maximum stock price and the minimum stock price and estimate the extremal tail index. The last goal of the study is to find the domain to which the total stock price random variable belongs to. For example, normal or stable. Taking these into consideration, we organize the project in the following way.

1.Literature review will be presented in section 2.

2.Research gap will be presented in section 3

3.Motivation for the study will be discussed in section 4

4.Problem statement will be presented in section 5

5.Research questions, research objectives and research hypotheses will be presented in sections 6, 7, and 8 respectively.

6.Null and alternative hypotheses are given in section 9

7.Research methodology is presented in section 10

8.Data analysis and key findings is presented in section 11

9.Conclusion and managerial Implications are presented in sections 12 and 13 respectively. In section 14 we present the imitations and scope for the future work

10.References and appendix

Literature Review

In this section, we present the studies that have attempted to identify the probability model for the stock prices, estimate the tail index of the stock prices/ returns variable, identify the probability model for the extreme (maximum, minimum etc) stock process/ returns, identify the probability model for the total stock prices/returns etc.

Mandelbrot (1963) studies the behaviour of the stock returns and points that the returns do not follow a normal model and suggests that a stable-Paretian will be an appropriate model to study the behaviour of returns. Note that, when the kurtosis or skewness increases there is every possibility for the variance to increase and sometimes can reach infinity Here, one can question on the validity of the statistical methods that depend on the assumption of the finite variance. Fama (1965) states that statistical methods developed based on the assumption of finite variance do not work if the variance of distribution of returns is large. He considers testing of the hypothesis of Mandelbrot for the case of stock prices. At this stage, one can question of alternative models. Hsu, Miller and Wichern (1974) proposes an alternative model to study the rates of return based on the hypothesized phenomenon of a changing variance. In cases where the variance increases one has to investigate the tail behaviour of the random variable. Akgiray and Booth (1988) investigates the tail shapes of empirical distributions of returns on an extensive group of common stocks. Their study finds that the returns distributions have tails thinner than an infinite variance stable distribution. They also argue that economic and statistical inferences drawn from stable-law parameters estimated from samples of stock returns may be misleading. In such cases one tends to look for normal distribution or a better alternative. Gray and French (1990) examines the ability of the normal distribution to model log price returns from the S&P 500 composite index and compare its performance to three alternative finite variance distributions (scaled- distribution, logistic distribution, and exponential power distribution). It is a known fact that the variance of any random variable increases due to the presence of extremes. But sometimes, the aggregate of the data points may neutralize the impact of these extremes. Also, large samples may decrease the variance. Hing-Ling Lau et.al. (1990) presents an effective procedure for determining whether a reasonably large sample comes from a stable population against the alternative that it comes from a population with finite higher moments. This procedure shows convincingly that stock returns, when taken as a group, do not come from stable populations. Even for individual stocks, their results show that the Stable-population- model null hypothesis can be rejected for more than 95% of the stocks. Tucker (1992) investigates the general (asymmetric) stable Paretian distribution and three finite-variance, time-independent distributions applied to daily stock-return series. The study shows that finite time-independent models outperform the asymmetric stable Paretian distribution. Mittinik and Rachev (1993) shows that a Weibull model associated with both the non-random-minimum and geometric-random summation schemes dominates the other stable distributions considered including the stable Paretian model. Piero (1994) suggests the use of Student's t- distribution to any other finite variance distributions including the normal distribution. Dillen and Stoltz (1999) shows that the market returns have a Leptokurtic distribution and their results suggest that much of the Leptokurtic can be attributed to a jump component in the distribution. Qi-Man Shao et.al. (2001) proposed a test statistic to discriminate between models with finite variance and models with infinite variance. Aparico and Estrada (2001) considers daily stock returns of 13 European securities markets and shows that normality may be a plausible assumption for monthly (but not for daily) stock returns. Hoechsoetter, Rachev and Fabozzi (2005) analyses the returns of stocks comprising the German stock index DAX with respect to the stable distributions and shows that the stable hypothesis cannot be rejected. They also show that stable distribution outperforms the skew t-distribution. Weidong Xu et.al. (2011) demonstrate that a stable distribution is better fitted to Chinese stock return data in the Shanghai Composite Index and the Shenzhen Component Index

than the classical Black-Scholes model. Ma and Serota (2014) proves that student-t distribution provides a better fit to returns of S&P component stocks and generalized inverse gamma distribution best fits VIX and VXO volatility data. Further the study proves that stock returns are best fit by the product distribution of the generalized inverse gamma and normal distributions. They find Gu ?nay (2015) checks whether daily returns of Brent crude oil, dollar/yen foreign exchange, Dow&Jones Industrial Average Index and 12-month libor display power law features in the scaling exponent and probability distributions or not, using different methods. They show that the Brent crude oil and 12-month libor have a high persistency in the returns, while the dollar/yen foreign exchange and Dow&Jones Industrial Average Index returns have short memory. According to the alpha-stable parameter estimations, all of the return series have thicker tails than normal distribution. Corlu et. al (2016) investigates the ability of five alternative distributions to represent the behaviour of daily equity index returns over the period 1979-2014: the skewed Student-t distribution, the generalized lambda distribution, the Johnson system of distributions, the normal inverse Gaussian distribution, and the g-and-h distribution. They found that the generalized lambda distribution is a prominent alternative for modelling the behaviour of daily equity index returns. Naumoski et.al. (2017) rejects through empirical evidence that equity returns do not follow a normal distribution. They consider the stock returns of southeast European emerging markets and show that stock returns are leptokurtic with negative skewness. The study shows that Johnson SU distribution best fits the daily returns and for weekly and monthly returns, there is no one predominant distribution that can best fit the stock returns.

Afuecheta et.al. (2018) proposes three models based on scale mixing of the Student's t distribution and shows that they better fits than some known generalizations of the Student's t distribution, including those having more parameters.

In the recent times, researchers have attempted to study the stylized facts about the Indian stock market. Sen and Manavthi (2019) studies the stylized facts about Indian stock market. One important observation they make is, as the time scale over which returns are calculated increases, then the distribution looks like normal. They consider the 50 stocks listed under NIFTY and finds that fewer stocks are non-normal. P-values are less and less concentrated around zero and many stocks become similar to normal as time over which returns are calculated is lengthened.

We note from the above discussion that, the problem of identifying the probability distribution that best fits the stock prices is still open and revolves around identifying the probability model. Through this study, we make a fresh attempt to identify the probability model that best fits the stock price random variable.

Another aspect usually researchers are interested is to study the behaviour of the extreme prices (maxima and minima). The studies of Longin (1996), Jondeau and Rockinger (2003), Tolikas and Gettinby (2009) have indicated that the assumption of normality may lead to underestimation of risk. Normal distribution may not be a right choice to model the extreme stock returns. Extreme value theory (EVT) focuses on extreme returns and helps one to identify the distribution that best fits the behaviour of the extreme returns. EVT is used to model the stock returns by specifically focusing on the tails. Parkinson (1980) states that the tail of the empirical distribution contains important information for the variance of the returns. EVT is also used in the calculation of value at risk (VAR) and details related to the same can be found in Cotter (2007), Allen et.al. (2013), Marimoutou et.al. (2009) and Karmakar (2013).

The other studies that have focused on the study of extreme returns are Longin (1996), Jondeau and Rockinger (2003) and Gencay and Selcuk (2004). These studies reveal that extreme stock returns in the US can be characterized by the GEV distribution and can be used for calculating VaR measures and capital requirements. Generalized Logistic distribution and Generalized extreme value distributions are used frequently to study the behaviour of the extreme returns. The study by Gettinby et al. (2004 & 2006) shows that Generalized Logistic (GL) distribution fits extreme daily return better than Generalized extreme value (GEV) distribution. Tolikas and Gettinby (2009) shows that GL distribution is the best fit for the distribution of the extreme daily share returns in Singapore.

Hussain and Li (2015) studies the distribution of the extreme daily returns of the Shanghai Stock Exchange (SSE) composite index. Their results suggest that Generalized Logistic (GL) is a better fit for the minima series and the Generalized extreme value (GEV) is a distribution for the maxima series. Gabriel (2017) considers the Peruvian stock market returns and uses EVT to model the daily loss probability, estimates the maximum quantiles and tail probabilities of the distribution and models extremes through a maximum threshold. The same is used to measure value at risk (VAR) and expected shortfall (ES). They show that Gumbel and Fréchet fits the extreme returns and Generalized pareto distribution (GPD) in comparison with normal distribution, gives better estimates for VAR and ES.

From the literature we conclude that the best distribution for extreme returns differs from market to market. One of the reasons may be the economic environment and market mechanism of each market. Taking this into consideration, we make an attempt to identify the distribution of the extreme stock price random variables.

We use EVT to identify the domain for each of the stocks considered. Note many have attempted to study the extreme behaviour of the individual stock prices and we consider the same in the current study.

Research Gap

Based on the literature review we have identified the research gap. In this section, we present the research gap and the motivation for the study.

Attempts have been made to find the probability model that best fits the stock market returns and every study provides evidence on good fit of a probability model. The behaviour of the stock prices or returns changes with change in the market conditions and policies taken by the government or due to any other reason. Not many studies have focused on identifying the best possible distribution for the stocks listed under NIFTY and estimating the tail index. Especially, not many studies have been conducted to study this problem under market crashes. That is, at those time points where the market has collapsed and again revived. It is very important for an investor to understand the differences in the behaviour of the stock prices before the crisis, during the crisis and after the crisis. Sometimes, the probability model may change with change in the events and time. It may help one to observe and note the changes that take place. This also helps one to check if the market crashes have affected the behaviour of the stock prices. Another important point is, sometimes no probability model best fits the stock prices. In such cases, one has to study and measure the thickness of the tail of the stock price random variable. Based on the thickness of the tail, one can approximately identify the probability model and calculate the required probabilities. This is the motivation for us to consider this as one of the objectives of the study.

The next aspect that one looks at is, identifying the extreme value distribution for each stock separately. This will help one to calculate the risk measures associated with the extreme returns.

Knowing the model will help one to take appropriate decisions on the stocks and compare the stocks before taking any decision. Attempts have been made to fit extreme value distributions like GEV, GPD etc. But not many have been considered to specifically observe the stocks and note the changes in the domain with the change in the market crashes. Studying this will help one to note the volatility or change in the behaviour of extreme returns. We consider each stock and study the change in the extreme domain with change in the time periods.

The last aspect is studying the behaviour of the total stock price random variable. It is very well known that extreme affect the behaviour of the stock prices. One way of checking the same is studying the behaviour of sums or total stock price. If the extreme affect is high, then the behaviour of the total price random variable gets affected severely. If so, then the normal behaviour gets changed to stable behaviour. Under stable behaviour, the variance will be very high and close of infinity. In such cases, even the tails become very heavy and one has to estimate the tail index value to understand the behaviour of the stock prices. We study the total stock price of each of the stocks during the market crash time periods and based on the changes we classify the stocks. In the data analysis section, we present the analysis and the corresponding findings.

Problem Statement

Identifying a probability model for the stock prices or returns will help one to estimate the corresponding probabilities as well as risk measures. In the recent times, attempts have been made to identify the models and several models have emerged as best fits to the returns. Among these, a normal model has been rejected and alternative models such as Student-t, log-normal, Stable pareto, generalized extreme value distribution etc are being as alternative models. One of the reasons for a normal model getting rejected is, high kurtosis or skewness. Presence of extremes may disturb the behaviour of the stock prices and makes the tails heavy. This leads to high variance and a normal model fails to best fit the stock prices. Another important aspect is, to observe the behaviour at times when the market crashes or a financial crisis occurs. Studying the behaviour of the stock prices during these time periods will help one to list out those stocks that are highly volatile and stocks that are not volatile. One can avoid those stocks that are highly volatile and consider other stocks for investment. Here the problem is, identifying the model and classifying the stocks that are volatile. One way of achieving this is to fit a model during the time periods where the market crash or financial crisis has occurred and observing the changes in the behaviour. Not many have attempted to observe this and remained as an open problem. Another interesting aspect is, observing the behaviour of the extreme stock returns

and identifying the corresponding distribution. Though attempts have been made to identify the models, not many have observed the changes in the domains with changes in the events associated. As stated earlier, the presence of extremes may affect the behaviour of the stock prices. One way of identifying the level of affect is, to study the behaviour of the total stock price random variable. If the affect is high, then one can identify the stocks that have got affected and measure the risk associated with the stocks.

Earlier studies have made an attempt to solve the issues stated above. But studying the behaviour for individual stocks listed under NIFTY and during the market crashes is still an open problem. Through the current study we make an attempt to provide answers to these questions.

Research Questions

We propose the following research questions and try to find the answers through the study.

1. Are there other probability distributions that fit the stock prices significantly?

2.Will the change in the time points change the probability distribution or tail size or tail index value or the behaviour of the stock price random variable?

3.Will the change in the time points change the behaviour of the extreme stock prices? How many stocks have heavy tails or light tails?

4.What is the behaviour of the total stock price random variable? Is it normal or stable?

5.Will there be frequent change in the domain of total stock price random variable and whether the market crashes have affected the behaviour of the total stock prices.

Research Objectives

The following are the objectives of the study.

1.To identify the probability distribution of the stock price random variable, for each of the stocks considered and estimate the tail index.

2.To estimate the tail index and identify the domain of attraction for the maximum and minimum stock price.

3.To estimate the tail index and find the probability model for the total stock price random variable.

4.To find the differences in the probability models, at different critical time points.

5.To note the changes in the domains of the total price random variables during the market crash periods and identify the stocks that got affected by the market crashes.

Research Methodology

In this section, we present the research methodology adopted to achieve the objectives of the study.

Research Design

We adopt descriptive research design to address the objectives of the study.

Descriptive research design is used to describe the characteristics of the population under consideration. It mainly addresses the "What" "How", and "When" questions. That is, what are the characteristics of the population being studied? It looks at describing the given situation or the population, using descriptive categories. Descriptive research aims at understanding the current issue through a process of data collection that enables one to describe the situation completely. It is an appropriate choice, if one is interested in identifying the characteristics, frequencies, and trends.

In the current research, the main objective is to observe the changes in the pattern of the stock prices, with changes in the time points. That is, observe how the probability distribution of the stock prices change with the change in the time partitions considered. Also, observe the size of the tail index, understand the extreme value behaviour of the stock prices, and also the behaviour of the total stock price random variable. Hence to address these issues, we adopt descriptive research design.

Nifty Stocks considered

We have considered all the 50 stocks listed under NSE-Nifty 50 and the following table gives the details of the same.

Data and Time period

The daily stock prices of the 50 stocks listed on NSE, are considered as the data points in the current study. We have considered the daily stock prices between the years 2007 to 2020.

We have considered daily stock prices from the year 2007 to 2020 and the same are divided into six blocks/ groups. The first group consists of the daily stock prices from the year 2007 to 2009, the second consists of daily stock prices for the year 2010, the third has the stock prices from the year 2011 to 2014, fourth group has stock prices taken for the years 2015 and 2016, the fifth group has the stock prices from the year 2017 to 2019 and the last group has the daily stock prices for the year 2020. The cut-off points considered to divide the stock prices are chosen based on the critical events/ market crashes happened at those time points. For example, the year 2007 is when the market recession has started and continued till the year 2009. Hence, 2007 and 2009 are chosen as a cut-off points and the stock prices during this time period is considered as one group. Similarly, in the year 2010 there is a flash crash, during 2015-16 the world has experienced the Chinese stock market turbulence, markets have collapsed again in the year 2020 due to covid-19 issue. To observe the changes, the stock prices between the year 2017 and 2019 are taken as a separate group. The main objective of such divisions is, to observe the change in the distributions during the market crashes and other times. This will help the practitioners to model the stock prices using the suitable probability distribution and use the same for building the predictive models.

Symbol	Date of Inclusion in NSE	Symbol	Date of Inclusion in NSE
ADANIPORTS	27.Nov.2007	IOC	24.Jul.1996
ASIANPAINT	31.May.1995	ITC	23.Aug.1995
AXISBANK	16.Nov.1998	JSWSTEEL	23.Mar.2005
BAJAJ-AUTO	26.May.2008	KOTAKBANK	20.Dec.1995
BAJAJFINSV	26.May.2008	LT	23.June.2004
BAJFINANCE	01.Apr.2003	M&M	03.Jan.1996
BHARTIARTL	15.Feb.2002	MARUTI	09.Jul.2003
BPCL	13.Sep.1995	NESTLEIND	08.Jan.2010
BRITANNIA	05.Nov.1998	NTPC	05.Nov.2004
CIPLA	08.Feb.1995	ONGC	19.Jul.1995
COALINDIA	04.Nov.2010	POWERGRID	05.Oct.2007
DRREDDY	09.Jul.2003	RELIANCE	29.Nov.1995
EICHERMOT	07.Sep.2004	SBIN	01.Mar.1995
GAIL	02.Apr.1997	SUNPHARMA	08.Feb.1995
GRASIM	10.May.1995	TATAMOTORS	22.Jul.1998
HCLTECH	06.Jan.2000	TATASTEEL	18.Nov.1998
HDFC	23.Oct.1996	TCS	25.Aug.2004
HDFCBANK	08.Nov.1995	TECHM	28.Aug.2006
HEROMOTOCO	11.Apr.2003	TITAN	24.Sep.2004
HINDALCO	08.Jan.1997	ULTRACEMCO	24.Aug.2004
HINDUNILVR	06.Jul.1995	UPL	23.Jan.2004
ICICIBANK	17.Sep.1997	VEDL	13.May.1998
INDUSINDBK	28.Jan.1998	WIPRO	08.Nov.1995
INFRATEL	28.Dec.2012	YESBANK	12.Jul.2005
INFY	14.June.1993	ZEEL	09.Sep.1998

Methods used for analysing the data

In this section, we present the methods used to analyse the data and test the hypotheses proposed. We also present the approaches adopted to achieve the objectives of the study. We first present the probability models/distributions usually used in stock market analysis and also new models proposed through this study. We then present the test procedures adopted to test the significance of the probability models. Later we present the methods used to estimate the tail index of the stock price random variables. In the next section, we discuss the methods used to estimate the tail index of the extreme value distributions. In the last part of this section, we present the methods adopted to estimate the tail index of the stable random variables.

Probability distributions in modelling the stock prices

In this section, we present the probability distributions chosen to fit the stock prices. These distributions include the traditional distributions as well as other distributions proposed through this study. We only state the distributions and one can refer to standard books for more information on them.

The following table gives the list of distributions and the corresponding density functions.

Table-8 : List of Probability distributions

S. No	Distribution name	Parameters	Density Function
1	Beta	α > 0 shape (real) β > 0 shape (real)	$\frac{x^{\alpha-1}(1-x)^{\beta-1}}{\mathrm{B}(\alpha,\beta)}$ where $\mathrm{B}(\alpha,\beta)=\frac{\Gamma(\alpha)\Gamma(\beta)}{\Gamma(\alpha+\beta)}$ and Γ is the Gamma function.
2	Burr	c>0 k>0	$ck\frac{x^{c-1}}{(1+x^c)^{k+1}}$
3	Burr (4P)	$k>0,\alpha>0,$ $\beta>0,$ $\gamma>0$	$f(x)=\frac{\alpha k\left(\frac{x-\gamma}{\beta}\right)^{\alpha-1}}{\beta\left(1+\left(\frac{x-\gamma}{\beta}\right)^{\alpha}\right)^{k+1}}$
4	Cauchy	x_0 location (real) $\gamma>0$ scale (real)	$\frac{1}{\pi\gamma\left[1+\left(\frac{x-x_0}{\gamma}\right)^2\right]}$
5	Chi-Squared	k>0	$\frac{1}{2^{k/2}\Gamma(k/2)}x^{k/2-1}e^{-x/2}$
6	Ch-Squared (2P)	v>0, γ>0	$f(x)=\frac{(x-\gamma)^{\nu/2-1}\exp(-(x-\gamma)/2)}{2^{\nu/2}\Gamma(\nu/2)}$
7	Dagum	$p>0$ shape $a>0$ shape $b>0$ scale	$\frac{ap}{x}\left(\frac{(\frac{x}{b})^{ap}}{\left((\frac{x}{b})^a+1\right)^{p+1}}\right)$
8	Dagum (4P)	$k>0,\alpha>0,\beta$ $>0,$ $\gamma>0$	$f(x)=\frac{\alpha k\left(\frac{x-\gamma}{\beta}\right)^{\alpha k-1}}{\beta\left(1+\left(\frac{x-\gamma}{\beta}\right)^{\alpha}\right)^{k+1}}$
9	Erlang	$m>0$ $\gamma>0$	$f(x)=\frac{x^{m-1}}{\beta^m\Gamma(m)}\exp(-x/\beta)$
10	Erlang (3P)	$m>0,\alpha>0,$ $\beta>0,$ $\gamma>0$	$f(x)=\frac{(x-\gamma)^{m-1}}{\beta^m\Gamma(m)}\exp(-(x-\gamma)/\beta)$
11	Error	$k>0,\sigma>0$	$f(x)=c_1\sigma^{-1}\exp(-\lvert c_0z\rvert^k)$
12	Error Function	$h>0$	$f(x)=\frac{h}{\sqrt{\pi}}\exp\left(-(hx)^2\right)$
13	Exponential	λ>0	$\lambda e^{-\lambda x}$
14	Exponential (2P)	$k>0,\sigma>0$	$f(x)=\lambda\exp(-\lambda(x-\gamma))$

15	Fatigue Life	$\alpha > 0, \beta > 0,$	$f(x) = \frac{\sqrt{x/\beta} + \sqrt{\beta/x}}{2\alpha x} \cdot \phi\left(\frac{1}{\alpha}\left(\sqrt{\frac{x}{\beta}} - \sqrt{\frac{\beta}{x}}\right)\right)$
16	Fatigue Life (3P)	$\alpha > 0, \beta > 0,$ $\gamma > 0$	$f(x) = \frac{\sqrt{(x-\gamma)/\beta} + \sqrt{\beta/(x-\gamma)}}{2\alpha(x-\gamma)} \cdot \phi\left(\frac{1}{\alpha}\left(\sqrt{\frac{x-\gamma}{\beta}} - \sqrt{\frac{\beta}{x-\gamma}}\right)\right)$
17	Fréchet	$\alpha > 0, s > 0,$ $m \in (-\infty, \infty)$	$\frac{\alpha}{s}\left(\frac{x-m}{s}\right)^{-1-\alpha} e^{-\left(\frac{x-m}{s}\right)^{-\alpha}}$
18	Fréchet (3P)	$\alpha > 0, \beta > 0,$ $\gamma > 0$	$f(x) = \frac{\alpha}{\beta}\left(\frac{\beta}{x-\gamma}\right)^{\alpha+1} \exp\left(-\left(\frac{\beta}{x-\gamma}\right)^{\alpha}\right)$
19	Gamma	$\alpha > 0, \beta > 0,$	$\frac{\beta^\alpha}{\Gamma(\alpha)} x^{\alpha-1} e^{-\beta x}$
20	Gamma (3P)	$\alpha > 0, \beta > 0,$ $\gamma > 0$	$f(x) = \frac{(x-\gamma)^{\alpha-1}}{\beta^\alpha \Gamma(\alpha)} \exp(-(x-\gamma)/\beta)$
21	Gen Extreme Value	$k > 0, \sigma > 0,$ $\mu > 0$	$f(x) = \begin{cases} \frac{1}{\sigma} \exp\left(-(1+kz)^{-1/k}\right)(1+kz)^{-1-1/k} & k \neq 0 \\ \frac{1}{\sigma} \exp(-z - \exp(-z)) & k = 0 \end{cases}$
22	Gen Gamma	$\alpha > 0, \beta > 0,$ $k > 0$	$f(x) = \frac{k x^{k\alpha-1}}{\beta^{k\alpha}\Gamma(\alpha)} \exp(-(x/\beta)^k)$
23	Gen Gamma (4P)	$\alpha > 0, \beta > 0,$ $\gamma > 0, k > 0$	$f(x) = \frac{k(x-\gamma)^{k\alpha-1}}{\beta^{k\alpha}\Gamma(\alpha)} \exp(-((x-\gamma)/\beta)^k)$
24	Gen Pareto	$k, \sigma > 0, \mu$	$f(x) = \begin{cases} \frac{1}{\sigma}\left(1 + k\frac{(x-\mu)}{\sigma}\right)^{-1-1/k} & k \neq 0 \\ \frac{1}{\sigma} \exp\left(-\frac{(x-\mu)}{\sigma}\right) & k = 0 \end{cases}$
25	Gumbel Max	$\sigma > 0,$ μ	$f(x) = \frac{1}{\sigma} \exp(-z - \exp(-z))$
26	Gumbel Min	$\sigma > 0,$ μ	$f(x) = \frac{1}{\sigma} \exp(z - \exp(z))$
27	Hyperbolic secant	$\sigma > 0,$ μ	$f(x) = \frac{\operatorname{sech}\left(\frac{\pi(x-\mu)}{2\sigma}\right)}{2\sigma}$
28	Inv. Gaussian	$\sigma > 0,$ $\mu > 0$	$f(x) = \sqrt{\frac{\lambda}{2\pi x^3}} \exp\left(-\frac{\lambda(x-\mu)^2}{2\mu^2 x}\right)$

29	Inv. Gaussian (3P)	$k > 0, \sigma > 0,$ $\gamma < x < \infty$	$f(x) = \sqrt{\frac{\lambda}{2\pi(x-\gamma)^3}} \exp\left(-\frac{\lambda(x-\gamma-\mu)^2}{2\mu^2(x-\gamma)}\right)$
30	Johnson SB	$\gamma, \delta > 0,$ $\lambda > 0, \zeta$	$f(x) = \frac{\delta}{\lambda\sqrt{2\pi}\, z(1-z)} \exp\left(-\frac{1}{2}\left(\gamma + \delta \ln\left(\frac{z}{1-z}\right)\right)^2\right)$
31	Kumaraswamy	$\alpha_1 > 0, \alpha_2$ $> 0,$ $a < b$	$f(x) = \frac{\alpha_1 \alpha_2 z^{\alpha_1 - 1}(1 - z^{\alpha_1})^{\alpha_2 - 1}}{(b-a)}$
32	Laplace	$\lambda > 0, \mu$	$f(x) = \frac{\lambda}{2} \exp(-\lambda\|x-\mu\|)$
33	Levy	$\sigma > 0$	$f(x) = \sqrt{\frac{\sigma}{2\pi}} \frac{\exp(-0.5\sigma/x)}{(x-\gamma)^{3/2}}$
34	Levy (2P)	$\sigma > 0,$ γ	$f(x) = \sqrt{\frac{\sigma}{2\pi}} \frac{\exp(-0.5\sigma/(x-\gamma))}{(x-\gamma)^{3/2}}$
35	Log-Gamma	$\alpha > 0, \beta > 0,$	$f(x) = \frac{(\ln(x))^{\alpha-1}}{x\beta^\alpha \Gamma(\alpha)} \exp(-\ln(x)/\beta)$
36	Log-Logistic	$\alpha > 0, \beta > 0,$	$f(x) = \frac{\alpha}{\beta}\left(\frac{x}{\beta}\right)^{\alpha-1}\left(1 + \left(\frac{x}{\beta}\right)^{\alpha}\right)^{-2}$
37	Log-Logistic (3P)	$\alpha > 0, \beta > 0,$ $\gamma \geq x$	$f(x) = \frac{\alpha}{\beta}\left(\frac{x-\gamma}{\beta}\right)^{\alpha-1}\left(1 + \left(\frac{x-\gamma}{\beta}\right)^{\alpha}\right)^{-2}$
38	Log-Pearson 3	$\alpha > 0, \beta > 0,$	$f(x) = \frac{1}{x\|\beta\|\Gamma(\alpha)}\left(\frac{\ln(x)-\gamma}{\beta}\right)^{\alpha-1} \exp\left(-\frac{\ln(x)-\gamma}{\beta}\right)$
39	Logistic	$\sigma > 0,$ μ	$f(x) = \frac{\exp(-z)}{\sigma(1+\exp(-z))^2} \quad z \equiv \frac{x-\mu}{\sigma}$
40	Lognormal	$\sigma > 0,$ μ	$f(x) = \frac{\exp\left(-\frac{1}{2}\left(\frac{\ln x - \mu}{\sigma}\right)^2\right)}{x\sigma\sqrt{2\pi}}$
41	Lognormal (3P)	$\sigma > 0,$ $\mu, \gamma > x$	$f(x) = \frac{\exp\left(-\frac{1}{2}\left(\frac{\ln(x-\gamma)-\mu}{\sigma}\right)^2\right)}{(x-\gamma)\sigma\sqrt{2\pi}}$
42	Nakagami	$m \geq 0.5,$ $\Omega > 0$	$f(x) = \frac{2m^m}{\Gamma(m)\Omega^m} x^{2m-1} \exp\left(-\frac{m}{\Omega}x^2\right)$

43	Normal	$\sigma > 0,$ μ	$f(x) = \frac{\exp\left(-\frac{1}{2}\left(\frac{x-\mu}{\sigma}\right)^2\right)}{\sigma\sqrt{2\pi}}$
44	Pareto	$\alpha > 0, \beta > 0$	$f(x) = \frac{\alpha\,\beta^{\alpha}}{x^{\alpha+1}}$
45	Pareto 2	$\alpha > 0, \beta > 0$	$f(x) = \frac{\alpha\beta^{\alpha}}{(x+\beta)^{\alpha+1}}$
46	Pearson 5	$\alpha > 0, \beta > 0$	$f(x) = \frac{\exp(-\beta/x)}{\beta\,\Gamma(\alpha)\,(x/\beta)^{\alpha+1}}$
47	Pearson 5 (3P)	$\alpha > 0, \beta > 0,$ $\gamma > x$	$f(x) = \frac{\exp(-\beta/(x-\gamma))}{\beta\,\Gamma(\alpha)\,((x-\gamma)/\beta)^{\alpha+1}}$
48	Pearson 6	$\alpha_1 > 0, \alpha_2 > 0,$ $\beta > 0, \gamma > x$	$f(x) = \frac{(x/\beta)^{\alpha_1-1}}{\beta\,B(\alpha_1,\alpha_2)\,(1+x/\beta)^{\alpha_1+\alpha_2}}$
49	Pearson 6 (4P)	$\alpha_1 > 0, \alpha_2 > 0,$ $\beta > 0$	$f(x) = \frac{((x-\gamma)/\beta)^{\alpha_1-1}}{\beta\,B(\alpha_1,\alpha_2)\,(1+(x-\gamma)/\beta)^{\alpha_1+\alpha_2}}$
50	Pert	$a < b,$ $a \leq m \leq b$	$f(x) = \frac{1}{B(\alpha_1, \alpha_2)}\frac{(x-a)^{\alpha_1-1}(b-x)^{\alpha_2-1}}{(b-a)^{\alpha_1+\alpha_2-1}}$
51	Power Function	$\alpha > 0, a \leq x \leq b$	$f(x) = \frac{\alpha\,(x-a)^{\alpha-1}}{(b-a)^{\alpha}}$
52	Rayleigh	$\sigma > 0$	$f(x) = \frac{x}{\sigma^2}\exp\left(-\frac{1}{2}\left(\frac{x}{\sigma}\right)^2\right)$
53	Rayleigh (2P)	$\sigma > 0, \gamma \geq x$	$f(x) = \frac{x-\gamma}{\sigma^2}\exp\left(-\frac{1}{2}\left(\frac{x-\gamma}{\sigma}\right)^2\right)$
54	Reciprocal	$a, b, a \leq x \leq b$	$f(x) = \frac{1}{x(\ln(b)-\ln(a))}$
55	Rice	$\vartheta \geq 0, \sigma > 0$	$f(x) = \frac{x}{\sigma^2}\exp\left(\frac{-(x^2+\upsilon^2)}{2\sigma^2}\right)I_0\left(\frac{x\upsilon}{\sigma^2}\right)$
56	Student's t	$\vartheta \geq 0$	$f(x) = \frac{1}{\sqrt{\pi\,\nu}}\frac{\Gamma((\nu+1)/2)}{\Gamma(\nu/2)}\left(\frac{\nu}{\nu+x^2}\right)^{\frac{\nu+1}{2}}$
57	Triangular	$a, b,$ $a \leq m \leq b,$ $a < b$	$f(x) = \begin{cases} \frac{2(x-a)}{(m-a)(b-a)} & a \leq x \leq m \\ \frac{2(b-x)}{(b-m)(b-a)} & m < x \leq b \end{cases}$
58	Uniform	$a, b,$ $a < b$	$f(x) = \frac{1}{b-a}$

59	Weibull	$\alpha > 0, \beta > 0,$	$f(x) = \frac{\alpha}{\beta}\left(\frac{x}{\beta}\right)^{\alpha-1} \exp\left(-\left(\frac{x}{\beta}\right)^{\alpha}\right)$
60	Weibull (3P)	$\alpha > 0, \beta > 0,$ $\gamma > x$	$f(x) = \frac{\alpha}{\beta}\left(\frac{x-\gamma}{\beta}\right)^{\alpha-1} \exp\left(-\left(\frac{x-\gamma}{\beta}\right)^{\alpha}\right)$
61	Johnson SU	$\gamma, \delta > 0,$ $\lambda > 0, \zeta$	$f(x) = \frac{\delta}{\lambda\sqrt{2\pi}\sqrt{z^2+1}} \exp\left(-\frac{1}{2}\left(\gamma + \delta \ln\left(z + \sqrt{z^2+1}\right)\right)^2\right)$

Source: Compiled by the researcher

The above distributions have been fit to each of the 50 stocks considered, at all the time points, and the best distribution is chosen. To choose the best, we use Anderson-Darling test. Anderson Darling test is applied to each of the fits and the best one is chosen. EasyFit is used for this purpose. Also, Kolmogorov-Smirnov test is used along with this test.

We now present the Anderson-Darling test procedure.

1.1.1.Anderson-Darling test and Kolmogorov-Smirnov test

We present the test procedures used to test the significance of the probability models fit to the stock prices.

The null hypothesis is, H0: The probability model chosen best fits the stock prices.

The alternative hypothesis is, H1: The probability model chosen, do not best fits the stock prices.

Anderson-Darling test checks whether a sample drawn comes from a specified probability distribution. The following is the test statistic

$$A^2 = -n - \frac{1}{n}\sum_{i=1}^{n}(2i-1)\cdot[\ln F(X_i) + \ln(1 - F(X_{n-i+1}))]$$

The null hypothesis rejected at the chosen significance level if the test statistic, A2, is greater than the critical value obtained from a table. In general, critical values of the Anderson-Darling test statistic depend on the specific distribution being tested. However, tables of critical values for many distributions (except several the most widely used ones) are not easy to find.

The Anderson-Darling test implemented in EasyFit, uses the same critical values for all distributions. These values are calculated using the approximation formula and depend on the sample size only. This kind of test (compared to the "original" A-D test) is less likely to reject the good fit and can be successfully used to compare the goodness of fit of several fitted distributions.

Kolmogorov-Smirnov test is used to test if the sample come from a hypothesized continuous distribution. The test is based on the empirical cumulative distribution function (CDF) and one assumes that a random sample is drawn from some distribution with CDF F(x). The empirical CDF is defined by

$$F_n(x) = \frac{1}{n}\cdot\left[\text{Number of observations} \le x\right]$$

The test statistic D is given by

$$D = \max_{1 \le i \le n} \left(F(x_i) - \frac{i-1}{n}, \frac{i}{n} - F(x_i) \right)$$

H0 is rejected if the p-value is less than the level of significance. Based on the results of these tests, we find the probability model that best fits the stock price random variable.

One can refer to the book of David Sheskin (1996) for further details on these test procedures.

1.1.1. Methods used for estimating the tail index

We now present the tail index estimation methods used in this study. We present this in three parts, The first one deals with estimation of the tail index for each of the 50 stocks, the second one is related to estimation of the extremal tail index, and the last one is related to estimation of the stable index or exponent.

1.In order to estimate the tail index for each of the stock considered, we use the weighted least squares estimator proposed by Nair et.al. (2019). Here the weight Wi and tail index are given by

$$w_i = \left[\ln\left(\frac{x_i}{\hat{x}_{\min}}\right)\right]^{-1} \qquad \hat{\alpha} = \frac{-\sum_{i=1}^{N} \ln(\hat{y}_i/N)}{\sum_{i=1}^{N} \ln(x_i/\hat{x}_{\min})}$$

We use the package "ptsuite" available in R for calculation purposes.

2.In order to estimate the tail index for the extreme value distributions, we use the generalized extreme value distribution. For each of the stocks we fit the generalized extreme value distribution and based on the index value calculated, we classify the corresponding distribution for the maxima as either Fréchet, or Weibull or Gumbel. The following is the CDF of GEV distribution.

$$F(s;\xi) = \begin{cases} \exp(-(1+\xi s)^{-1/\xi}) & \xi \neq 0 \\ \exp(-\exp(-s)) & \xi = 0 \end{cases}$$

and the corresponding density function is given by

$$f(s;\xi) = \begin{cases} (1+\xi s)^{(-1/\xi)-1} \exp(-(1+\xi s)^{-1/\xi}) & \xi \neq 0 \\ \exp(-s)\exp(-\exp(-s)) & \xi = 0 \end{cases}$$

We fit the gev distribution using R package "evd". If the value of ?=0 or close to 0, then we classify the distribution as Gumbel. If the value of ?>0, then we classify the distribution as Fréchet. If the value of ?<0, then we classify the distribution as Weibull distribution.

1. In order to estimate the stable index or exponent, we use Koutrouvelis (1980) method. A regression-type method which starts with an initial estimate of the parameters and proceeds iteratively until some prespecified convergence criterion is satisfied. Each iteration consists of two weighted regression runs. The number of points to be used in these regressions depends on the sample size and starting values of . Typically, no more than two or three iterations are needed. The speed of the convergence, however, depends on the initial estimates and the convergence criterion. The regression method is based on the following observations concerning the characteristic function:

$$\ln(-\ln|\phi(t)|^2) = \ln(2\sigma^\alpha) + \alpha \ln|t|.$$

We use the package "libstableR" to estimate the stable index or exponent and the function used is, stable_fit_koutrouvelis () which implements Koutrouvellis' method based on the characteristic function.

Based on the value of the index, we classify the distribution as either normal or stable. If the index value is equal to 2, then the distribution is classified as normal. if the value of the index is less than 2, then we classified as stable distribution. We present the complete analysis in the next section. At the end of each part, we present the overall finding and conclusion.

1. Data Analysis and Key findings

In this section, we present the data analysis for each of the stocks listed under NSE. We divide the analysis for each of the stocks into three parts. The first is related to probability distribution of the stock prices, second part is related to the extreme stock price behaviour, and the third part is related to total stock price behaviour. We use EasyFit 5.6 Professional and R for data analysis.

Under part 1, we present the probability distribution associated with each of the stocks, properties of the distribution, change in the distribution with change in the critical events. We

Have considered all possible distributions that can fit the stock prices and chosen the distribution that can best among them. For each block of years considered, we fit the probability distributions and compare the change in the distributions, with change in the time points. Under part 2, we present the tail behaviour of the stock price random variable, estimation of the tail index, classification of the stock into one to the three extreme value distributions

. We first fit a generalized extreme value distribution and based on the values of the index; we classify the distribution into one of the three types. Under part 3, we present the behaviour of the total stock price variable, tail index value, probability distribution and the corresponding properties. We use the process explained earlier (section 1.6) to identify the stocks that got affected by the market crashes.

We present the analysis for each of the stocks partwise. That is, we first present the discussion on probability model for the stock price random variable, then discussion on extreme stock prices, and finally the discussion on total stock price random variable. The following table gives the probability distribution (model) of the stock prices and testing the significance of the model. Note that, among the models fit, we choose the model that has rank -1 by the Anderson-Darling test.

Part-1: Identifying the probability distribution of the stock prices.

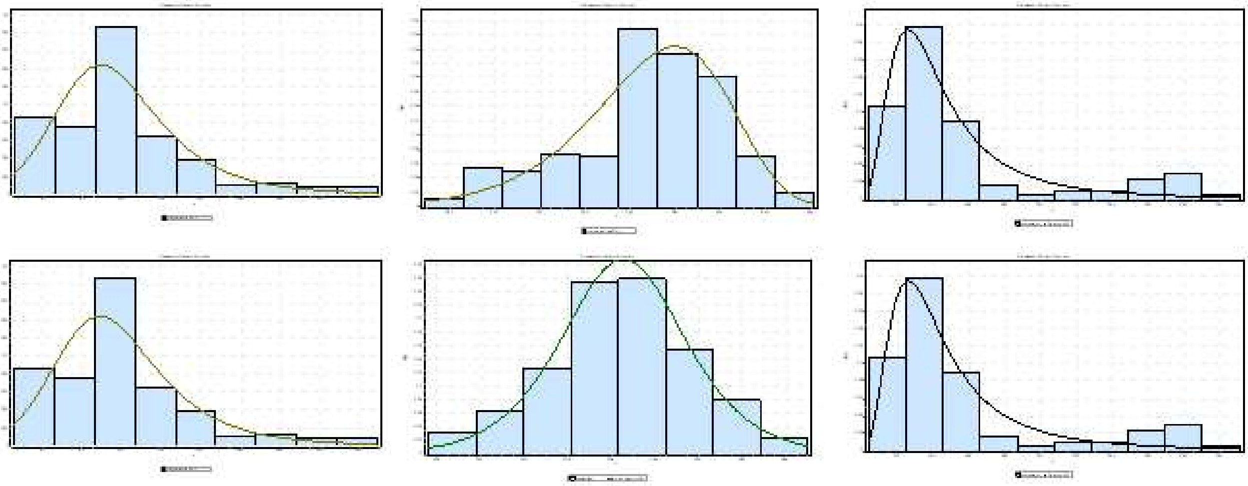
Stock-1: Adaniports

Table-9 : Distribution of the stock prices

Year	Distribution	Sample Size	Parameters	Anderson Darling	Kolmogorov Smirnov test		Tail Index Value
				Test statistic	Test statistic	p-value	
2007-2009	Burr	506	$k=1.0603$, $\alpha=5.153$, $\beta=96.736$	6.7755	0.12199	0.0001	1.3540
2010	Log-Logistic (3P)	250	$\alpha=1.3748E+8$, $\beta=1.0359E+9$, $\gamma=-1.0359E+9$	0.59837	0.05209	0.48998	3.3556
2011-2014	Dagum (4P)	983	$k=1.5918$, $\alpha=2.0874$ $\beta=29.895$, $\gamma=99.982$	10.839	0.09642	0.0001	2.6867
2015-2016	Beta	492	$\alpha_1=1.7421$, $\alpha_2=1.5574$ $a=168.18$, $b=359.68$	3.5666	0.08879	0.0001	2.1628
2017-2019	Burr	736	$k=90.784$, $\alpha=13.458$, $\beta=533.83$	2.1388	0.05408	0.02601	3.2085
2020	Log-Pearson 3	53	$\alpha=0.88759$, $\beta=-0.09509$, $\gamma=5.9648$	0.87676	0.10868	0.52323	3.0035

Source: From researcher's data analysis

Figure-12 : Distribution of stock prices-Adaniports



Source: From researcher's data analysis

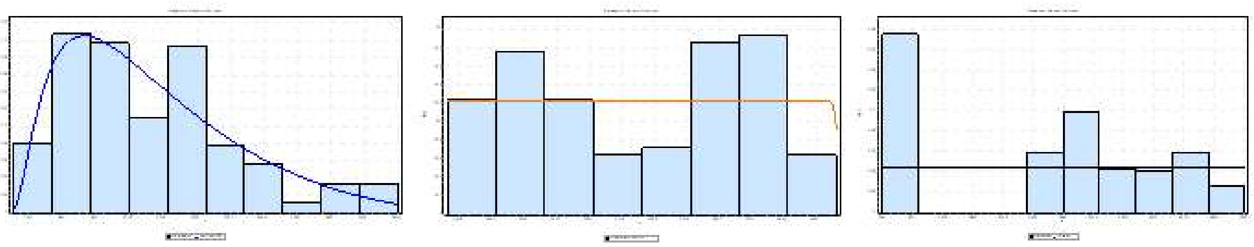
Stock-2: Asian Paints

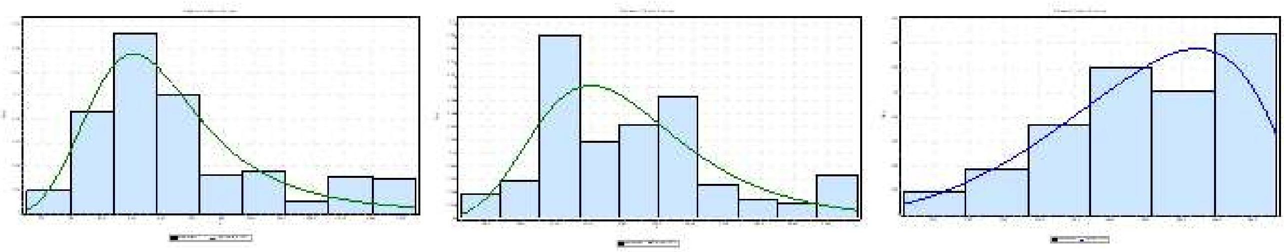
Table-10 : Distribution of the stock prices

Year	Distribution	Sample Size	Parameters	Anderson Darling	Kolmogorov Smirnov test		Tail Index Value
				Test statistic	Test statistic	p-value	
2007-2009	Johnson SB	738	γ=1.2699, δ=1.0766, λ=1573.8, ξ=641.89	2.0996	0.04965	0.05085	2.1764
2010	Error	252	k=100.0, σ=355.11, μ= 2352.7	3.6212	0.11412	0.00258	3.5479
2011-2014	Uniform	992	a=-193.64, b=5215.1	34.28	0.16764	0.0001	0.6480
2015-2016	Log-Logistic (3P)	495	α=3.4577 β=199.29, γ =673.18	4.0223	0.08617	0.0012	4.0154
2017-2019	Frechet (3P)	739	α=5.3218E+7, β=8.9225E+9, γ=-8.9225E+9	5.0642	0.07691	0.0001	2.7762
2020	Johnson SB	54	γ=-0.97245, δ=1.1956 λ=310.24, ξ=1611.3	0.39349	0.08679	0.77825	12.2448

Source: From researcher's data analysis

Figure-13 : Distribution of stock prices





Source: From researcher's data analysis

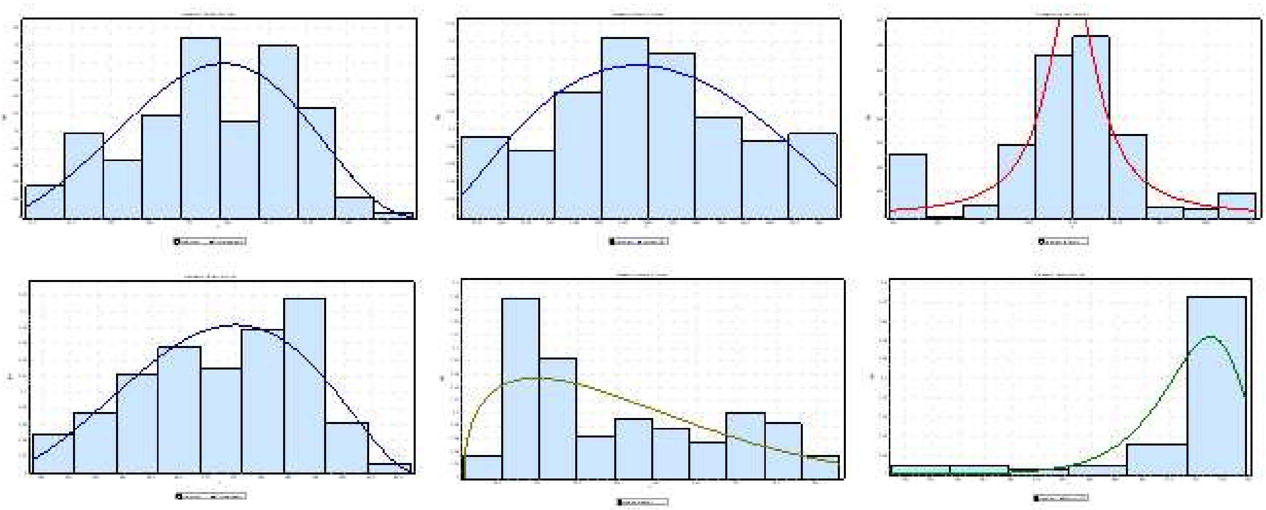
Stock-3: Axis Bank

Table-11 : Distribution of the stock prices

Year	Distribution	Sample Size	Parameters	Anderson Darling	Kolmogorov Smirnov test		Tail Index Value
				Test statistic	Test statistic	p-value	
2007-2009	Kumaraswamy	584	α_1=2.7806, α_2=3.91 a=179.37, b=1298.5	3.5574	0.07097	0.00529	1.049
2010	Johnson SB	252	γ=0.15231 δ=1.1398 λ=812.31 ξ=899.26	0.73876	0.04484	0.67425	3.662
2011-2014	Cauchy	992.	σ=138.28 μ=1196.3	7.9589	0.06405	0.0001	0.917
2015-2016	Kumaraswamy	495	α_1=2.5002 α_2=2.9028 a=349.41 b=652.75	2.6626	0.07272	0.01011	3.230
2017-2019	Pert	739	m=517.54 a=445.0 b=1097.1	11.723	0.10016	0.0001	3.492
2020	Weibull (3P)	54	α=1.0330E+9 β=2.9626E+10 γ=-2.9626E+10	3.752	0.2247	0.00707	2.562

Source: From researcher's data analysis

Figure-14 : Distribution of stock prices



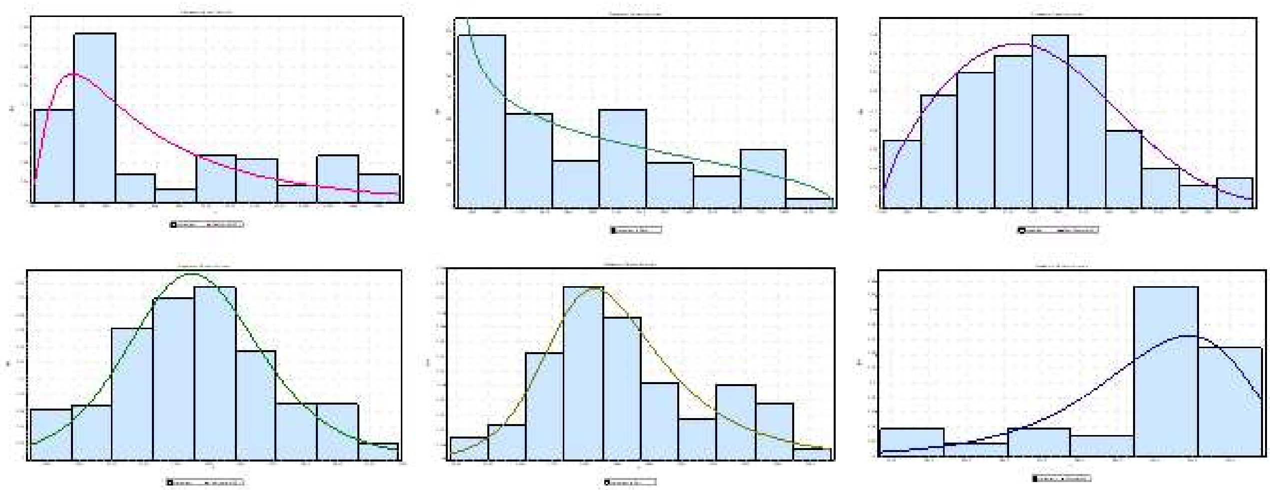
Source: From researcher's data analysis

Stock-4: Bajaj Auto

Table-12 : Distribution of the stock prices

Year	Distribution	Sample Size	Parameters	Anderson Darling	Kolmogorov Smirnov test		Tail Index Value
				Test statistic	Test statistic	p-value	
2007-2009	Dagum	391	k=0.55834 α=4.296 β=352.63	1.9214	0.05526	0.17681	0.8948
2010	Power Function	252	α=1.0394 a=305.85 b=543.5	5.3263	0.12044	0.12044	3.1239
2011-2014	Gen Gamma (4P)	992	k=2.4265 α=0.51143 β=510.8 γ=399.73	1.3266	0.03224	0.24849	1.8540
2015-2016	Log-Logistic (3P)	495	α=2.4423 β=678.82 γ=1157.9	5.8134	0.08987	0.0001	2.1904
2017-2019	Triangular	739	m=5258.7 a=2723.8 b=9856.7	2.4321	0.07176	0.0001	1.4762
2020	Weibull (3P)	54	α=5.9909E+8 β=2.0763E+11 γ=-2.0763E+11	2.5487	0.18482	0.04358	3.4740

Figure-15 : Distribution of the stock prices



Source: From researcher's data analysis

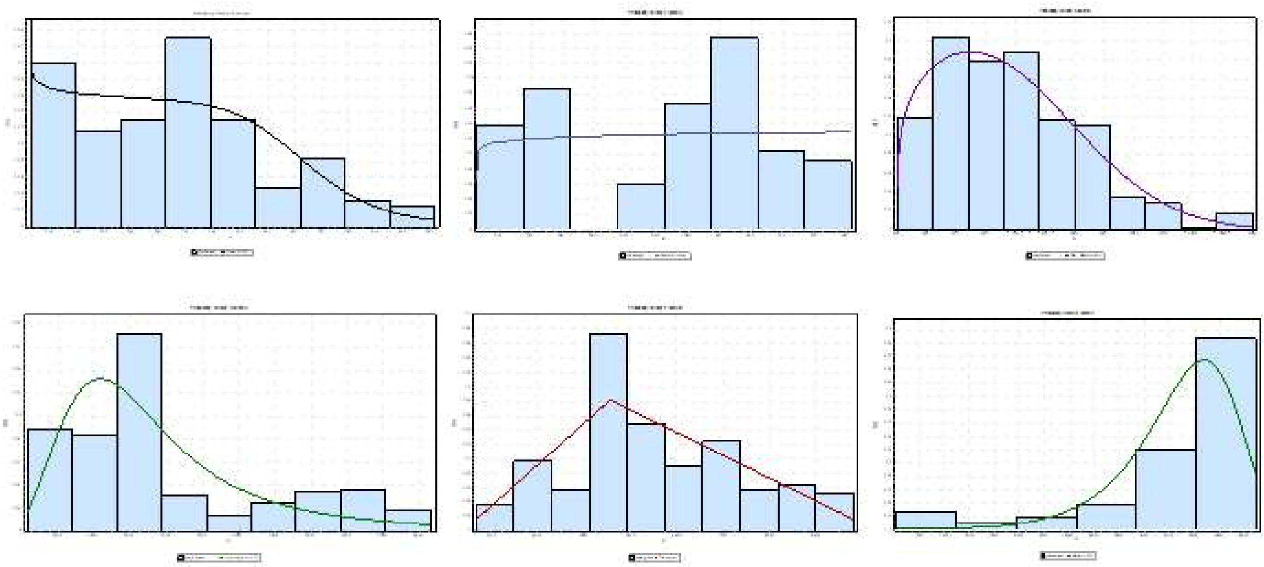
Stock-5: Bajaj FinSV

Table-13 : Distribution of the stock prices

Year	Distribution	Sample Size	Parameters	Anderson Darling	Kolmogorov Smirnov test		Tail Index Value
				Test statistic	Test statistic	p-value	
2007-2009	Dagum	391	k=0.55834 α=4.296 β=352.63	1.9214	0.05526	0.17681	0.8948
2010	Power Function	252	α=1.0394 a=305.85 b=543.5	5.3263	0.12044	0.12044	3.1239
2011-2014	Gen Gamma (4P)	992	k=2.4265 α=0.51143 β=510.8 γ=399.73	1.3266	0.03224	0.24849	1.8540
2015-2016	Log-Logistic (3P)	495	α=2.4423 β=678.82 γ=1157.9	5.8134	0.08987	0.0001	2.1904
2017-2019	Triangular	739	m=5258.7 a=2723.8 b=9856.7	2.4321	0.07176	0.0001	1.4762
2020	Weibull (3P)	54	α=5.9909E+8 β=2.0763E+11 γ=-2.0763E+11	2.5487	0.18482	0.04358	3.4740

Source: From researcher's data analysis

Figure-16 : Distribution of stock prices



Source: From researcher's data analysis

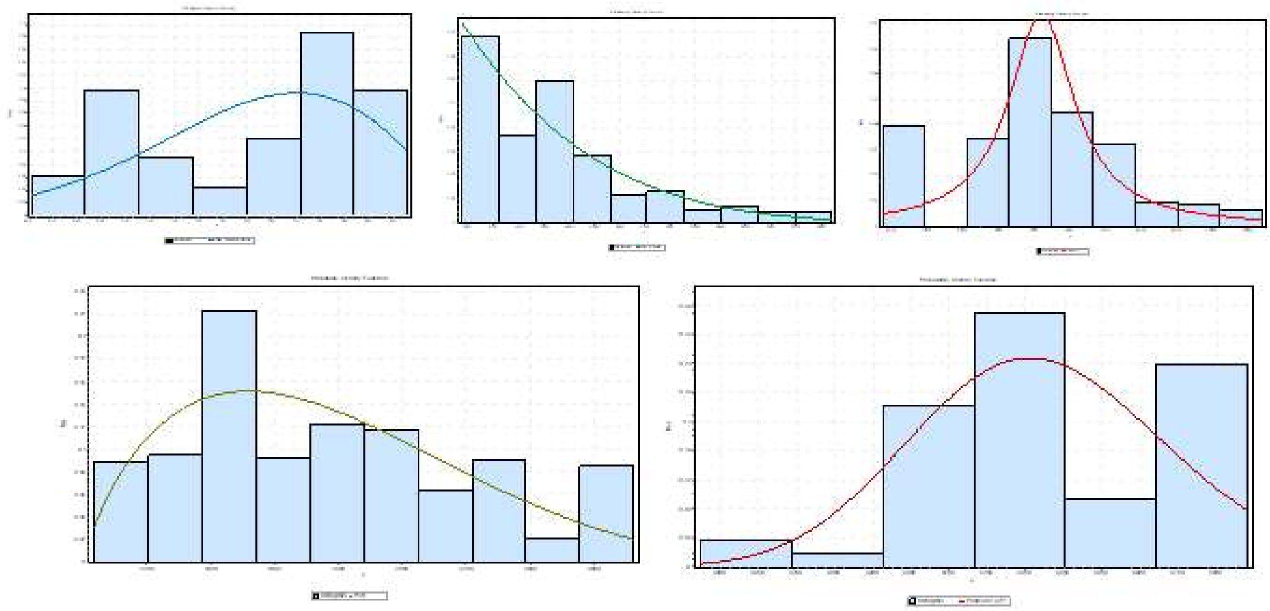
Stock-6: Bajaj Finance

Table-14 : Distribution of the stock prices

Year	Distribution	Sample Size	Parameters	Anderson Darling	Kolmogorov Smirnov test		Tail Index Value
				Test statistic	Test statistic	p-value	
2010	Gen Extreme Value	66	k=-0.51552 s=49.837 m=739.85	1.4804	0.13014	0.19568	7.6014
2011-2014	Gen Pareto	992	k=-0.15677 s=862.95 m=537.72	8.9946	0.06878	0.0001	1.3386
2015-2016	Cauchy	495	s=1125.8 m=5214.4	4.3529	0.07889	0.00398	0.5733
2017-2019	Pert	739	m=1837.4 a=803.79 b=5748.0	3.1447	0.06847	0.00186	1.09191
2020	Pearson 5 (3P)	54	a=284.24 b=1.5950E+6 g=-1282.2	1.0579	0.10736	0.5271	4.1291

Source: From researcher's data analysis

Figure-17 : Distribution of stock prices



Source: From researcher's data analysis

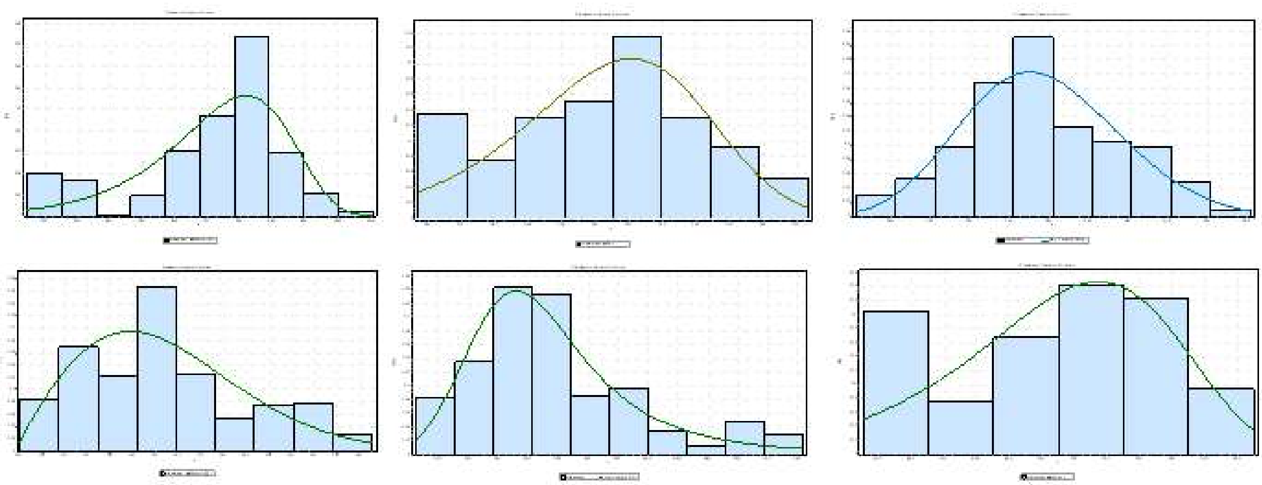
Stock-7: Bharathi Airtel

Table-15 Distribution of the stock prices

Year	Distribution	Sample Size	Parameters	Anderson Darling	Kolmogorov Smirnov test		Tail Index value
				Test statistic	Test statistic	p-value	
2007-2009	Weibull (3P)	738	α=1.7487E+8 β=2.4278E+10 γ=-2.4278E+10	9.1737	0.08163	0.0001	1.06084
2010	Burr	252	k=6.9584 α=13.293 β=373.22	1.0186	0.0524	0.0524	5.1754
2011-2014	Gen Extreme value	992	k=-0.21181 σ=37.153 μ=321.45	2.8088	0.04455	0.04455	3.0968
2015-2016	Weibull (3P)	495	α=1.9143 β=74.034 γ=288.3	2.1474	0.04988	0.16464	5.0869
2017-2019	Log-Logistic (3P)	739	α=3.8501 β=111.37 γ=254.78	1.5944	0.03758	0.24134	3.6893
2020	Weibull	54	α=17.396 β=518.95	0.6696	0.09939	0.62427	7.6252

Source: From researcher's data analysis

Figure-18 : Distribution of stock prices



Source: From researcher's data analysis

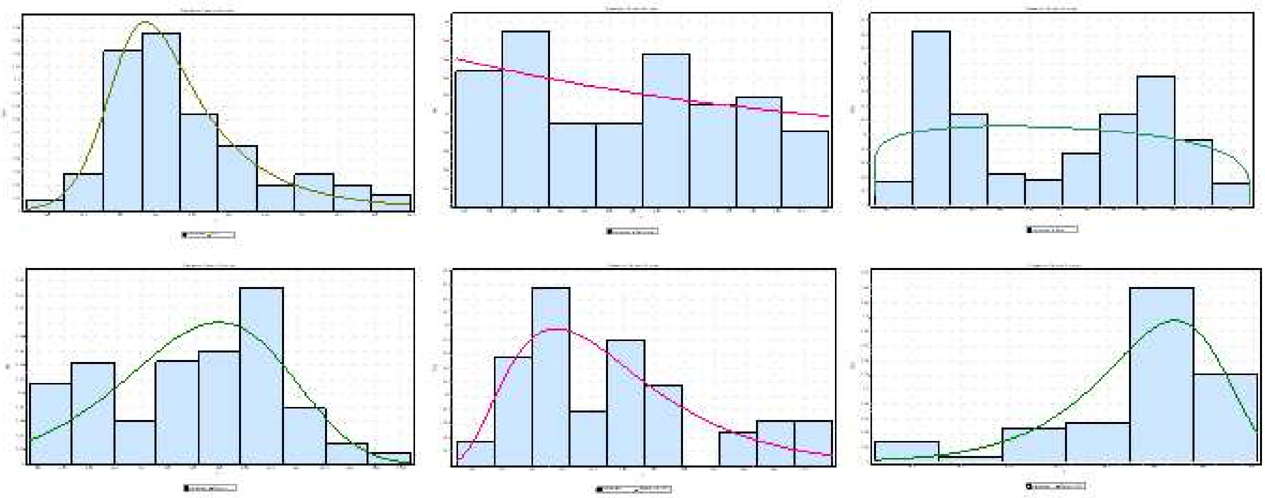
Stock-8: BPCL

Table-16 : Distribution of the stock prices

Year	Distribution	Sample Size	Parameters	Anderson Darling	Kolmogorov Smirnov test		Tail Index Value
				Test statistic	Test statistic	p-value	
2007-2009	Burr	738	k=0.40318 α=13.831 β=330.57	1.5406	0.03856	0.21684	1.7513
2010	Reciprocal	252	a=491.3 b=802.15	1.1533	0.06392	0.24403	4.0308
2011-2014	Beta	992	α_1=1.1285 α_2=1.2408 a=261.45 b=785.45	20.68	0.10949	0.0001	1.5869
2015-2016	Weibull	495	α=7.096 β=855.68	5.4511	0.09083	0.0001	2.6797
2017-2019	Fatigue Life (3P)	739	α=0.45737 β=245.84 γ=191.89	6.9963	0.07243	0.0001	1.7870
2020	Weibull (3P)	54	α=1.6232E+8 β=4.0061E+9 γ=-4.0061E+9	1.3038	0.15811	0.1204	3.4553

Source: From researcher's data analysis

Figure-19 : Distribution of stock prices



Source: From researcher's data analysis

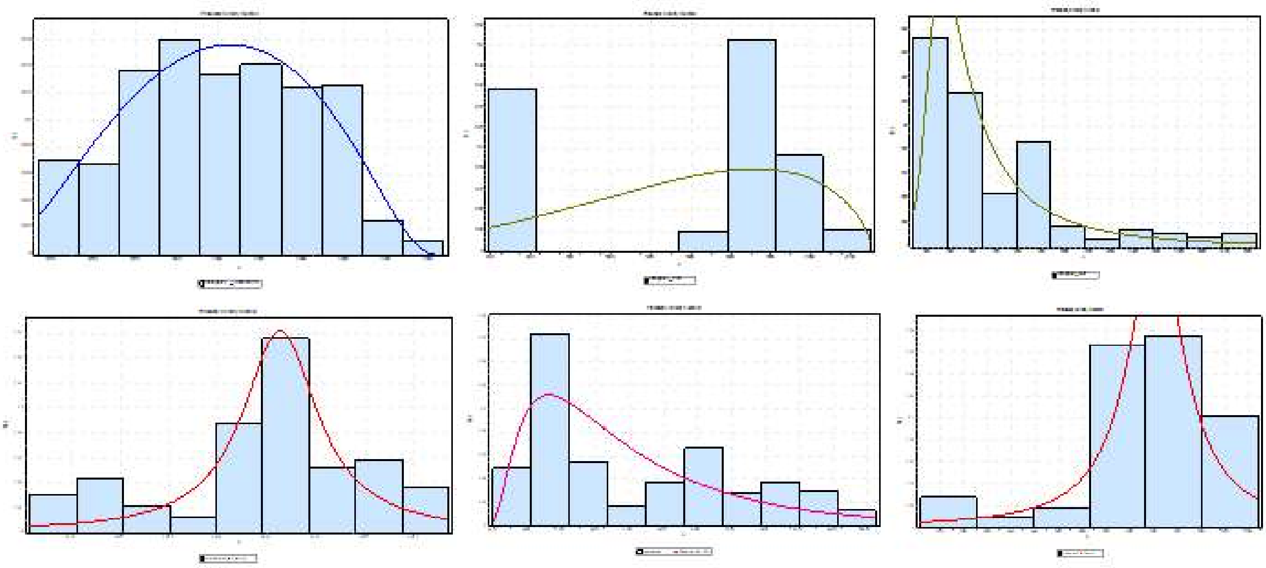
Stock-9: Britannia

Table-17 : Distribution of the stock prices

Year	Distribution	Sample Size	Parameters	Anderson Darling	Kolmogorov Smirnov test		Tail Index value
				Test statistic	Test statistic	p-value	
2007-2009	Johnson SB	737	γ=-0.12419 δ=1.1385 λ=901.32 ξ=971.43	0.76359	0.02281	0.82934	3.7019
2010	Pert	252	m=1722.2 a=-1187.3 b=2308.0	19.966	0.27342	0.0001	0.94413
2011-2014	Burr	992	k=0.18759 α=12.803 β=421.65	14.096	0.10934	0.0001	1.6035
2015-2016	Cauchy	495	σ=185.82 μ=2852.2	5.9927	0.08634	0.00117	2.4309
2017-2019	Fatigue Life (3P)	739	α=0.71619 β=1492.1 γ=2186.9	11.958	0.12196	0.0001	2.0201
2020	Cauchy	54	σ=56.454 μ=3084.2	0.65643	0.10109	0.60322	7.0526

Source: From researcher's data analysis

Figure-20 : Distribution of stock prices



Source: From researcher's data analysis

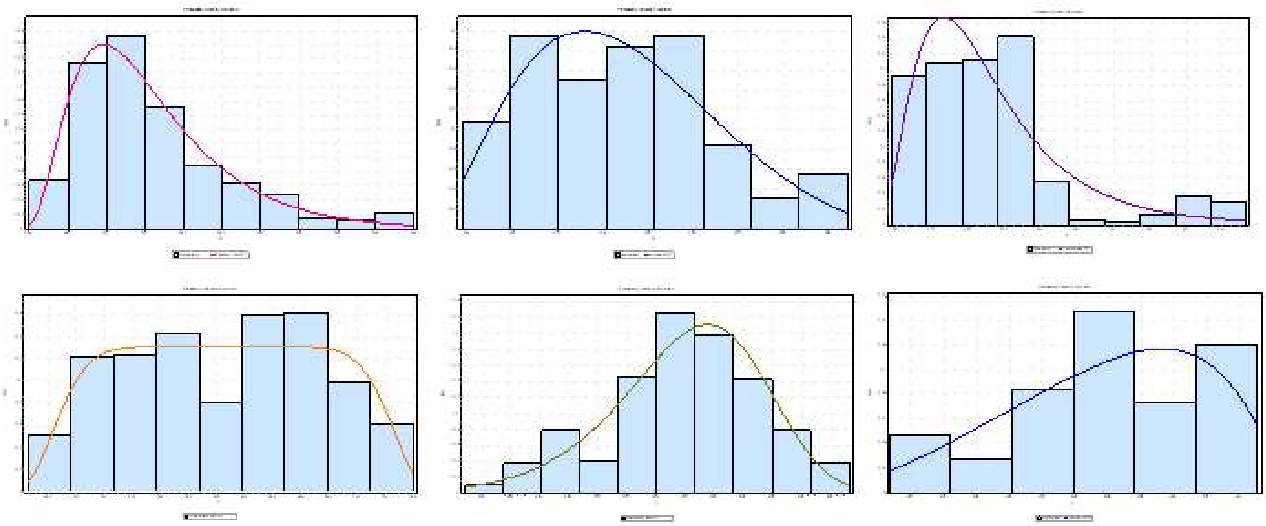
Stock-10: Cipla

Table-18 : Distribution of the stock prices

Year	Distribution	Sample Size	Parameters	Anderson Darling	Kolmogorov Smirnov test		Tail index value
				Test statistic	Test statistic	p-value	
2007-2009	Fatigue Life (3P)	738	α=0.49524 β=70.178 γ=144.41	1.0017	0.03518	0.31324	3.1222
2010	Johnson SB	252	γ=0.85267 δ=1.3829 λ=107.39 ξ=291.88	0.60085	0.04062	0.7842	11.2048
2011-2014	Log-Pearson 3	992	α=3.9429 β=0.09824 γ=5.5426	12.126	0.09664	0.0001	3.1597
2015-2016	Error	495	k=8.0555 σ=69.333 μ=604.56	1.6062	0.06296	0.03782	3.8739
2017-2019	Burr	739	k=8.9376 α=13.225 β=683.33	1.2197	0.0402	0.17857	3.1981
2020	Johnson SB	54	γ=-0.67407 δ=1.0936 λ=129.89 ξ=366.05	0.38036	0.10251	0.58578	7.5954

Source: From researcher's data analysis

Figure-21 : Distribution of stock prices



Source: From researcher's data analysis

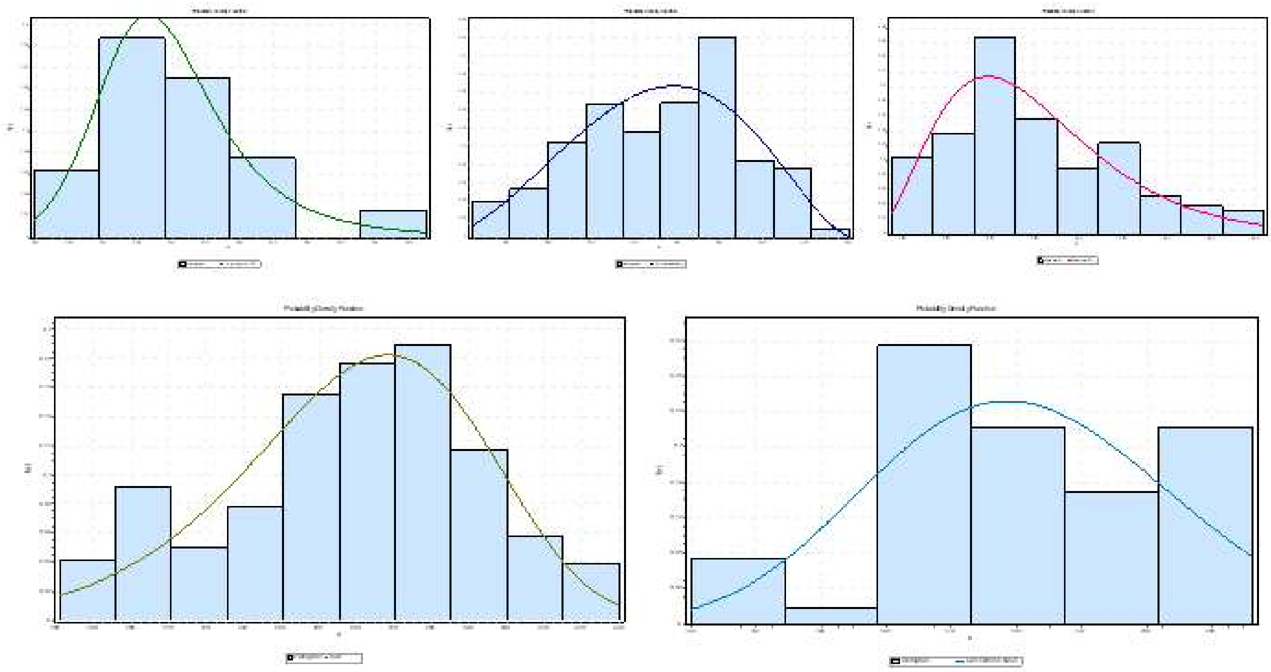
Stock-11: Coal India

Table-19 : Distribution of the stock prices

Year	Distribution	Sample Size	Parameters	Anderson Darling	Kolmogorov Smirnov test		Tail Index value
				Test statistic	Test statistic	p-value	
2010	Log-Logistic (3P)	40	α=5.579 β=26.396 γ=292.45	0.12137	0.0637	0.99354	17.7340
2011-2014	Kumaraswamy	992	α_1=2.446 α_2=2.8946 a=231.66 b=422.93	2.7703	0.0566	0.00334	3.2927
2015-2016	Gamma (3P)	495	α=3.6708 β=20.81 γ=262.61	2.048	0.06113	0.04743	4.8322
2017-2019	Burr	739	k=22.095 α=9.186 β=380.86	1.9681	0.04437	0.10571	2.8497
2020	Gen Extreme Value	54	k=-0.25439 σ=17.433 μ=177.91	0.79458	0.11804	0.40768	3.9771

Source: From researcher's data analysis

Figure-22 : Distribution of stock prices



Source: From researcher's data analysis

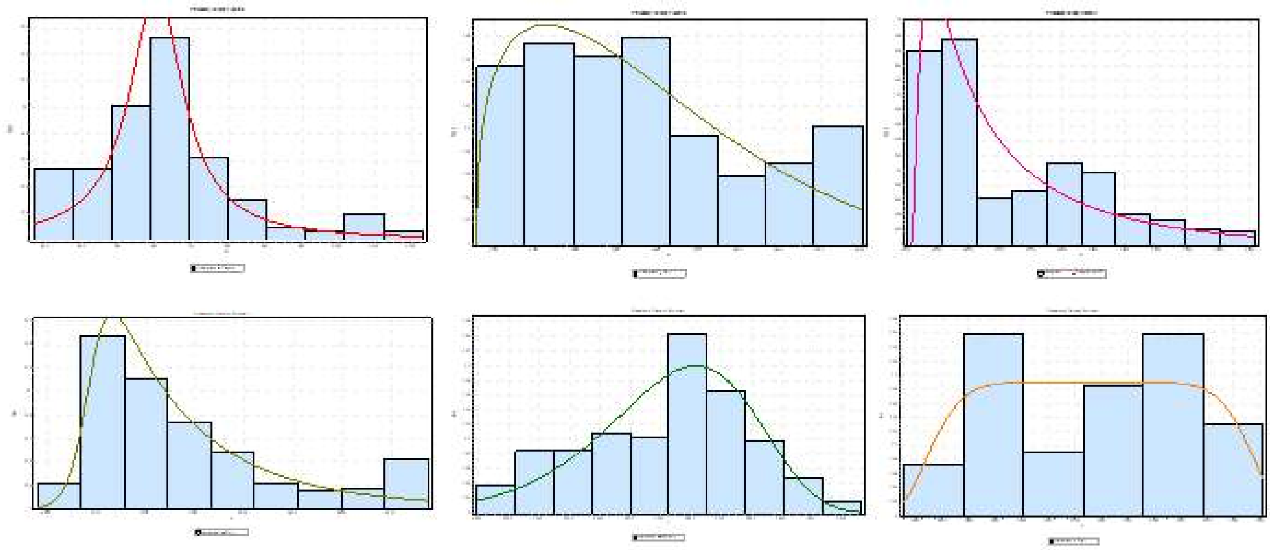
Stock-12: Dr Reddy

Table-20 : Distribution of the stock prices

Year	Distribution	Sample Size	Parameters	Anderson Darling	Kolmogorov Smirnov test		Tail Index value
				Test statistic	Test statistic	p-value	
2007-2009	Cauchy	738	σ=71.957 μ=642.02	5.1307	0.0844	0.0001	1.8393
2010	Pert	252	m=1219.9 a=1083.4 b=2456.5	0.95537	0.05014	0.5341	3.9786
2011-2014	Fatigue Life (3P)	992	α=1.0446 β=452.24 γ=1411.9	12.492	0.08462	0.0001	2.8913
2015-2016	Burr	495	k=0.12349 α=68.698 β=2975.4	1.7457	0.04264	0.32001	5.1845
2017-2019	Weibull	739	α=11.338 β=2636.0	3.5552	0.05121	0.04006	3.5417
2020	Error	54	k=7.4412 σ=142.02 μ=3063.1	0.39281	0.09145	0.09145	9.9061

Source: From researcher's data analysis

Figure-23 : Distribution of stock prices



Source: From researcher's data analysis

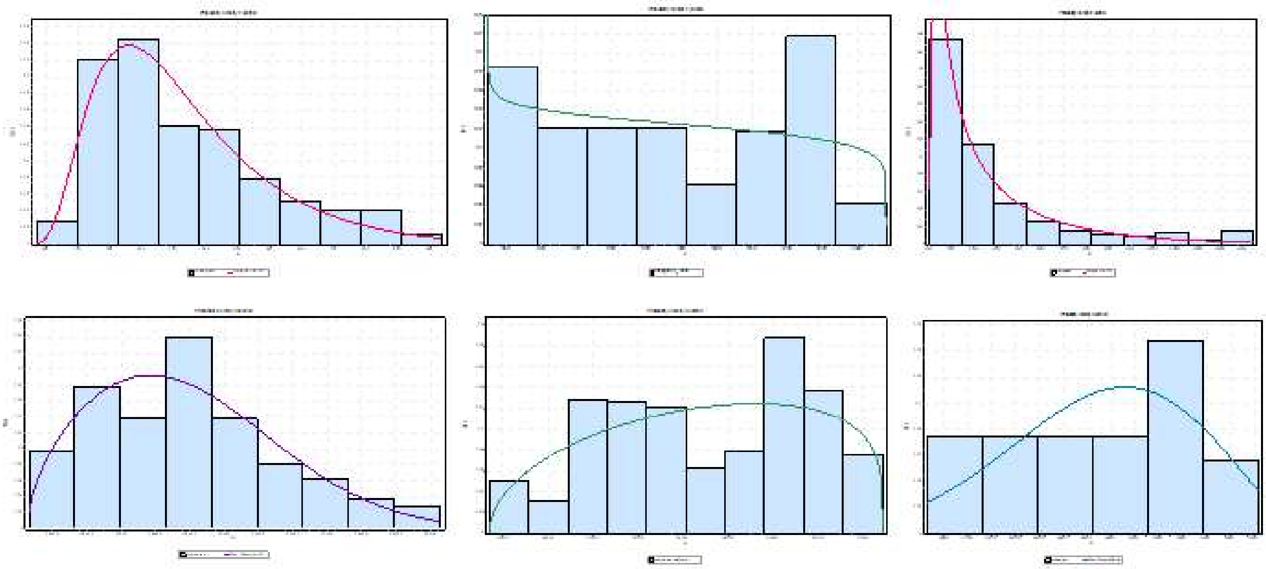
Stock-13: Eicher Motors Ltd.

Table-21 : Distribution of the stock prices

Year	Distribution	Sample Size	Parameters	Anderson Darling	Kolmogorov Smirnov test		Tail Index value
				Test statistic	Test statistic	p-value	
2007-2009	Fatigue Life (3P)	738	α=0.49663 β=194.83 γ=113.02	2.442	0.04502	0.09742	1.3095
2010	Beta	252	α_1=0.94831 α_2=1.0946 a=518.5 b=1424.4	2.5447	0.09671	0.01672	1.7695
2011-2014	Fatigue Life (3P)	992	α=1.2416 β=1682.3 γ=890.49	1.7199	0.03621	0.14476	0.9265
2015-2016	Gen Gamma (4P)	495	k=2.3293 α=0.66343 β=6674.2 γ=14276.0	1.4755	0.0585	0.06487	3.6555
2017-2019	Beta	739	α_1=1.508 α_2=1.2413 a=15383.0 b=32862.0	4.4988	0.07867	0.0001	2.1099
2020	Gen Extreme Value	54	k=-0.443 σ=1708. 3 μ=18948.0	0.63856	0.11018	0.49419	5.9705

Source: From researcher's data analysis

Figure-24 : Distribution of stock prices



Source: From researcher's data analysis

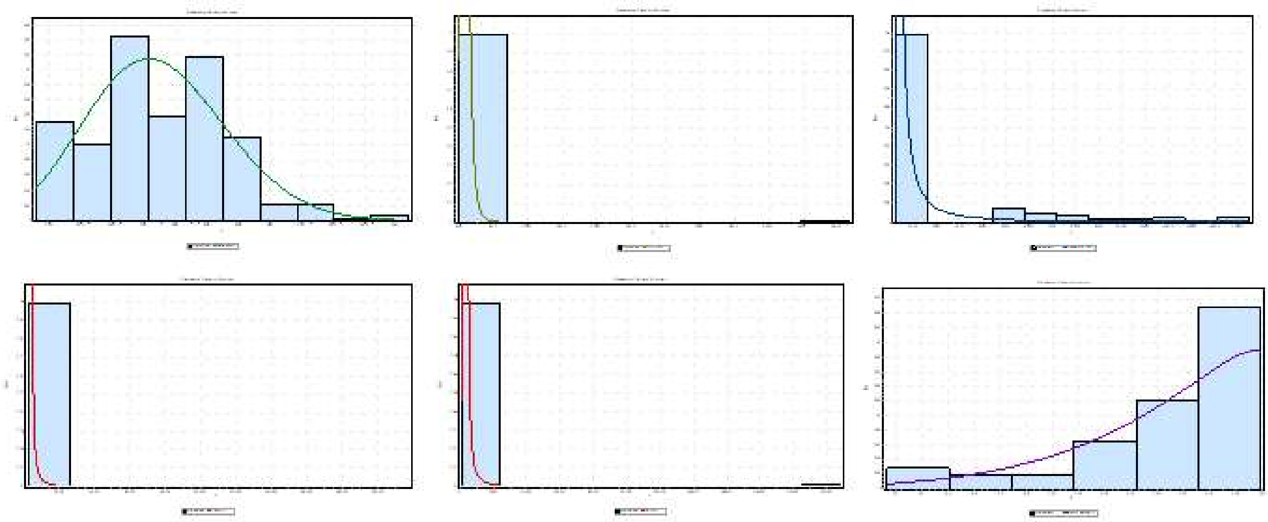
Stock-14: Gail (India) Limited

Table-22 : Distribution of the stock prices

Year	Distribution	Sample Size	Parameters	Anderson Darling	Kolmogorov Smirnov test		Tail Index value
				Test statistic	Test statistic	p-value	
2007-2009	Nakagami	746	m=3.8654 Ω=1.2154E+5	3.9465	0.05773	0.01331	1.7365
2010	Burr (4P)	253	k=2.2832 α=2.2527 β=99.464 γ=384.9	4.2859	0.09288	0.02378	6.8058
2011-2014	Pearson 6 (4P)	1254	α_1=38.498 α_2=0.67711 β=1.6657 γ=278.76	64.216	0.21468	0.0001	3.2885
2015-2016	Cauchy	496	σ=21.46 μ=376.84	5.129	0.09109	0.0001	3.2599
2017-2019	Cauchy	748	σ=41.28 μ=363.47	9.0686	0.09631	0.0001	0.9315
2020	Log-Pearson 3	54	α=1.197 β=-0.1242 γ=4.9016	1.3797	0.13425	0.26055	2.1441

Source: From researcher's data analysis

Figure-25 : Distribution of stock prices



Source: From researcher's data analysis

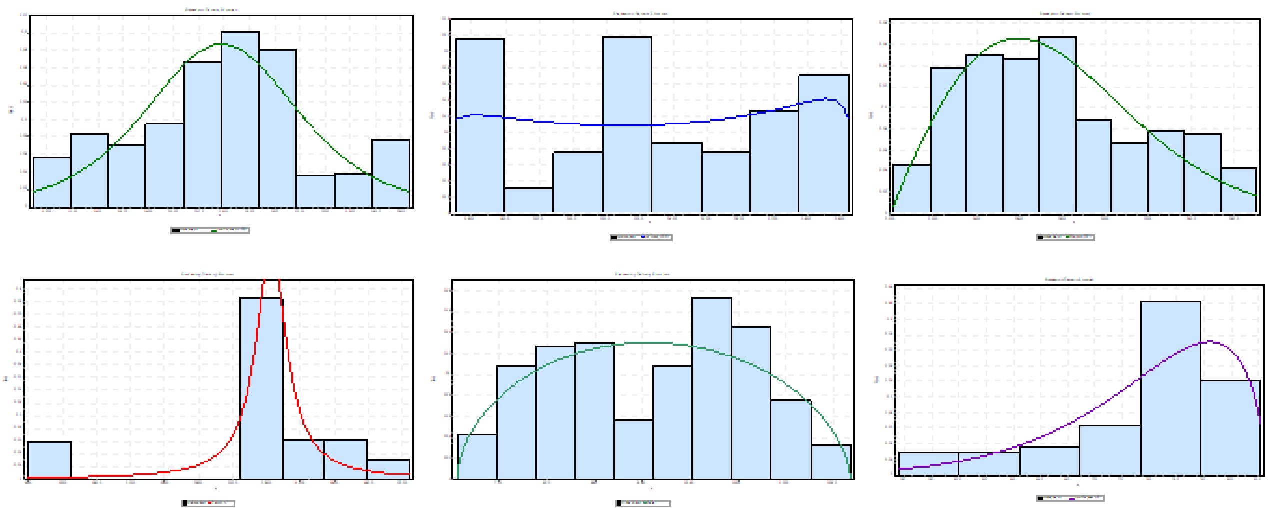
Stock-15: Grasim

Table-23 : Distribution of the stock prices

Year	Distribution	Sample Size	Parameters	Anderson Darling	Kolmogorov Smirnov test		Tail index value
				Test statistic	Test statistic	p-value	
2007-2009	Log-Logistic (3P)	738	α=1.6324E+8 β=6.5219E+10 γ=-6.5219E+10	3.504	0.04585	0.08709	1.0638
2010	Johnson SB	252	γ=-0.05417 δ=0.59221 λ=1262.4 ξ=1685.5	1.8793	0.07535	0.10858	3.5682
2011-2014	Weibull (3P)	992	α=1.9402 β=860.89 γ=2002.4	3.7286	0.05043	0.01243	3.2485
2015-2016	Cauchy	495	σ=218.79 μ=3654.8	8.2739	0.09277	0.0001	0.7036
2017-2019	Beta	739	α_1=1.5526 α_2=1.5797 a=649.0 b=1307.8	4.13	0.06887	0.00171	2.5226
2020	Log-Pearson 3	54	α=1.6815 β=-0.07107 γ=6.7167	0.66779	0.10549	0.54952	3.3953

Source: From researcher's data analysis

Figure-26 : Distribution of stock prices



Source: From researcher's data analysis

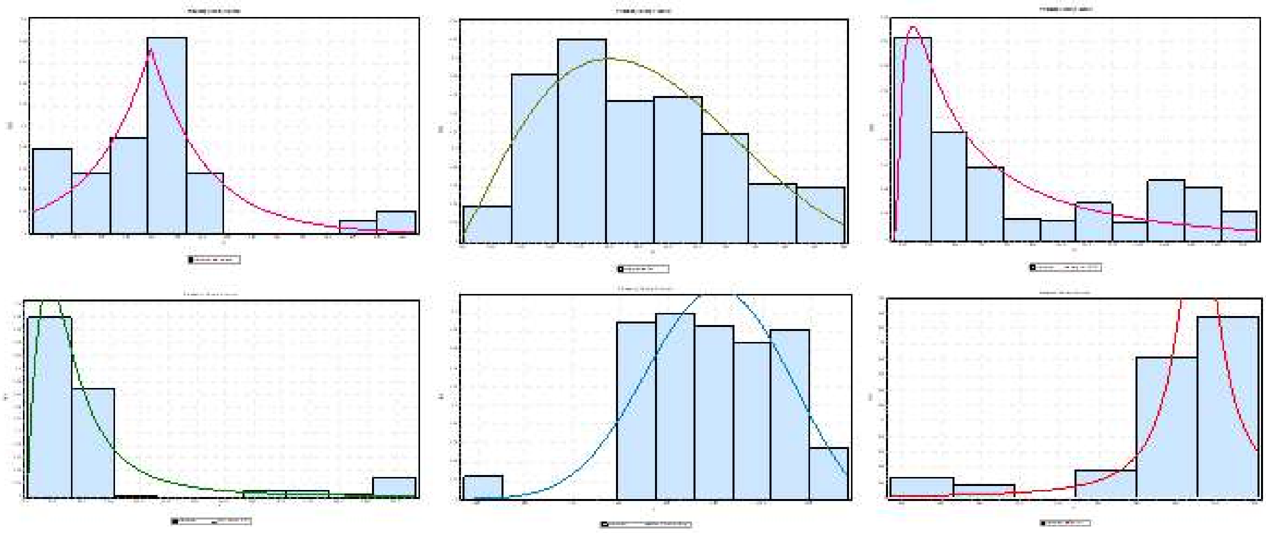
Stock-16: HCL Tech

Table-24 : Distribution of the stock prices

Year	Distribution	Sample Size	Parameters	Anderson Darling	Kolmogorov Smirnov test		Tail Index value
				Test statistic	Test statistic	p-value	
2007-2009	Laplace	738	λ=0.01146 μ=276.59	15.686	0.13382	0.0001	0.9623
2010	Pert	252	m=380.0 a=328.28 b=487.87	0.92724	0.0706	0.15453	6.0987
2011-2014	Fatigue Life (3P)	992	α=1.1271 β=296.77 γ=348.69	16.9	0.10293	0.0001	1.3955
2015-2016	Log-Logistic (3P)	495	α=1.8925 β=144.44 γ=705.37	6.502	0.10043	0.00001	3.8564
2017-2019	Gen Extreme Value	739	k=-0.3513 σ=113.82 μ=919.15	7.9598	0.079	0.0001	1.7482
2020	Cauchy	55	σ=13.038 μ=590.93	1.5363	0.14495	0.17955	3.3530

Source: From researcher's data analysis

Figure-27 : Distribution of stock prices



Source: From researcher's data analysis

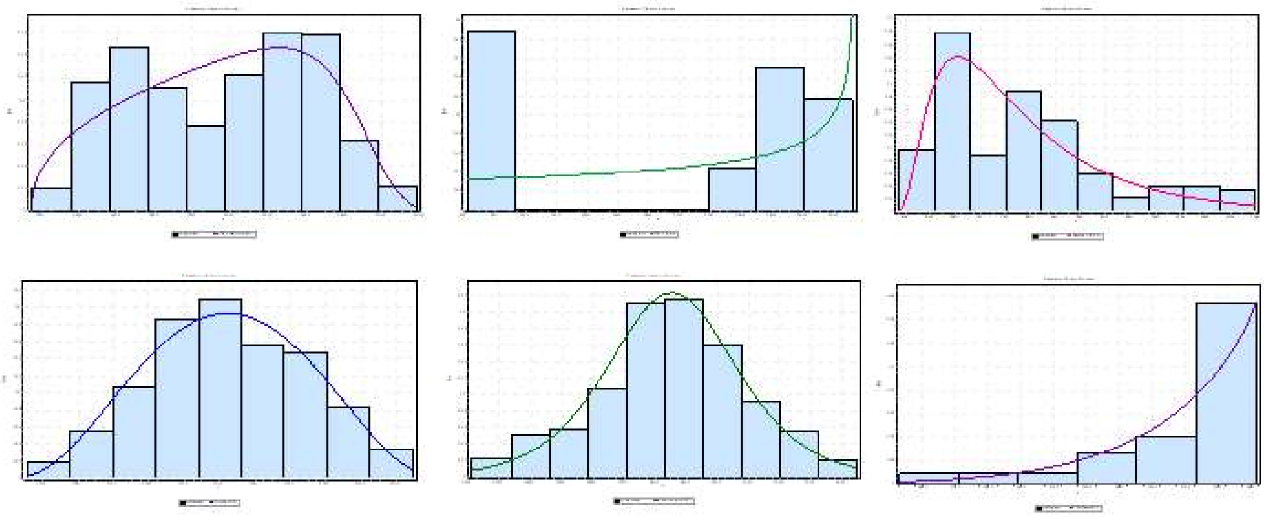
Stock-17: HDFC

Table-25 : Distribution of the stock prices

Year	Distribution	Sample Size	Parameters	Anderson Darling	Kolmogorov Smirnov test		Tail Index value
				Test statistic	Test statistic	p-value	
2007-2009	Gen Gamma (4P)	738	k=10.194 α=0.14144 β=1777.8 γ=1147.5	3.7237	0.05793	0.01356	1.6531
2010	Gen Pareto	252	k=-1.661 σ=5163.0 μ=28.548	16.702	0.22775	0.0001	1.0200
2011-2014	Fatigue Life (3P)	992	α=0.64363 β=184.21 γ=565.5	8.814	0.08429	0.0001	3.5905
2015-2016	Johnson SB	495	γ=0.00209 δ=1.3393 λ=537.65 ξ=980.05	0.32783	0.02883	0.79402	5.0168
2017-2019	Log-Logistic (3P)	739	α=2.1560E+8 β=2.9754E+10 γ=-2.9754E+10	1.2149	0.0377	0.23825	2.4079
2020	Log-Pearson 3	55	α=0.9284 β=-0.09523 γ=7.8305	1.7001	0.16451	0.09071	2.7023

Source: From researcher's data analysis

Figure-28 : Distribution of stock prices



Source: From researcher's data analysis

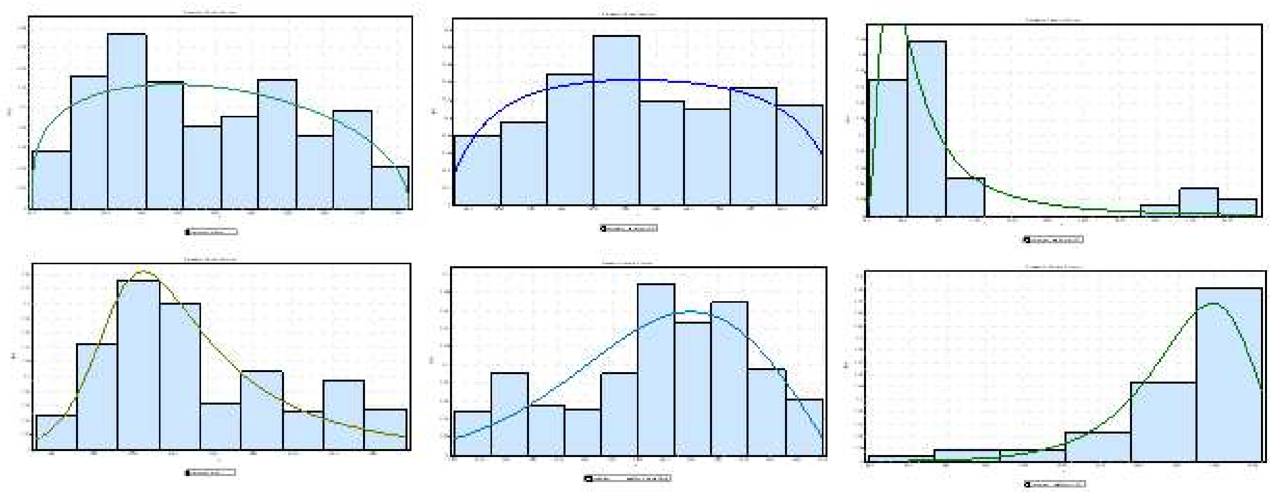
Stock-18: HDFC Bank

Table-26 : Distribution of the stock prices

Year	Distribution	Sample Size	Parameters	Anderson Darling	Kolmogorov Smirnov test		Tail Index value
				Test statistic	Test statistic	p-value	
2007-2009	Beta	738	α_1=1.2797 α_2=1.4802 a=798.65 b=1833.3	2.9666	0.05984	0.00971	2.2372
2010	Johnson SB	252	γ=0.01263 δ=0.80272 λ=1045.4 ξ=1524.0	0.9188	0.06471	0.2318	3.8258
2011-2014	Fréchet (3P)	992	α=1.7122 β=275.14 γ=318.43	17.214	0.09481	0.0001	1.6185
2015-2016	Burr	495	k=0.27512 α=43.988 β=1021.9	3.6698	0.08645	0.00114	6.3855
2017-2019	Gen Extreme Value	739	k=-0.49401 σ=374.88 μ=1780.4	4.8563	0.06616	0.00295	1.9525
2020	Weibull (3P)	55	α=1.6417E+8 β=8.0800E+9 γ=-8.0800E+9	1.1534	0.11069	0.47693	3.0019

Source: From researcher's data analysis

Figure-29 : Distribution of stock prices



Source: From researcher's data analysis

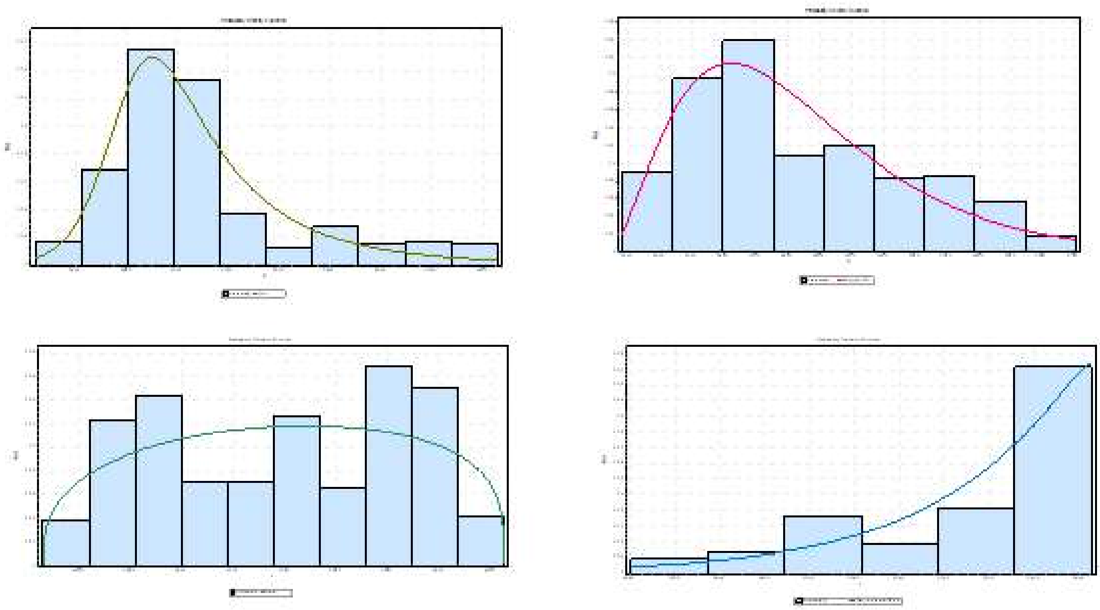
Stock-19: Hero MotoCorp Ltd

Table-27: Distribution of the stock prices

Year	Distribution	Sample Size	Parameters	Anderson Darling	Kolmogorov Smirnov test		Tail Index value
				Test statistic	Test statistic	p-value	
2011-2014	Burr	842	k=0.35904 α=19.164 β=1819.7	4.4781	0.06362	0.00209	2.7992
2015-2016	Gamma (3P)	495	α=2.8818 β=206.35 γ=2233.9	3.6485	0.07744	0.00499	4.7557
2017-2019	Beta	739	α_1=1.3601 α_2=1.2708 a=2258.8 b=4049.0	6.4332	0.07535	0.0001	2.9788
2020	Gen Extreme Value	55	k=-0.97279 σ=225.62 μ=2272.8	0.7137	0.11258	0.45553	3.1756

Source: From researcher's data analysis

Figure-30 : Distribution of stock prices



Source: From researcher's data analysis

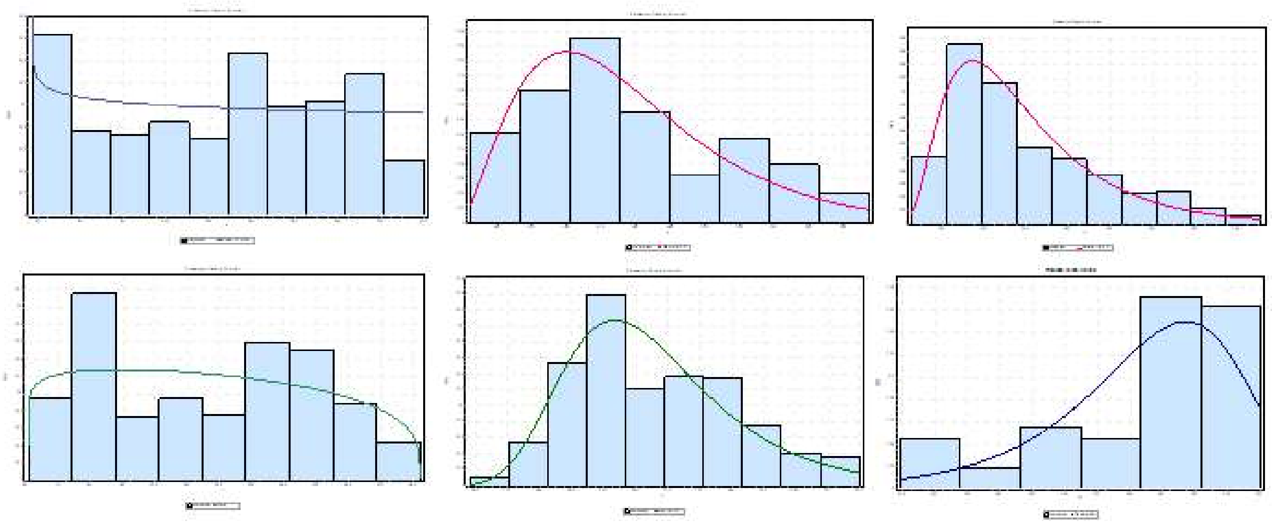
Stock-20: Hindalco Industries Ltd

Table-28 : Distribution of the stock prices

Year	Distribution	Sample Size	Parameters	Anderson Darling	Kolmogorov Smirnov test		Tail index value
				Test statistic	Test statistic	p-value	
2007-2009	Power Function	577	α=0.93081 a=37.4 b=219.9	3.4978	0.06067	0.0274	0.9040
2010	Gamma (3P)	252	α=2.7409 β=17.909 γ=128.68	1.2988	0.07869	0.08356	3.4617
2011-2014	Fatigue Life (3P)	992	α=0.54387 β=57.682 γ=72.237	4.2755	0.07205	0.0001	2.2025
2015-2016	Beta	495	α_1=1.0857 α_2=1.2774 a=60.9 b=182.1	4.1816	0.07569	0.00652	1.6314
2017-2019	Fréchet (3P)	739	α=1.9634E+8 β=4.2538E+9 γ=-4.2538E+9	3.7991	0.06654	0.00274	3.2656
2020	Gumbel Min	55	σ=22.726 μ=196.96	0.99622	0.12831	0.2994	1.8667

Source: From researcher's data analysis

Figure-31 ; Distribution of the stock prices



Source: From researcher's data analysis

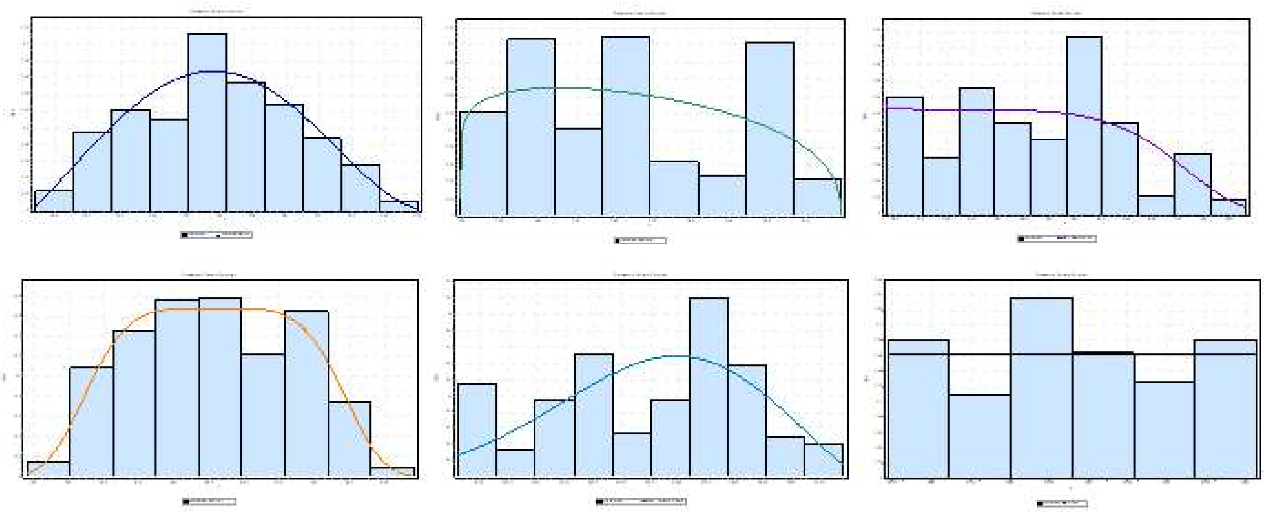
Stock-21: Hindustan Unilever Ltd

Table-29 : Distribution of the stock prices

Year	Distribution	Sample Size	Parameters	Anderson Darling	Kolmogorov Smirnov test		Tail index value
				Test statistic	Test statistic	p-value	
2007-2009	Kumaraswamy	603	α_1=2.0904 α_2=3.1983 a=182.74 b=304.42	0.41219	0.03641	0.39167	3.8983
2010	Beta	252	α_1=1.1319 α_2=1.3797 a=219.4 b=319.0	2.3585	0.09532	0.01916	5.4804
2011-2014	Gen Gamma (4P)	992	k=6.3082 α=0.15781 β=478.35 γ=266.15	6.1329	0.07411	0.0001	1.6948
2015-2016	Error	495	k=4.5788 σ=45.462 μ=862.73	0.5676	0.03655	0.51112	7.5815
2017-2019	Gen Extreme Value	739	k=-0.44375 σ=376.44 μ=1396.8	7.4875	0.08144	0.0001	1.7523
2020	Uniform	55	a=1905.8 b=2292.9	0.53632	0.09225	0.70271	10.4887

Source: From researcher's data analysis

Figure-32: Distribution of stock prices



Source: From researcher's data analysis

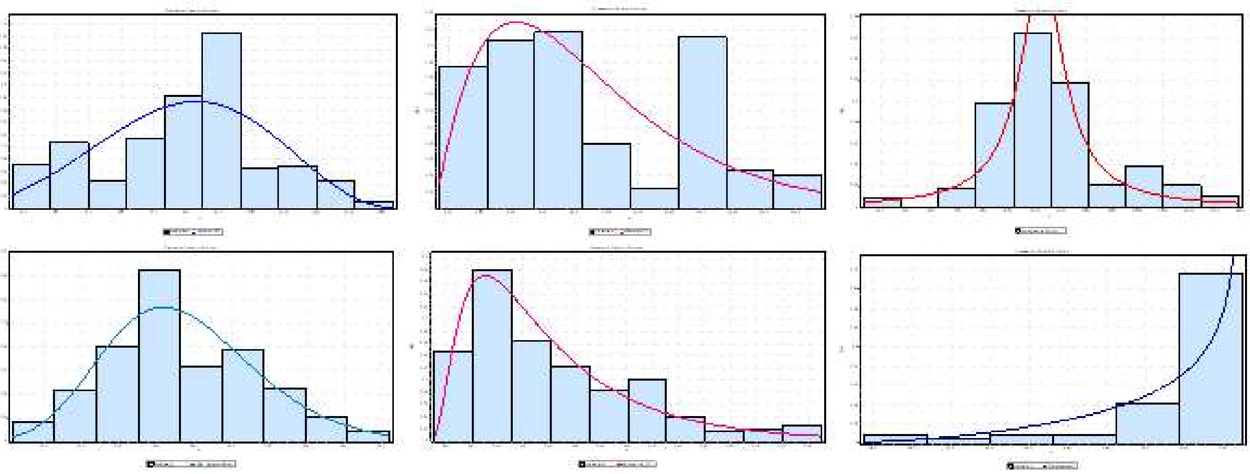
Stock-22: ICICI Bank

Table-30 : Distribution of the stock prices

Year	Distribution	Sample Size	Parameters	Anderson Darling	Kolmogorov Smirnov test		Tail index value
				Test statistic	Test statistic	p-value	
2007-2009	Johnson SB	738	γ=-0.43744 δ=1.6593 λ=1819.7 ξ=-224.92	7.7633	0.08352	0.0001	0.9494
2010	Gamma (3P)	252	α=2.132 β=92.303 γ=780.31	2.9613	0.13425	0.0001	4.7363
2011-2014	Cauchy	992	σ=105.49 μ=1028.6	9.2515	0.07373	0.0001	0.8755
2015-2016	Gen Extreme Value	495	k=-0.15001 σ=36.574 μ=257.66	1.8129	0.06864	0.01796	2.5220
2017-2019	Fatigue Life (3P)	739	α=0.6774 β=83.447 γ=239.24	2.6031	0.05673	0.01652	3.4102
2020	Kumaraswamy	55	α_1=2.9926 α_2=0.56855 a=327.88 b=549.3	3.3102	0.18905	0.03401	2.5592

Source: From researcher's data analysis

Figure-33 : Distribution of stock prices



Source: From researcher's data analysis

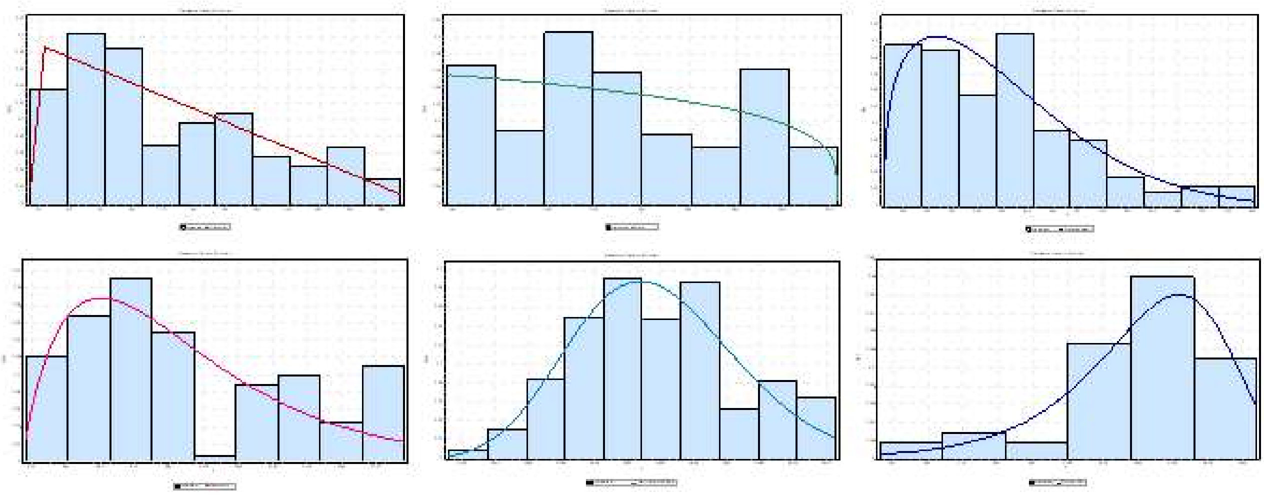
Stock-23: IndusInd Bank Ltd

Table-31 : Distribution of the stock prices

Year	Distribution	Sample Size	Parameters	Anderson Darling	Kolmogorov Smirnov test		Tail index value
				Test statistic	Test statistic	p-value	
2007-2009	Triangular	738	m=31.9 a=26.845 b=153.48	3.3582	0.07958	0.0001	1.1634
2010	Beta	252	α_1=1.0013 α_2=1.243 a=137.2 b=303.0	1.1149	0.05723	0.36734	2.4204
2011-2014	Kumaraswamy	992	α_1=1.3292 α_2=8.3562 a=209.46 b=1283.8	2.7601	0.05121	0.01062	1.7120
2015-2016	Gamma (3P)	495	α=1.9394 β=98.171 γ=787.5	4.9364	0.0904	0.0001	4.8859
2017-2019	Gen Extreme Value	739	k=-0.18854 σ=186.73 μ=1511.7	1.7588	0.04173	0.14822	2.6725
2020	Gumbel Min	55	σ=183.21 μ=1317.5	0.4813	0.0938	0.68336	1.0038

Source: From researcher's data analysis

Figure-34 : Distribution of stock prices



Source: From researcher's data analysis

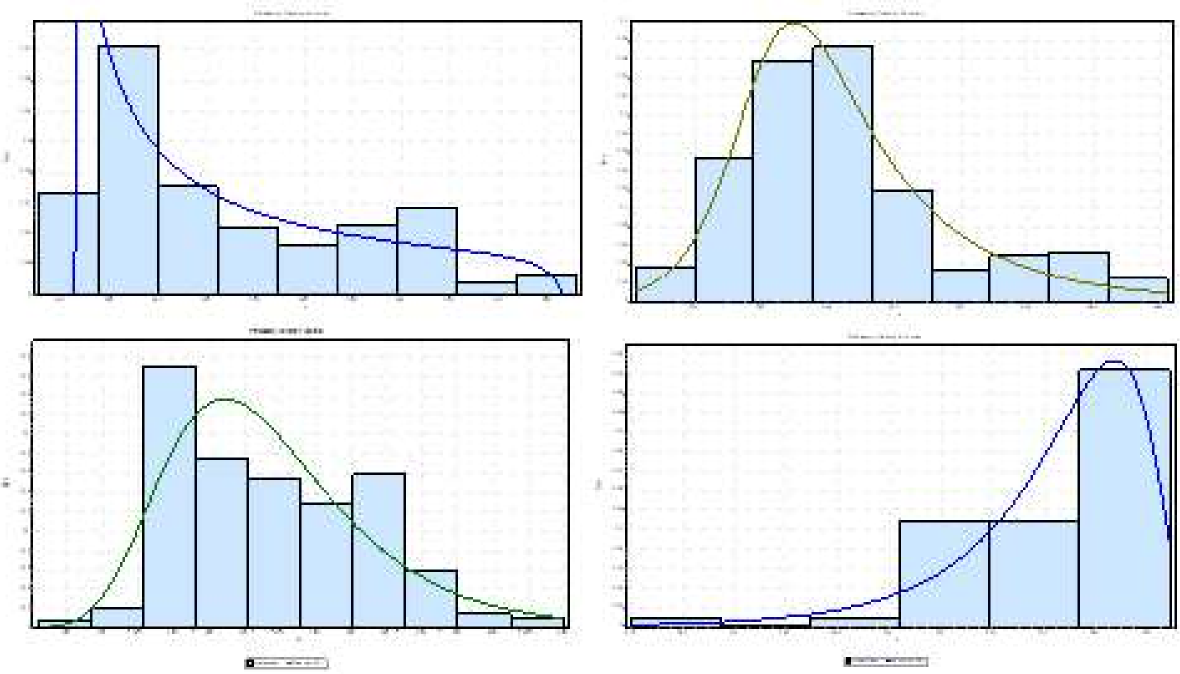
Stock-24: Infratel

Table-32 : Distribution of the stock prices

Year	Distribution	Sample Size	Parameters	Anderson Darling	Kolmogorov Smirnov test		Tail index value
				Test statistic	Test statistic	p-value	
2011-2014	Johnson SB	496	γ=0.6991 δ=0.56123 λ=200.99 ξ=145.48	66.463	0.05102	0.14601	2.3037
2015-2016	Burr	495	k=0.37896 α=36.876 β=361.16	1.1967	0.04059	0.37834	5.7274
2017-2019	Fréchet (3P)	739	α=1.5744E+8 β=7.2285E+9 γ=-7.2285E+9	5.8598	0.06351	0.00492	1.8909
2020	Johnson SB	55	γ=-5.1484 δ=1.6166 λ=635.07 ξ=-373.52	0.75266	0.09843	0.62526	2.1864

Source: From researcher's data analysis

Figure-35 : Distribution of stock prices



Source: From researcher's data analysis

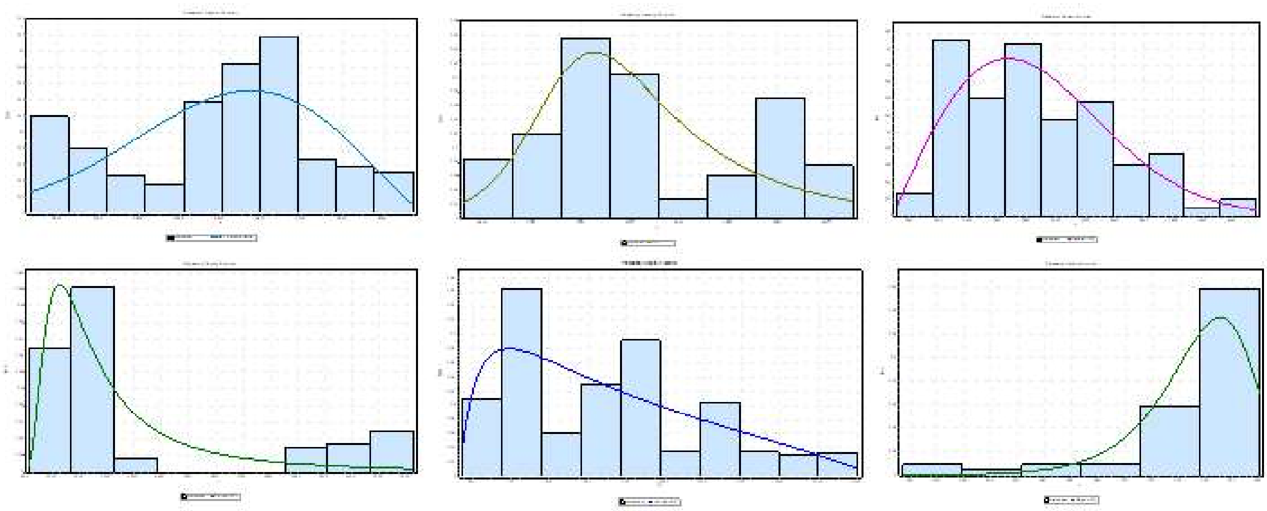
Stock-25: Infosys

Table-33 : Distribution of the stock prices

Year	Distribution	Sample Size	Parameters	Anderson Darling	Kolmogorov Smirnov test		Tail index value
				Test statistic	Test statistic	p-value	
2007-2009	Gen Extreme Value	553	k=-0.45587 σ=1035.2 μ=4139.4	6.4962	0.08281	0.0001	1.8775
2010	Burr	250	k=0.3591 α=38.216 β=5124.1	3.6969	0.12081	0.00123	6.8814
2011-2014	Rayleigh (2P)	870	σ=786.14 γ=1888.4	4.7571	0.06462	0.00133	2.5632
2015-2016	Fréchet (3P)	495	α=1.6767 β=249.74 γ=835.6	12.776	0.14276	0.0001	3.016
2017-2019	Johnson SB	739	γ=0.69269 δ=0.81374 λ=913.19 ξ=606.48	5.8696	0.08621	0.0001	2.6834
2020	Weibull (3P)	55	α=3.4683E+8 β=1.0536E+10 γ=-1.0536E+10	2.1216	0.18711	0.03694	2.8216

Source: From researcher's data analysis

Figure-36 : Distribution of stock prices



Source: From researcher's data analysis

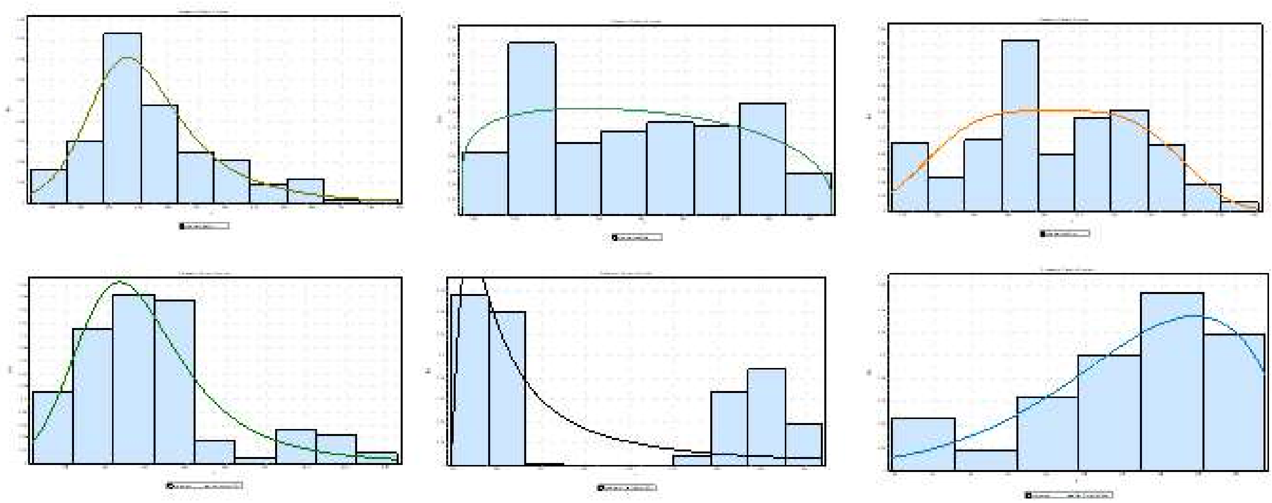
Stock-26: IOC

Table-34 : Distribution of the stock prices

Year	Distribution	Sample Size	Parameters	Anderson Darling	Kolmogorov Smirnov test		Tail index value
				Test statistic	Test statistic	p-value	
2007-2009	Burr	738	k=0.57436 α=11.794 β=411.21	3.2861	0.05903	0.0112	2.2496
2010	Beta	252	α_1=1.1752 α_2=1.3459 a=274.3 b=449.75	1.2819	0.0714	0.14592	3.9215
2011-2014	Error	992	k=3.7562 σ=47.04 μ=285.32	4.5521	0.06103	0.00118	2.6363
2015-2016	Log-Logistic (3P)	495	α=4.13 β=156.32 γ=234.36	4.8822	0.09697	0.0001	2.9876
2017-2019	Dagum (4P)	739	k=5.3683 α=1.0274 β=9.1437 γ=114.46	33.351	0.22613	0.0001	1.5816
2020	Gen Extreme Value	55	k=-0.62625 σ=11.627 μ=110.99	0.4971	0.10573	0.53521	3.7922

Source: From researcher's data analysis

Figure-37 : Distribution of the stock prices



Source: From researcher's data analysis

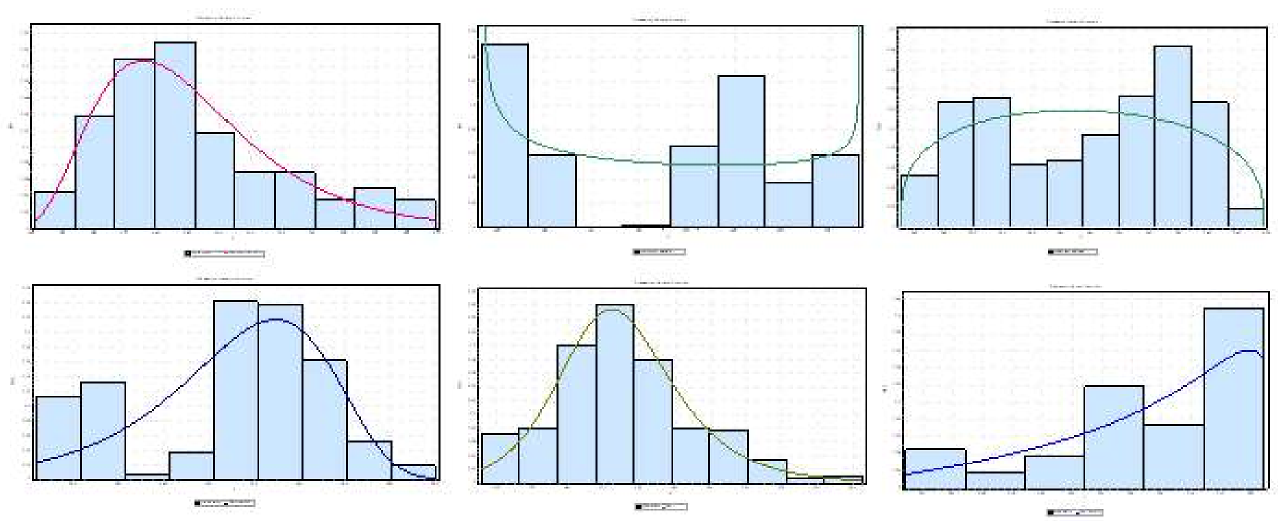
Stock-27: ITC

Table-35 : Distribution of the stock prices

Year	Distribution	Sample Size	Parameters	Anderson Darling	Kolmogorov Smirnov test		Tail index value
				Test statistic	Test statistic	p-value	
2007-2009	Fatigue Life (3P)	738	α=0.39979 β=67.172 γ=118.74	1.7437	0.04092	0.16428	3.3643
2010	Beta	252	α_1=0.69172 α_2=0.8259 a=152.95 b=312.8	8.6049	0.18385	0.0001	2.6675
2011-2014	Beta	992	α_1=1.3092 α_2=1.3433 a=150.65 b=397.8	15.303	0.09895	0.0001	1.7251
2015-2016	Gumbel Min	495	σ=33.104 μ=329.02	9.7113	0.12216	0.0001	3.1285
2017-2019	Burr	739	k=0.79058 α=27.888 β=270.58	1.4688	0.03902	0.20507	6.4791
2020	Johnson SB	55	γ=-0.97963 δ=0.8162 λ=131.48 ξ=118.21	1.0581	0.1436	0.18762	2.6388

Source: From researcher's data analysis

Figure-38 : Distribution of stock prices



Source: From researcher's data analysis

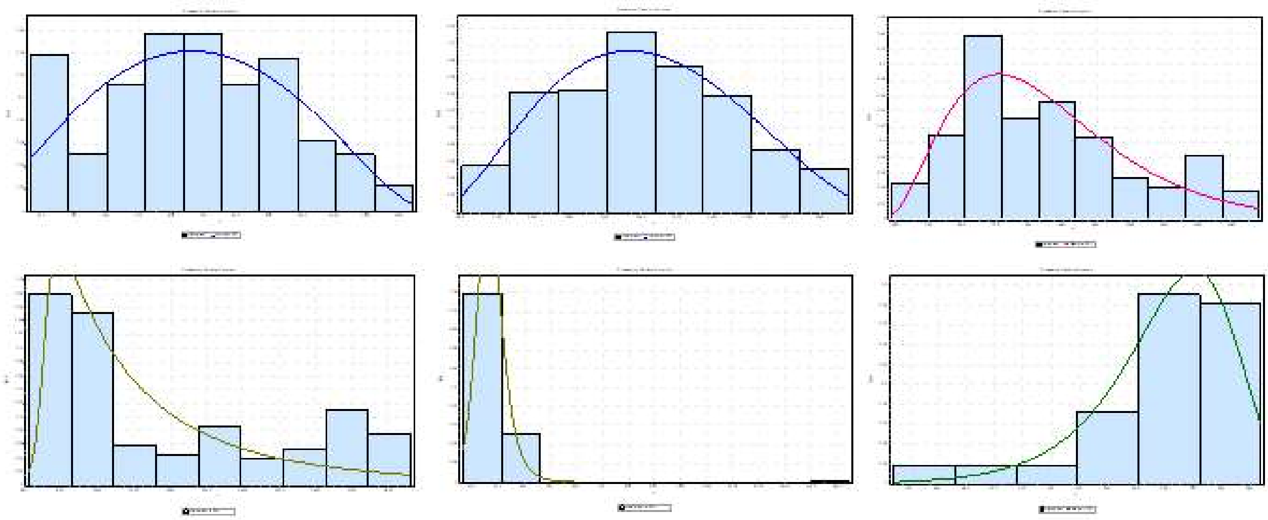
Stock-28: JSW Steel Limited

Table-36 : Distribution of the stock prices

Year	Distribution	Sample Size	Parameters	Anderson Darling	Kolmogorov Smirnov test		Tail index value
				Test statistic	Test statistic	p-value	
2007-2009	Johnson SB	738	γ=0.04932 δ=1.1666 λ=1548.5 ξ=-89.563	2.7201	0.05527	0.02118	0.7677
2010	Johnson SB	252	γ=0.27502 δ=1.2634 λ=574.73 ξ=905.54	0.26466	0.03135	0.95888	5.1759
2011-2014	Gamma (3P)	992	α=3.4161 β=116.1 γ=444.04	3.7069	0.05692	0.0031	1.7978
2015-2016	Burr	495	k=0.05736 α=58.28 β=855.11	9.1435	0.10786	0.0001	2.8173
2017-2019	Burr	739	k=1.2245 α=7.8494 β=275.69	4.8177	0.06194	0.00659	2.0481
2020	Weibull (3P)	55	α=1.0574E+8 β=1.9543E+9 γ=-1.9543E+9	0.44394	0.44394	0.85185	2.1137

Source: From researcher's data analysis

Figure-39 : Distribution of stock prices



Source: From researcher's data analysis

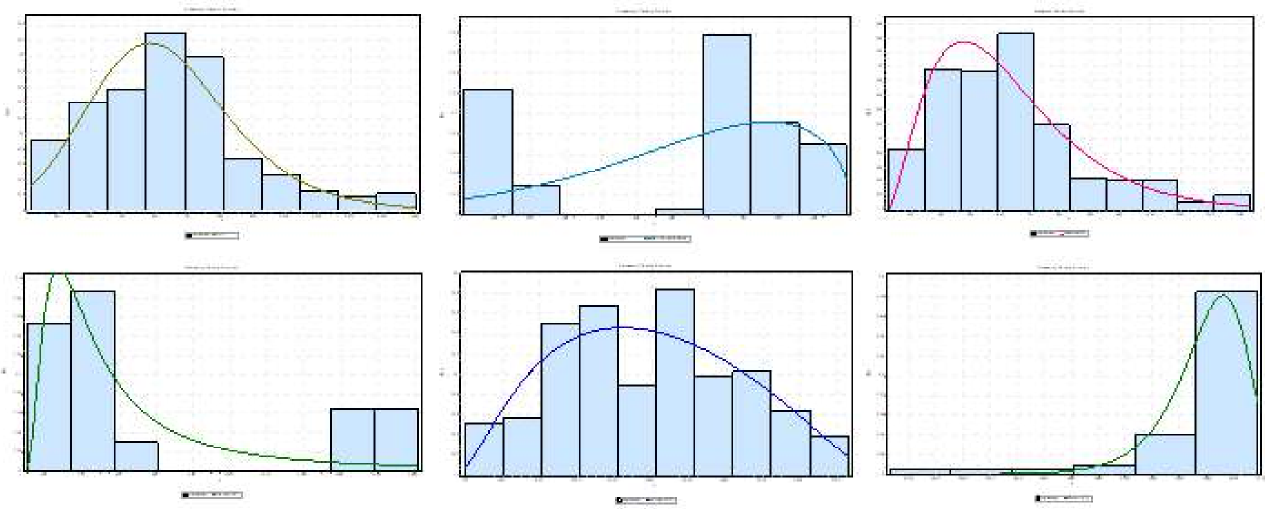
Stock-29: Kotak Bank

Table-37 : Distribution of the stock prices

Year	Distribution	Sample Size	Parameters	Anderson Darling	Kolmogorov Smirnov test		Tail index value
				Test statistic	Test statistic	p-value	
2007-2009	Burr	738	k=0.00443 α=2.2719E+5 β=1.1914E+5 γ=-1.1947E+5	1.8918	0.04085	0.16557	0.97798
2010	Gen Extreme Value	252	k=-0.69904 σ=150.28 μ=664.99	13.425	0.20452	0.0001	2.4215
2011-2014	Gamma (3P)	992	α=2.7156 β=120.0 γ=332.28	4.6603	0.05681	0.00318	1.5911
2015-2016	Fréchet (3P)	495	α=1.4769 β=146.52 γ=564.88	12.019	0.16144	0.0001	2.9551
2017-2019	Johnson SB	739	γ=0.26092 δ=1.0436 λ=1211.3 ξ=651.58	2.5651	0.05833	0.01256	1.9146
2020	Weibull (3P)	55	α=6.3315E+8 β=2.8993E+10 γ=-2.8993E+10	2.2715	0.14755	0.16481	2.8736

Source: From researcher's data analysis

Figure-40 : Distribution of stock prices



Source: From researcher's data analysis

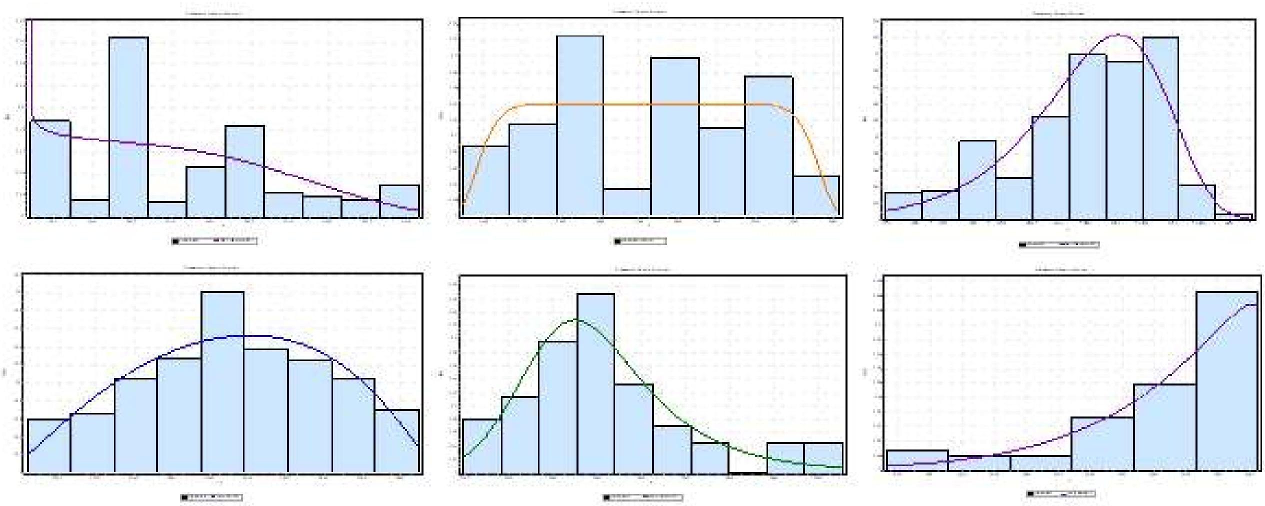
Stock-30: L & T

Table-38 : Distribution of the stock prices

Year	Distribution	Sample Size	Parameters	Anderson Darling	Kolmogorov Smirnov test		Tail index value
				Test statistic	Test statistic	p-value	
2007-2009	Gen Gamma (4P)	738	k=3.7881 α=0.2436 β=3182.6 γ=562.05	6.9928	0.10455	0.0001	0.8516
2010	Error	252	k=12.265 σ=200.93 μ=1778.3	1.2999	0.0729	0.13064	4.1867
2011-2014	Gen Gamma (4P)	992	k=5.0749E+7 α=1.0972 β=1.1324E+10 γ=-1.1324E+10	4.0097	0.05026	0.01287	1.4718
2015-2016	Johnson SB	495	γ=-0.13684 δ=1.0246 λ=986.81 ξ=964.62	0.77949	0.05102	0.14677	2.9695
2017-2019	Log-Logistic (3P)	739	α=5.0235 β=394.12 γ=956.78	2.6421	0.0435	0.11842	4.9245
2020	Log-Pearson 3	55	α=1.1332 β=-0.08838 γ=7.231	1.5888	0.17288	0.06593	2.9274

Source: From researcher's data analysis

Figure-41 : Distribution of stock prices



Source: From researcher's data analysis

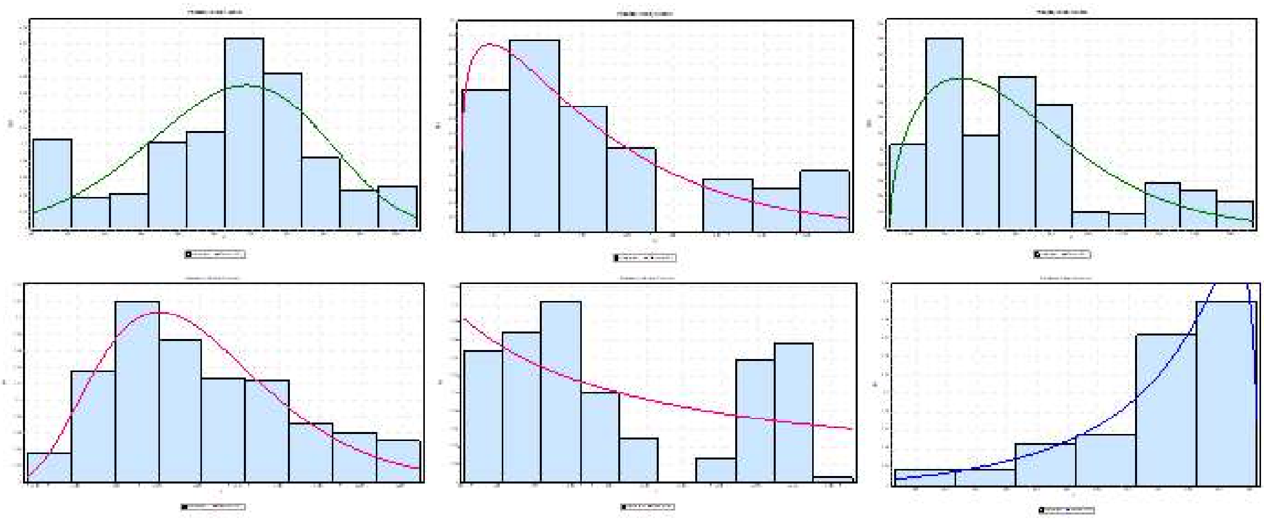
Stock-31: M&M

Table-39 : Distribution of the stock prices

Year	Distribution	Sample Size	Parameters	Anderson Darling	Kolmogorov Smirnov test		Tail index value
				Test statistic	Test statistic	p-value	
2007-2009	Weibull (3P)	738	α=5.3754 β=984.39 γ=-238.44	5.4308	0.05991	0.00959	1.0393
2010	Gamma (3P)	252	α=1.2649 β=192.63 γ=502.01	2.4184	0.08402	0.05376	2.7191
2011-2014	Gen Gamma (4P)	992	k=0.70783 α=3.9946 β=38.149 γ=592.42	8.4409	0.07159	0.0001	2.6950
2015-2016	Gamma (3P)	495	α=4.9487 β=40.866 γ=1079.4	1.5518	0.05089	0.14872	7.0415
2017-2019	Reciprocal	739	a=505.7 b=1556.3	13.147	0.10868	0.0001	1.8258
2020	Johnson SB	55	γ=-1.4792 δ=0.85419 λ=330.78 ξ=255.91	0.3285	0.08879	0.74521	2.3615

Source: From researcher's data analysis

Figure-42 : Distribution of stock prices



Source: From researcher's data analysis

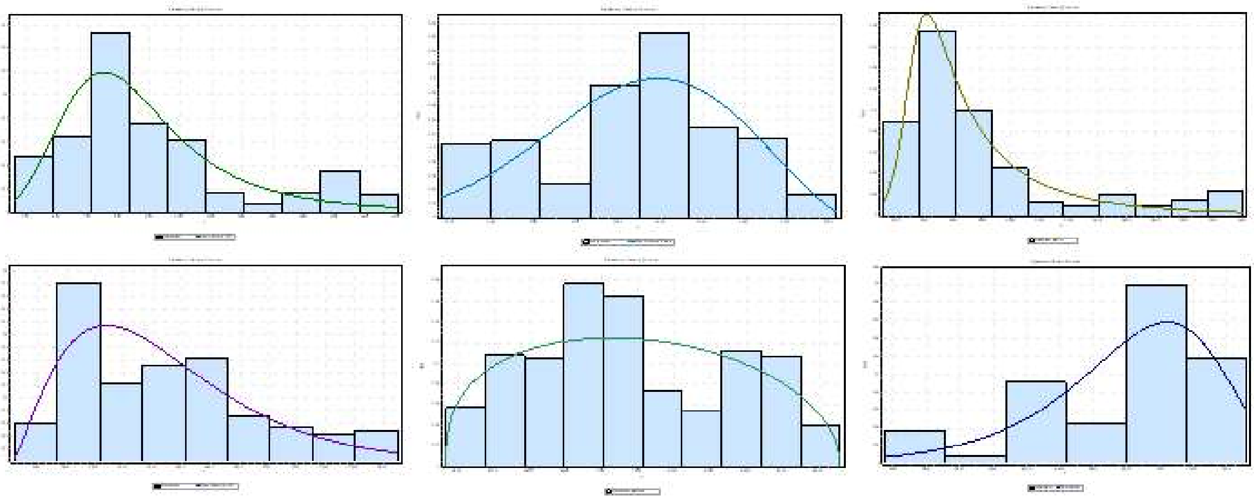
Stock-32: Maruti Suzuki India Ltd

Table-40 : Distribution of the stock prices

Year	Distribution	Sample Size	Parameters	Anderson Darling	Kolmogorov Smirnov test		Tail index value
				Test statistic	Test statistic	p-value	
2007-2009	Log-Logistic (3P)	738	α=3.1886 β=456.43 γ=378.61	4.7748	0.06002	0.0094	1.5783
2010	Gen Extreme Value	252	k=-0.4195 σ=95.382 μ=1350.4	1.6518	0.07334	0.12645	6.9386
2011-2014	Burr	992	k=0.18979 α=16.759 β=1121.9	2.684	0.04902	0.01642	1.9893
2015-2016	Gen Gamma (4P)	495	k=1.0983 α=2.1707 β=529.81 γ=3220.0	3.6572	0.09007	0.0001	3.7093
2017-2019	Beta	739	α_1=1.3669 α_2=1.5054 a=5466.0 b=9832.5	4.3266	0.08479	0.0001	3.2180
2020	Gumbel Min	55	σ=419.54 μ=7042.9	0.73165	0.12132	0.36368	4.0091

Source: From researcher's data analysis

Figure-43 : Distribution of stock prices



Source: From researcher's data analysis

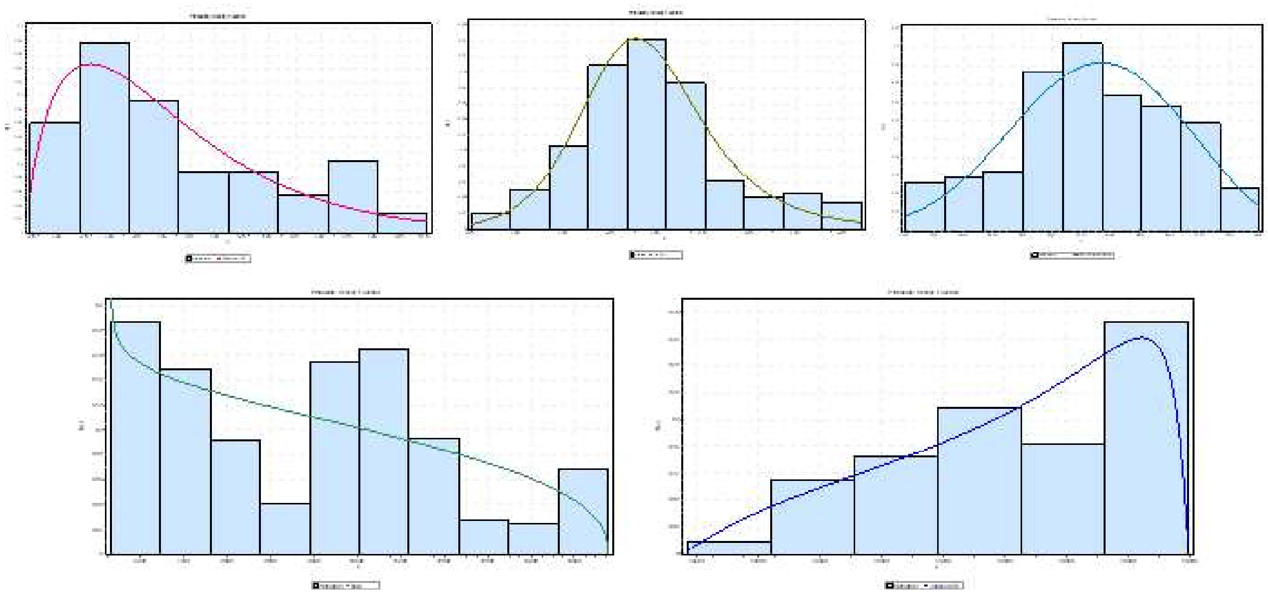
Stock-33: Nestle India Limited

Table-41 : Distribution of the stock prices

Year	Distribution	Sample Size	Parameters	Anderson Darling	Kolmogorov Smirnov test		Tail index value
				Test statistic	Test statistic	p-value	
2010	Gamma (3P)	248	α=1.7915 β=310.16 γ=2474.1	1.388	0.06424	0.24702	5.2191
2011-2014	Burr	992	k=0.84963 α=14.217 β=4613.6	1.7287	0.03414	0.19346	2.5854
2015-2016	Gen Extreme Value	495	k=-0.34502 σ=573.27 μ=6109.4	1.0492	0.04659	0.22578	4.4302
2017-2019	Beta	739	α_1=0.92428 α_2=1.4012 a=5851.8 b=15020.0	6.7855	0.07884	1.9164E-4	2.2329
2020	Johnson SB	55	γ=-0.63032 δ=0.75229 λ=3328.0 ξ=13467.0	0.62804	0.08257	0.8177	6.6215

Source: From researcher's data analysis

Figure-44 : Distribution of stock prices



Source: From researcher's data analysis

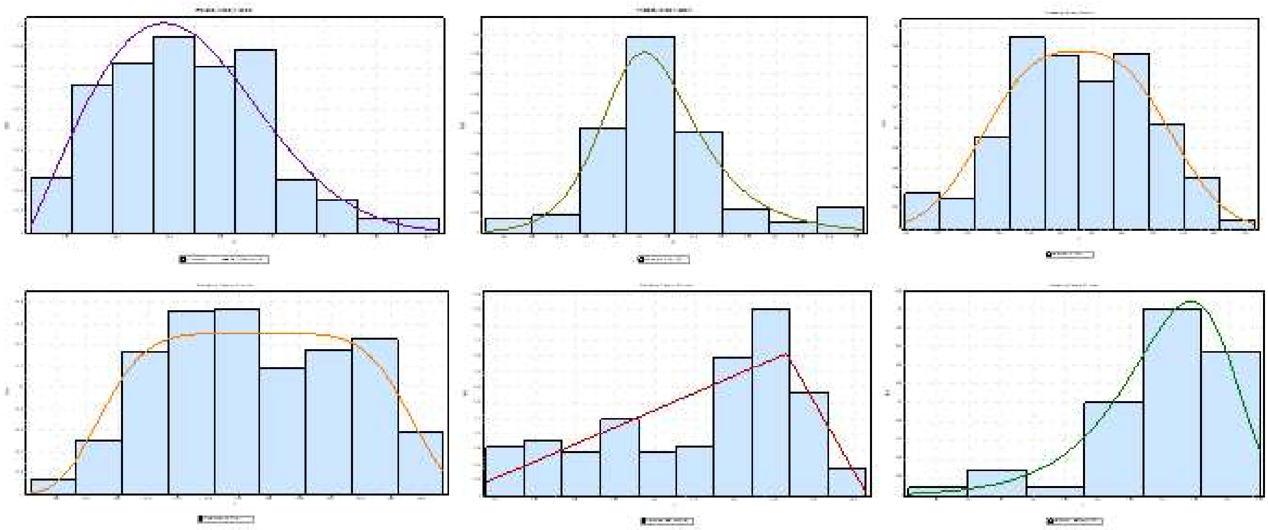
Stock-34: NTPC

Table-42 : Distribution of the stock prices

Year	Distribution	Sample Size	Parameters	Anderson Darling	Kolmogorov Smirnov test		Tail index value
				Test statistic	Test statistic	p-value	
2007-2009	Gen Gamma (4P)	738	k=2.3515 α=0.86083 β=75.147 γ=124.85	1.1012	0.03618	0.28212	2.6188
2010	Burr (4P)	252	k=0.5895 α=57.827 β=226.78 γ=-28.194	1.3631	0.06868	0.17705	7.3038
2011-2014	Error	992	k=2.7694 σ=18.084 μ=155.97	1.3168	0.03259	0.23747	3.0002
2015-2016	Error	495	k=5.1366 σ=12.329 μ=142.12	1.032	0.04011	0.39293	4.3179
2017-2019	Triangular	739	m=170.3 a=103.6 b=186.69	8.0136	0.08483	0.0001	3.0631
2020	Weibull (3P)	55	α=1.1134E+8 β=7.0972E+8 γ=-7.0972E+8	0.53884	0.1023	0.57707	2.9218

Source: From researcher's data analysis

Figure-45 : Distribution of stock prices



Source: From researcher's data analysis

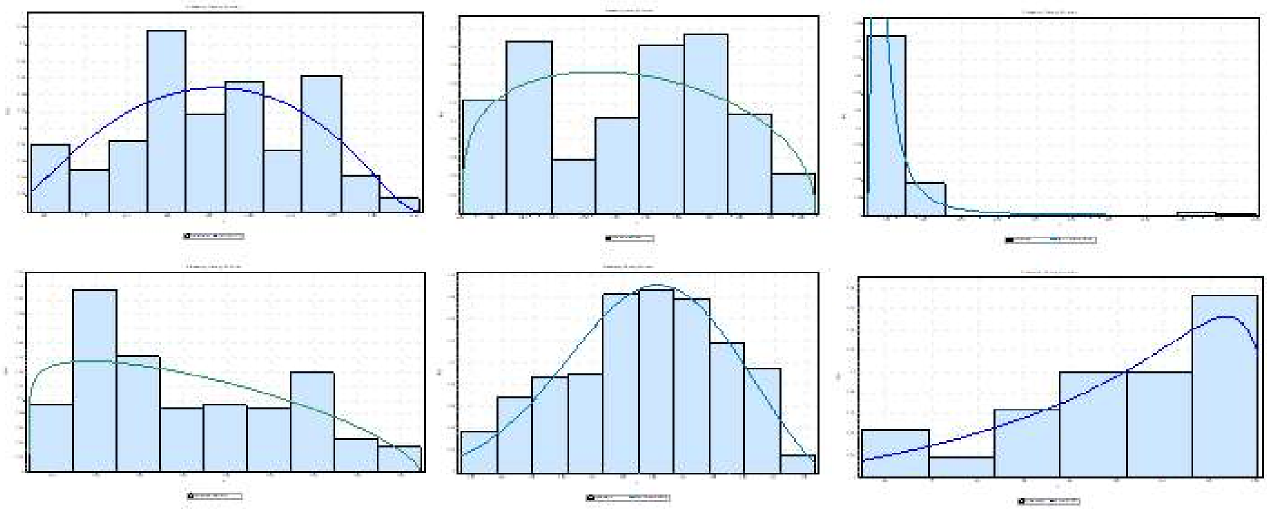
Stock-35: ONGC

Table-43 : Distribution of the stock prices

Year	Distribution	Sample Size	Parameters	Anderson Darling	Kolmogorov Smirnov test		Tail index value
				Test statistic	Test statistic	p-value	
2007-2009	Johnson SB	738	γ=-0.04057 δ=1.0534 λ=852.82 ξ=531.13	3.3699	0.05195	0.03592	2.2656
2010	Beta	252	α_1=1.2887 α_2=1.4713 a=1002.5 b=1458.1	2.4221	0.09665	0.01683	5.2016
2011-2014	Gen Extreme Value	992	k=0.57205 σ=25.768 μ=277.23	4.5879	0.0615	0.00105	4.0991
2015-2016	Beta	495	α_1=1.1202 α_2=1.6742 a=189.0 b=368.55	5.1755	0.09131	0.0001	3.2798
2017-2019	Gen Extreme Value	739	k=-0.38984 σ=22.085 μ=159.09	1.0888	0.02713	0.63821	2.9317
2020	Johnson SB	55	γ=-1.0354 δ=0.87447 λ=97.87 ξ=34.465	0.56835	0.105	0.54412	1.7505

Source: From researcher's data analysis

Figure-46 : Distribution of stock prices



Source: From researcher's data analysis

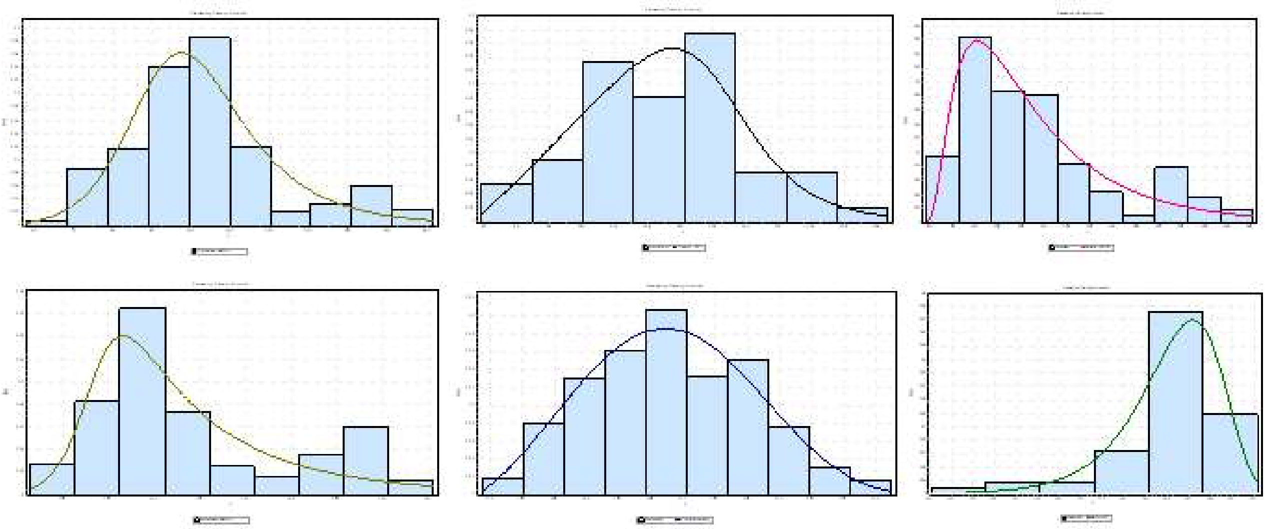
Stock-36: Powergrid

Table-44 : Distribution of the stock prices

Year	Distribution	Sample Size	Parameters	Anderson Darling	Kolmogorov Smirnov test		Tail index value
				Test statistic	Test statistic	p-value	
2007-2009	Burr	549	k=0.72904 α=11.122 β=96.65	2.825	0.06739	0.01301	1.7667
2010	Dagum (4P)	252	k=0.27415 α=7.4236 β=16.088 γ=93.382	0.51937	0.04174	0.756	8.8153
2011-2014	Fatigue Life (3P)	992	α=0.6546 β=17.037 γ=89.477	3.5004	0.05538	0.00438	5.4958
2015-2016	Burr	495	k=0.2001 α=42.674 β=133.81	5.1326	0.10477	0.0001	4.9398
2017-2019	Kumaraswamy	739	α_1=2.4489 α_2=6.7259 a=173.7 b=237.08	0.48181	0.02482	0.74285	7.9442
2020	Weibull (3P)	55	α=8086.2 β=57813.0 γ=-57621.0	0.76795	0.08822	0.75213	3.5635

Source: From researcher's data analysis

Figure-47 : Distribution of stock prices



Source: From researcher's data analysis

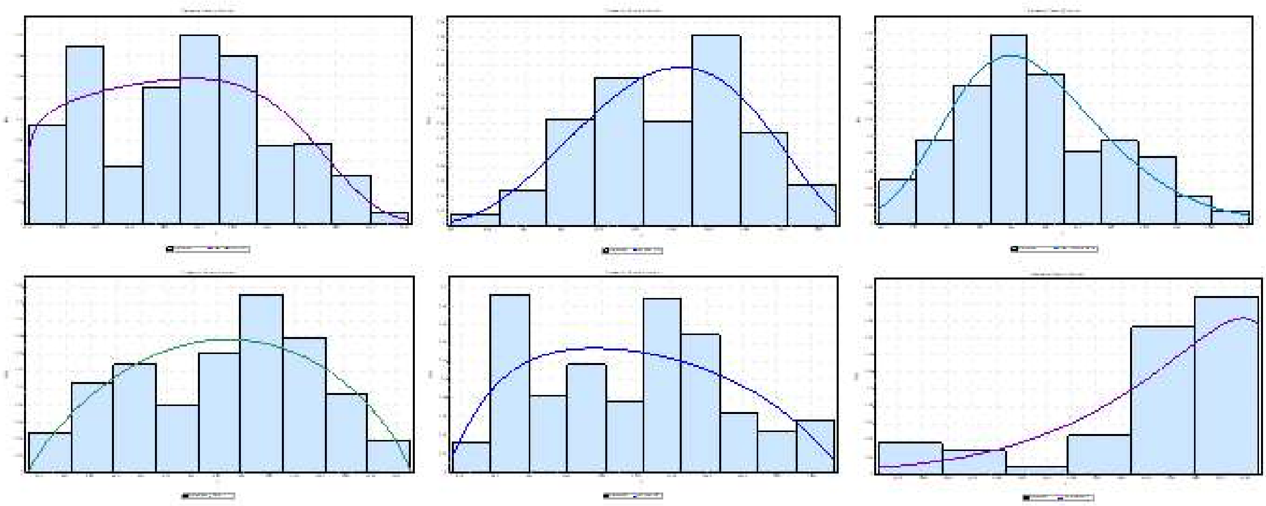
Stock-37: Reliance

Table-45 : Distribution of the stock prices

Year	Distribution	Sample Size	Parameters	Anderson Darling	Kolmogorov Smirnov test		Tail index value
				Test statistic	Test statistic	p-value	
2007-2009	Gen Gamma (4P)	738	$k=6.0924$ $\alpha=0.18747$ $\beta=1770.7$ $\gamma=1007.1$	2.0266	0.0575	0.01458	1.6357
2010	Johnson SB	252	$\gamma=-0.3534$ $\delta=1.3983$ $\lambda=274.74$ $\xi=884.32$	0.36608	0.05231	0.47962	8.2165
2011-2014	Gen Extreme Value	992	$k=-0.12372$ $\sigma=86.136$ $\mu=825.06$	1.9814	0.03717	0.12586	4.1341
2015-2016	Kumaraswamy	495	$\alpha_1=1.8735$ $\alpha_2=2.0704$ $a=806.13$ $b=1116.8$	2.6308	0.06855	0.01817	5.7918
2017-2019	Johnson SB	739	$\gamma=0.18322$ $\delta=0.89676$ $\lambda=949.39$ $\xi=749.87$	4.4768	0.06166	0.00694	2.4756
2020	Log-Pearson 3	55	$\alpha=1.2548$ $\beta=-0.10744$ $\gamma=7.381$	1.7406	0.16926	0.07582	2.5562

Source: From researcher's data analysis

Figure-48 : Distribution of stock prices



Source: From researcher's data analysis

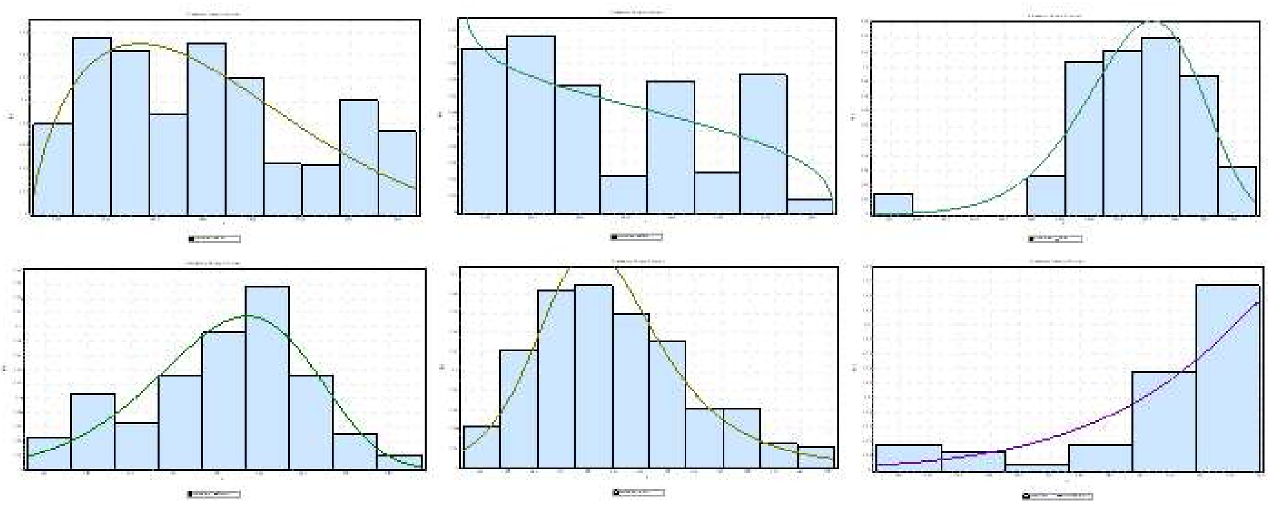
Stock-38: SBIN

Table-46 : Distribution of the stock prices

Year	Distribution	Sample Size	Parameters	Anderson Darling	Kolmogorov Smirnov test		Tail index value
				Test statistic	Test statistic	p-value	
2007-2009	Pert	738	m=1331.7 a=885.15 b=3298.6	4.6789	0.07458	0.0001	1.8352
2010	Beta	252	α_1=0.89063 α_2=1.3601 a=1895.0 b=3490.0	1.6968	0.08279	0.05969	3.6205
2011-2014	Beta	992	α_1=1.5381E+7 α_2=10.576 a=-1.9882E+9 b=3462.4	5.299	0.0526	0.00797	0.5208
2015-2016	Weibull	495	α=7.388 β=258.78	2.1856	0.05293	0.12052	2.1707
2017-2019	Burr (4P)	739	k=13.93 α=2.2143 β=212.27 γ=231.66	0.4725	0.02477	0.74514	4.6649
2020	Log-Pearson 3	55	α=1.0244 β=-0.11763 γ=5.8359	3.0439	0.18162	0.04644	2.6570

Source: From researcher's data analysis

Figure-49 : Distribution of stock prices



Source: From researcher's data analysis

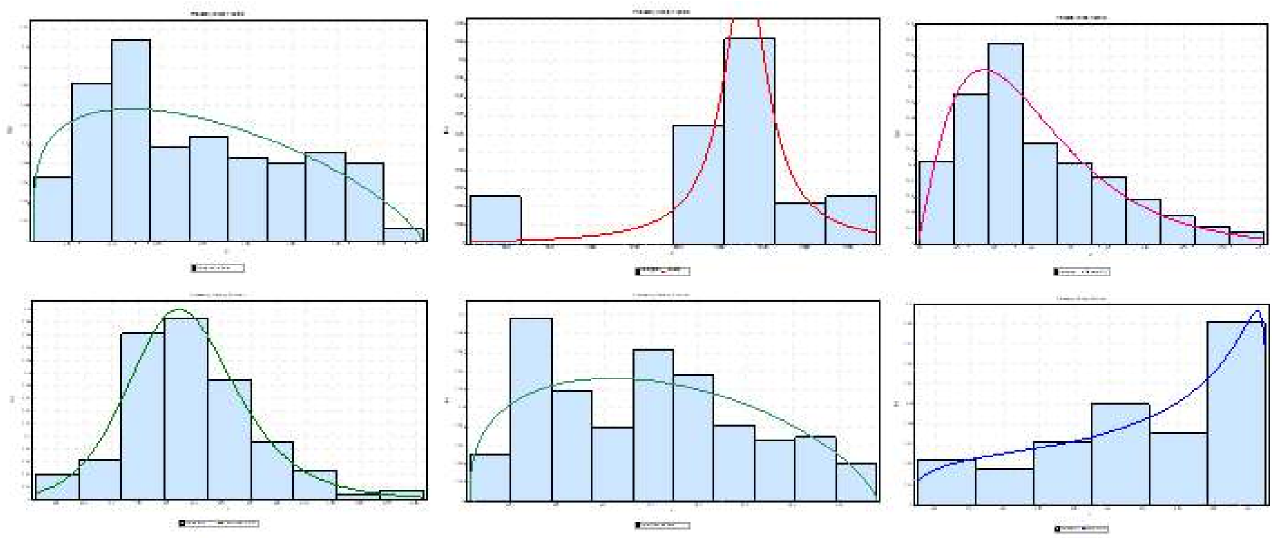
Stock-39: Sun Pharma

Table-47 : Distribution of the stock prices

Year	Distribution	Sample Size	Parameters	Anderson Darling	Kolmogorov Smirnov test		Tail index value
				Test statistic	Test statistic	p-value	
2007-2009	Beta	738	α_1=1.25 α_2=1.7528 a=897.85 b=1590.1	4.3399	0.07474	0.0001	3.7456
2010	Cauchy	252	σ=126.07 μ=1715.3	3.3808	0.09745	0.01554	0.7762
2011-2014	Gamma (3P)	992	α=2.3226 β=107.03 γ=392.31	2.1748	0.04537	0.03263	2.2071
2015-2016	Log-Logistic (3P)	495	α=11.615 β=605.0 γ=220.55	0.32898	0.02717	0.84824	3.2364
2017-2019	Beta	739	α_1=1.3665 α_2=1.6843 a=366.8 b=710.8	4.1268	0.06042	0.0087	3.004
2020	Johnson SB	55	γ=-0.53937 δ=0.60721 λ=104.8 ξ=350.87	0.26592	0.07683	0.87679	5.7729

Source: From researcher's data analysis

Figure-50 : Distribution of stock prices



Source: From researcher's data analysis

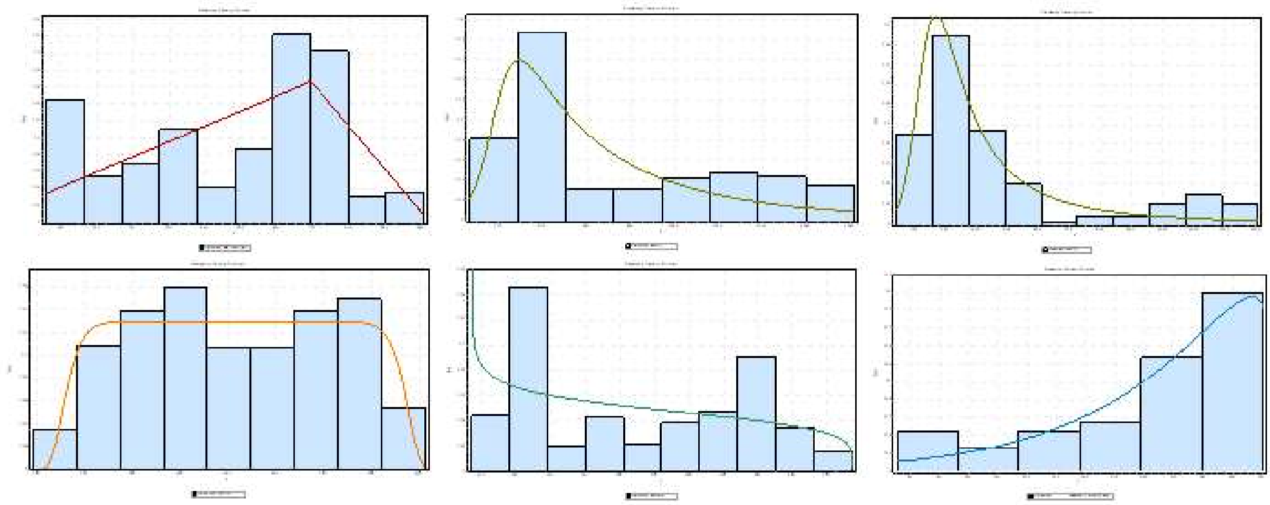
Stock-40: Tata Motors

Table-48 : Distribution of the stock prices

Year	Distribution	Sample Size	Parameters	Anderson Darling	Kolmogorov Smirnov test		Tail index value
				Test statistic	Test statistic	p-value	
2007-2009	Triangular	738	m=714.85 a=-25.813 b=978.83	12.232	0.07725	0.0001	0.7509
2010	Burr	252	k=0.12053 α=33.776 β=715.97	4.6427	0.12934	0.0001	3.1950
2011-2014	Burr	992	k=0.26467 α=7.2328 β=240.95	7.4184	0.07355	0.0001	0.9790
2015-2016	Error	495	k=16.004 σ=82.041 μ=446.09	1.0374	0.04665	0.22453	2.1479
2017-2019	Beta	739	α_1=0.85581 α_2=1.194 a=107.7 b=548.9	12.051	0.09902	0.0001	1.0810
2020	Gen Extreme Value	55	k=-0.9015 σ=38.455 μ=159.13	0.33696	0.06633	0.95566	1.3037

Source: From researcher's data analysis

Figure-51 : Distribution of stock prices



Source: From researcher's data analysis

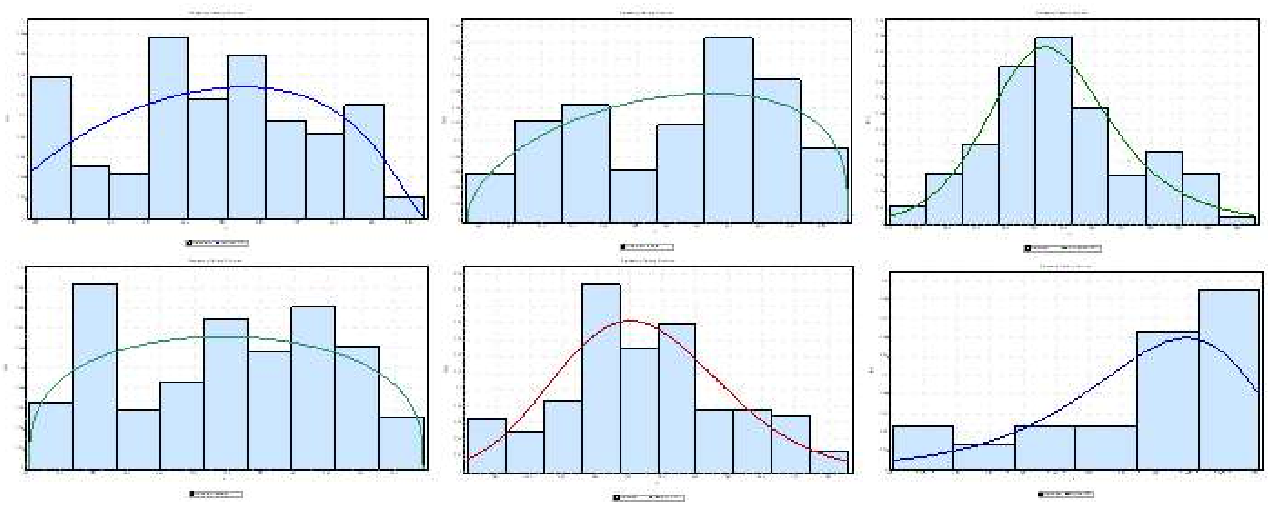
Stock-41: Tata Steel

Table-49 : Distribution of the stock prices

Year	Distribution	Sample Size	Parameters	Anderson Darling	Kolmogorov Smirnov test		Tail index value
				Test statistic	Test statistic	p-value	
2007-2009	Johnson SB	738	γ=-0.16974 δ=0.94377 λ=1001.0 ξ=5.2884	3.9512	0.06328	0.00518	0.8349
2010	Beta	252	α_1=1.5462 α_2=1.3084 a=451.4 b=695.7	1.918	0.0892	0.03404	3.8876
2011-2014	Log-Logistic (3P)	992	α=10.123 β=571.57 γ=-147.17	4.4131	0.05172	0.00956	1.3208
2015-2016	Beta	495	α_1=1.3267 α_2=1.3392 a=201.4 b=437.0	3.4564	0.07692	0.00541	2.2458
2017-2019	Pearson 5 (3P)	739	α=138.92 β=1.6448E+5 γ=-654.92	1.9967	0.04118	0.15864	2.0457
2020	Gumbel Min	55	σ=48.553 μ=458.12	1.0561	0.11103	0.47305	2.2827

Source: From researcher's data analysis

Figure-52 : Distribution of stock prices



Source: From researcher's data analysis

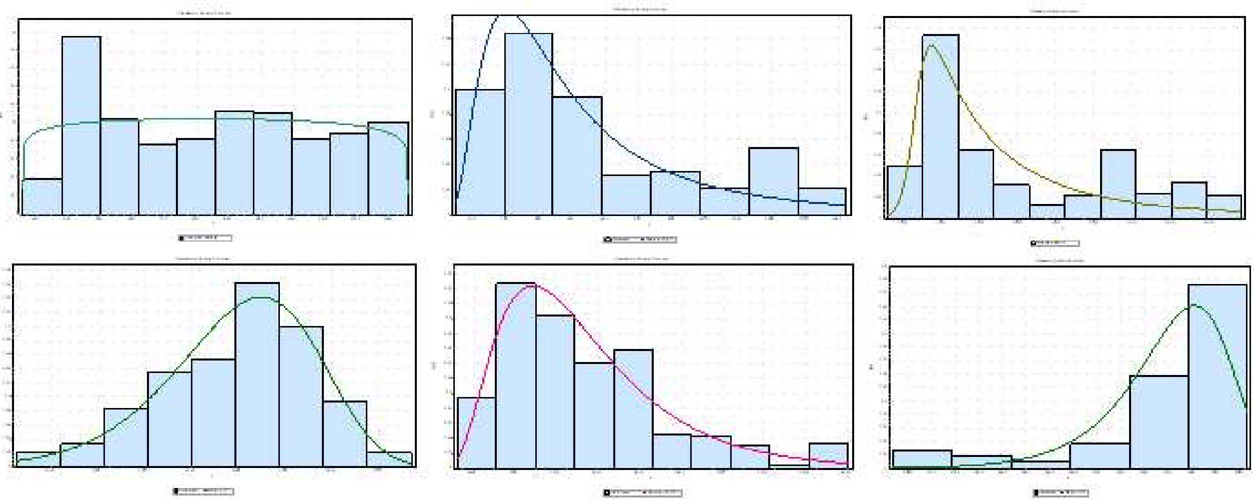
Stock-42: TCS

Table-50 : Distribution of the stock prices

Year	Distribution	Sample Size	Parameters	Anderson Darling	Kolmogorov Smirnov test		Tail index value
				Test statistic	Test statistic	p-value	
2007-2009	Beta	738	α_1=1.0802 α_2=1.0904 a=366.65 b=1326.4	3.2812	0.05512	0.02171	1.2906
2010	Pearson 6 (4P)	252	α_1=37.39 α_2=2.5211 β=8.768 γ=670.63	2.0383	0.06569	0.21721	4.9298
2011-2014	Burr	992	k=0.09446 α=29.672 β=1072.0	17.511	0.13887	0.0001	1.9644
2015-2016	Weibull (3P)	495	α=8.5257 β=976.68 γ=1556.6	0.87345	0.0463	0.23191	6.0549
2017-2019	Fatigue Life (3P)	739	α=0.4975 β=704.79 γ=1543.5	1.2231	0.04256	0.13367	3.4052
2020	Weibull (3P)	55	α=1.5505E+9 β=1.1800E+11 γ=-1.1800E+11	2.4112	0.15883	0.1116	3.9111

Source: From researcher's data analysis

Figure-53 : Distribution of stock prices



Source: From researcher's data analysis

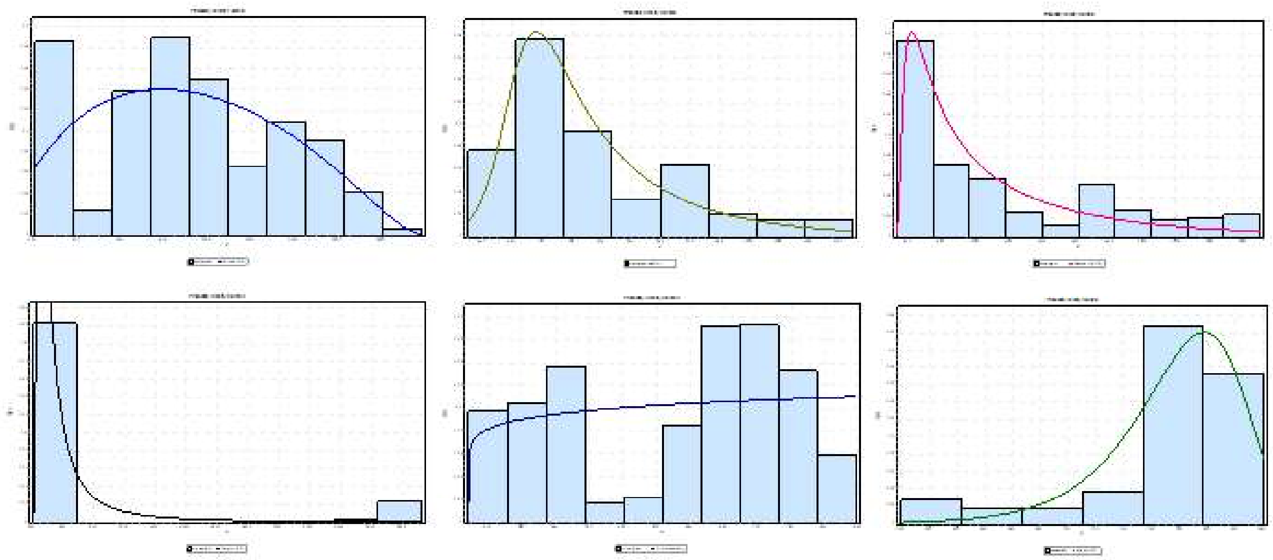
Stock-43: Tech Mahindra Ltd

Table-51 : Distribution of the stock prices

Year	Distribution	Sample Size	Parameters	Anderson Darling	Kolmogorov Smirnov test		Tail index value
				Test statistic	Test statistic	p-value	
2007-2009	Johnson SB	738	γ=0.21028 δ=1.0178 λ=2092.0 ξ=-51.734	6.47	0.0830	0.0001	0.7530
2010	Burr	252	k=0.21222 α=33.433 β=683.15	1.6326	0.0782	0.0866	4.3681
2011-2014	Fatigue Life (3P)	992	α=1.1563 β=400.35 γ=513.51	11.127	0.1114	0.0001	1.4632
2015-2016	Dagum (4P)	495	k=96.41 α=8.7255 β=172.34	14.962	0.1509	0.0001	2.4675
2017-2019	Kumaraswamy	739	α_1=1.1 α_2=1.0 a=376.3 b=837.0	11.762	0.1082	0.0001	2.1069
2020	Weibull (3P)	55	α=2.2454E+8 β=8.1480E+9 γ=-8.1480E+9	0.90782	0.1097	0.4876	3.3093

Source: From researcher's data analysis

Figure-54 : Distribution of stock prices



Source: From researcher's data analysis

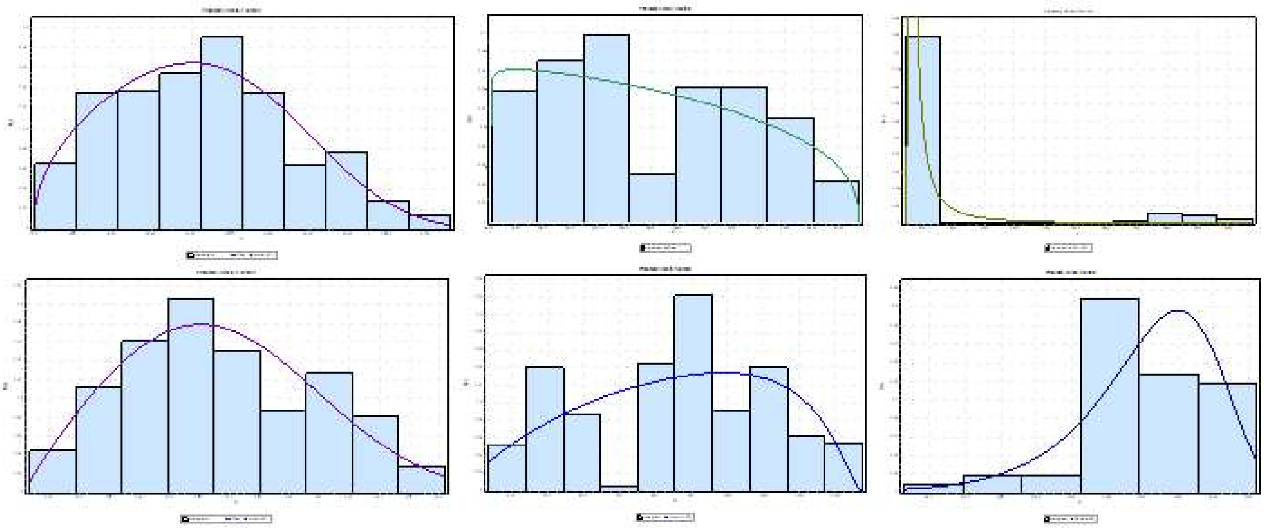
Stock-44: Titan

Table-52 : Distribution of the stock prices

Year	Distribution	Sample Size	Parameters	Anderson Darling	Kolmogorov Smirnov test		Tail index value
				Test statistic	Test statistic	p-value	
2007-2009	Gen Gamma (4P)	738	k=3.5862 α=0.40948 β=711.55 γ=698.46	0.85298	0.03884	0.20998	2.1779
2010	Beta	252	α_1=1.0286 α_2=1.383 a=1421.5 b=4146.8	1.4024	0.07903	0.08131	1.7708
2011-2014	Burr	992	k=0.08328 α=20.578 β=196.93	33.588	0.11711	0.0001	1.2311
2015-2016	Gen Gamma (4P)	495	k=2.7278 α=0.68171 β=89.599 γ=301.67	1.3237	0.05377	0.11012	5.2809
2017-2019	Johnson SB	739	γ=-0.25703 δ=0.90502 λ=1176.8 ξ=203.82	5.1064	0.08612	0.0001	1.1157
2020	Gumbel Min		σ=62.278 μ=1240.3	0.6966	0.12613	0.31855	3.7065

Source: From researcher's data analysis

Figure-55 : Distribution of stock prices



Source: From researcher's data analysis

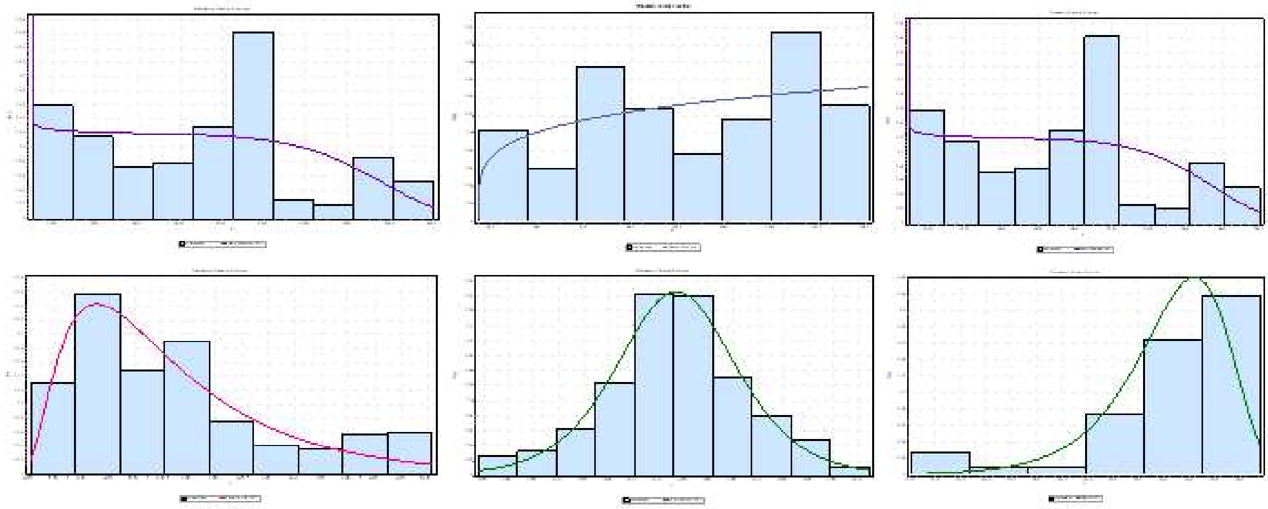
Stock-45: Ultra Cemco

Table-53 : Distribution of the stock prices

Year	Distribution	Sample Size	Parameters	Anderson Darling	Kolmogorov Smirnov test		Tail index value
				Test statistic	Test statistic	p-value	
2007-2009	Gen Extreme Value	738	k=-0.44397 σ=223.48 μ=683.21	2.3711	0.05236	0.03373	0.9901
2010	Power Function	252	α=1.2162 a=829.15 b=1163.1	1.5807	0.06881	0.17553	5.0468
2011-2014	Gen Gamma (4P)	992	k=6.3771 α=0.1528 β=1713.5 γ=897.25	11.225	0.10003	0.0001	1.6649
2015-2016	Fatigue Life (3P)	495	α=0.62924 β=541.43 γ=2500.1	1.8297	0.0459	0.24045	5.4400
2017-2019	Log-Logistic (3P)	739	α=1.9963E+8 β=3.1605E+10 γ=-3.1605E+10	0.70943	0.02311	0.81614	4.6749
2020	Weibull (3P)	55	α=1.3291E+8 β=2.3328E+10 γ=-2.3328E+10	1.6912	0.14795	0.16261	3.5991

Source: From researcher's data analysis

Figure-56 : Distribution of stock prices



Source: From researcher's data analysis

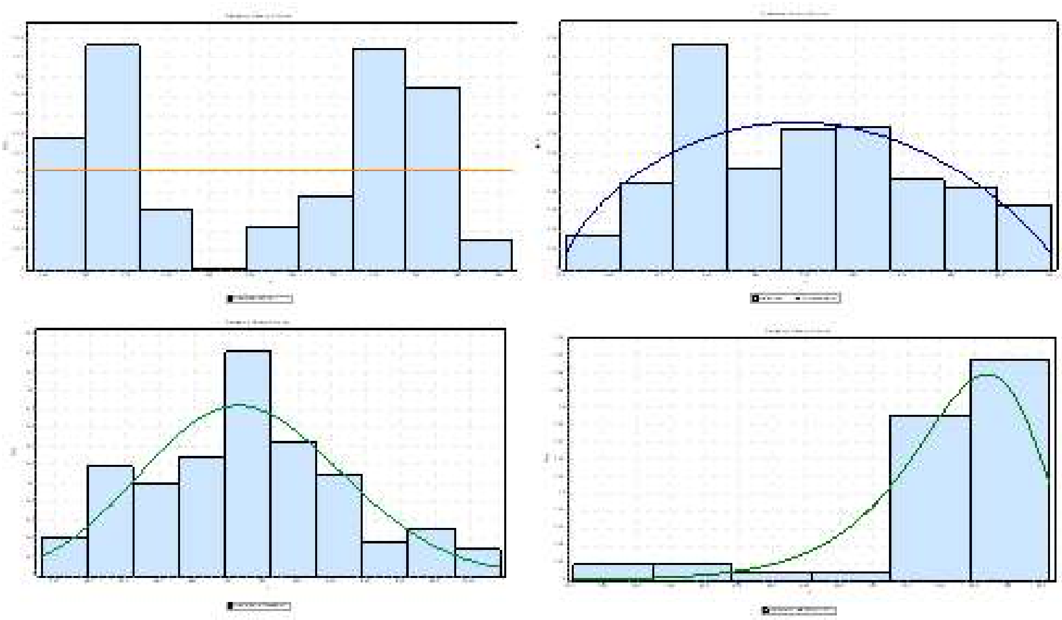
Stock-46: UPL

Table-54: Distribution of the stock prices

Year	Distribution	Sample Size	Parameters	Anderson Darling	Kolmogorov Smirnov test		Tail index value
				Test statistic	Test statistic	p-value	
2011-2014	Error	292	k=100.0 σ=72.459 μ=265.73	10.365	0.15745	0.0001	1.9473
2015-2016	Kumaraswamy	495	α_1=1.6077 α_2=1.8967 a=321.51 b=729.98	3.0032	0.07005	0.01478	2.1990
2017-2019	Nakagami	739	m=10.427 Ω=5.6173E+5	2.7591	0.0543	0.02465	2.6519
2020	Weibull (3P)	55	α=2.7704E+8 β=1.0060E+10 γ=-1.0060E+10	1.5307	0.14602	0.17337	1.8321

Source: From researcher's data analysis

Figure-57 : Distribution of stock prices



Source: From researcher's data analysis

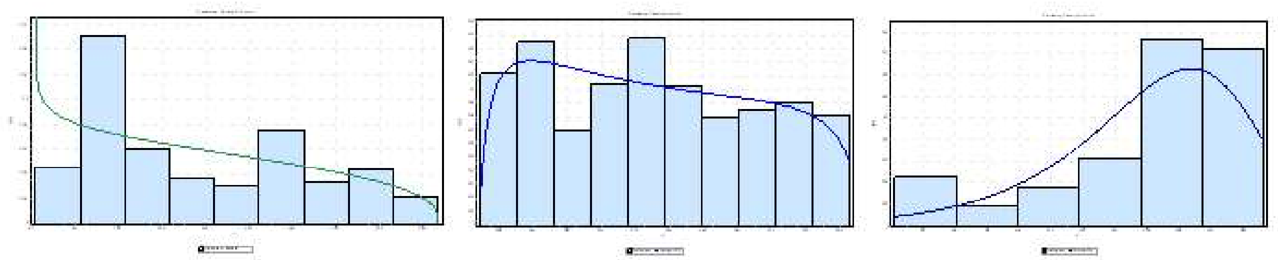
Stock-47: VEDL

Table-55 : Distribution of the stock prices

Year	Distribution	Sample Size	Parameters	Anderson Darling	Kolmogorov Smirnov test		Tail Index value
				Test statistic	Test statistic	p-value	
2015-2016	Beta	411	α_1=0.89292 α_2=1.3557 a=61.65 b=246.8	5.3751	0.10283	0.0001	1.3799
2017-2019	Johnson SB	739	γ=0.16433 δ=0.67362 λ=227.26 ξ=127.18	1.3939	0.0355	0.30227	1.8195
2020	Gumbel Min	55	σ=19.319 μ=146.74	1.0979	0.12982	0.28656	1.578

Source: From researcher's data analysis

Figure-58 : Distribution of stock prices



Source: From researcher's data analysis

Stock-48: Wipro

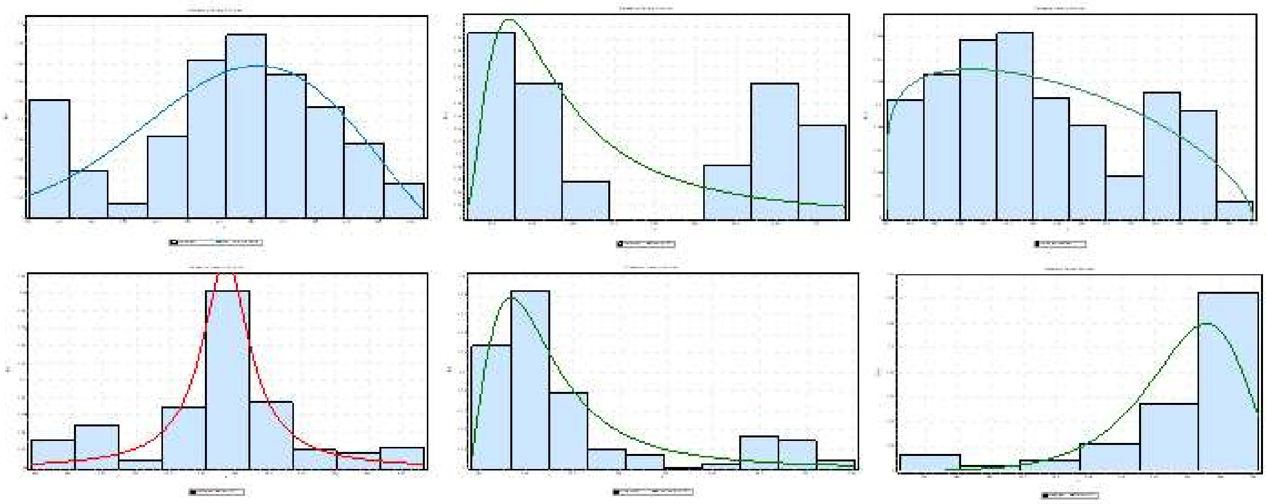
Table-56 : Distribution of the stock prices

Year	Distribution	Sample Size	Parameters	Anderson Darling	Kolmogorov Smirnov test		Tail index value
				Test statistic	Test statistic	p-value	
2007-2009	Gen Extreme Value	738	k=-0.45192 σ=130.2 μ=418.19	5.0169	0.07091	0.00114	1.2984
2010	Fréchet (3P)	252	α=1.4066 β=95.22 γ=351.0	12.69	0.24202	0.0001	2.9219
2011-2014	Beta	992	α_1=1.1808 α_2=1.6081 a=319.75 b=618.5	6.2004	0.07997	0.0001	3.15591
2015-2016	Cauchy	495	σ=17.568 μ=553.97	3.566	0.0831	0.00202	4.3877
2017-2019	Log-Logistic (3P)	739	α=2.0177 β=59.854 γ=232.08	6.6159	0.08341	0.0001	3.471
2020	Weibull (3P)	55	α=1.9471E+8 β=2.1709E+9 γ=-2.1709E+9	2.1266	0.17771	0.05444	2.8617

Source: From researcher's data analysis

Figure-59 : Distribution of stock prices

Source: From researcher's data analysis



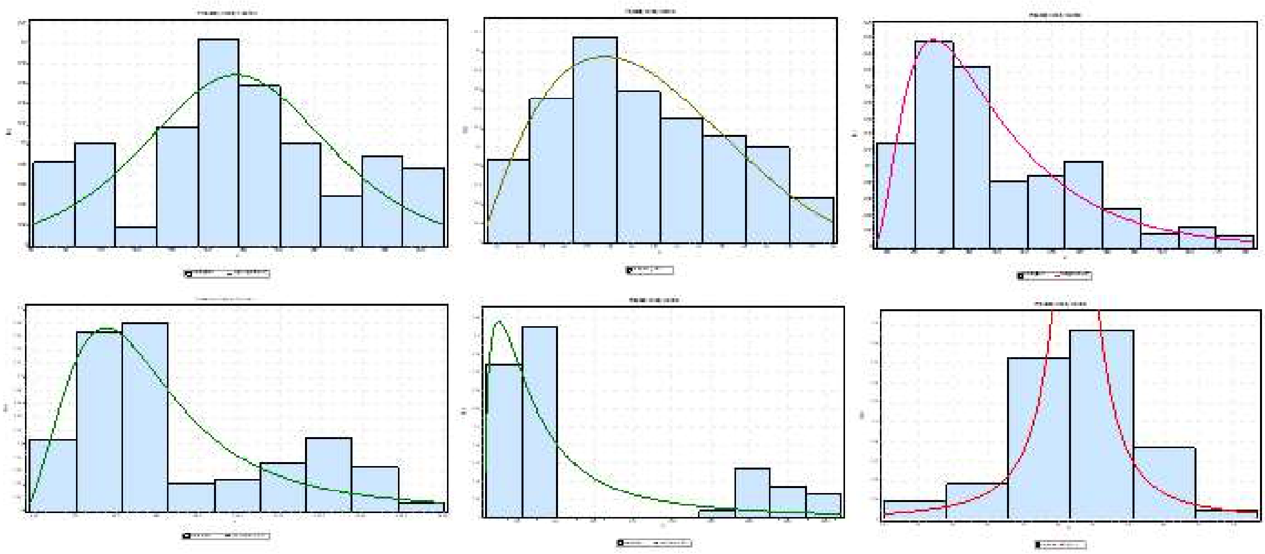
Stock-49: Yes Bank

Table-57 : Distribution of the stock prices

Year	Distribution	Sample Size	Parameters	Anderson Darling	Kolmogorov Smirnov test		Tail Index value
				Test statistic	Test statistic	p-value	
2007-2009	Log-Logistic (3P)	738	α=187.1 β=6417.9 γ=-6261.5	5.9896	0.07386	0.0001	0.8019
2010	Pert	252	m=277.1 a=222.3 b=426.87	0.68426	0.04427	0.68956	3.8198
2011-2014	Fatigue Life (3P)	992	α=0.61724 β=167.48 γ=196.78	3.4599	0.05599	0.00382	1.9059
2015-2016	Log-Logistic (3P)	495	α=2.3375 β=233.05 γ=620.92	6.6094	0.10075	0.0001	2.8037
2017-2019	Log-Logistic (3P)	739	α=1.3605 β=266.39 γ=31.419	19.092	0.15444	0.0001	0.4326
2020	Cauchy	54	σ=2.6347 μ=37.937	0.34265	0.06835	0.94752	1.1325

Source: From researcher's data analysis

Figure-60 : Distribution of stock prices



Source: From researcher's data analysis

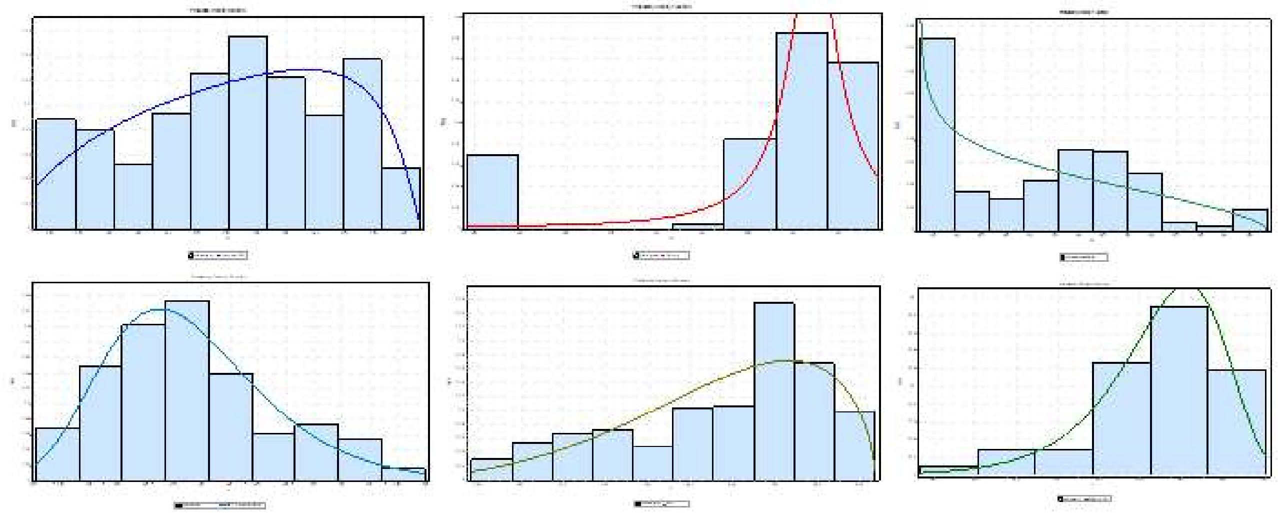
Stock-50: Zeel

Table-58 : Distribution of the stock prices

Year	Distribution	Sample Size	Parameters	Anderson Darling	Kolmogorov Smirnov test		Tail Index Value
				Test statistic	Test statistic	p-value	
2007-2009	Johnson SB	700	γ=-0.28057 δ=0.84085 λ=293.53 ξ=60.061	1.9499	0.0381	0.25509	1.1529
2010	Cauchy	252	σ=13.203 μ=288.65	15.137	0.15386	0.0001	1.5285
2011-2014	Beta	992	α_1=0.78173 α_2=1.5737 a=108.05 b=393.85	18.249	0.10831	0.0001	1.7568
2015-2016	Gen Extreme Value	495	k=-0.07298 σ=51.049 μ=385.72	1.4659	0.04742	0.20884	3.2718
2017-2019	Pert	739	m=532.37 a=73.581 b=613.87	5.4504	0.08823	0.0001	1.4655
2020	Weibull (3P)	55	α=7.1063E+7 β=1.6968E+9 γ=-1.6968E+9	0.3262	0.06846	0.94314	1.5497

Source: From researcher's data analysis

Figure-61 : Distribution of stock prices



Source: From researcher's data analysis

Overall Conclusion on the Probability models for the individual stocks

We now present the findings with respect to the fit of the probability models to the stock price random variable. For each of the stocks considered, we have fit all possible models and found the best fit. In few cases, no model best fits the data and such cases one has to observe the tail behaviour. Stocks with heavy tails, sometimes may not have a model that best fits them. In such cases, one has to understand their behaviour using the tail behaviour. As indicated earlier, the tail behaviour can be studied using the tail index value.

Note that, the null hypothesis H0 is, the distribution best fits the stock price random variable during the time period chosen. The alternative hypothesis is, the distribution does not best fit the stock price random variable during the time period chosen. If the p-value is more than the level of significance 5%, then we conclude that the distribution best fits the stock price random variable. Otherwise, we conclude that the distribution does not fit the stock price random variable. In other words, we claim that the distribution is not significant if the p-value is less than level of significance and claim that the distribution is significant if the p-value is more than the level of significance.

Note that the graphs presented under each of the stocks gives the distribution pattern that is extracted by the algorithm and is ranked as 1. The order is from 2007-09 to 2020 respectively and the tail behaviour can be understood from the histogram and the curve. From the graphs, one can draw appropriate inferences related to the tail behaviour of each of the stock prices.

From table-9 one can note that, there is a change in the distribution or model for Adaniports with change in the time points. During the financial crisis 2007-09, the stock prices of Adaniports have a behaviour close of Burr distribution, and the distribution is ranked 1 among all possible distributions that were fit. But it is not significant in fitting the stock prices in the best possible way. One can observe that the tail index value is less than 2 and hence we conclude that the tails are heavy. That is, the behaviour of the distribution is heavy tailed, and one can observe the same from the graph. From this, we conclude that the financial crisis has an impact on the tail behaviour of the stock price random variable. In the year 2010, the behaviour has improved and the appropriate distribution that best fits the stock price random variable during this period was Log-logistic distribution. The same can be observed from the tail behaviour. The value is more than 3 and this indicates that the moments of order less than 3 exists and the behaviour of the stock price random variable can be better understood. In this case, the mean and variance exist and are finite. But during the period 2011-14 again the behaviour has moved to heavy tailed with index value less than 3. In this case, the variance is infinite, and the tails become heavy. The algorithm has extracted Dagun (4P) as an appropriate distribution but is not significant in fitting the stock prices. There is further change in the probability model during the period 2015-16. Beta distribution was extracted but is not significant. Again, one can observe that the tail is heavy and less than 3. This implies that the variance is infinite and indicates that a heavy tail model is appropriate in understanding the behaviour of the stock price random variable during this period. One can also conclude that the market crash has an effect on the behaviour of the Adaniports stock prices during this period. There is an improvement in the behaviour of the stock prices during the period 2017-19. Burr distribution best fits the behaviour (but not significant) and the tail index is also more than 3. This indicates that the mean and variance of the stock price random variable exist, and one can study the behaviour using Burr distribution. In the year 2020, when COVID-19 is the root cause for the market crash, the stock prices follow a Log-Pearson 3 distribution and also the index value is more than 3. This indicates that the mean and variance exist during this period and the tail is not heavy as compared to other time periods. Of course, one cannot conclude that the market crash is not so severe as compared to other crashes, unless one observes the stock prices behaviour for longer period during COVID-19 and also after. From the entire analysis we conclude that, for Adaniports, the stock prices are affected more during the period 2007-2009, improved during the period 2010, again dropped during the period 2011-14, 2015-16, revived during the period 2017-19 and improved further during the period 2020.

Table 10 gives the behaviour of the stock prices related to Asian paints. One can observe from the analysis that, the stock prices were affected during the periods 2007-09, 2011-14, 2017-19 with respective tail index values less than 3. This indicates that, during these time periods the stock has faced severe turbulence and revived during other periods. During the period 07-09, the appropriate distribution that best fits the stock price random variable is Johnson SB distribution. But the tail index value is less than 3 and it indicates that the variance of the stock is very high. This indicates that the stock is heavy tailed, and the market crash has an affect on the behaviour. The most affected time period is 2011-14 where the index value is very low, and the graph shows the scatteredness of the stock prices during this period. This indicates that, the stock price random variable doesn't have the finite moments. Mean also doesn't exist. Note that the conclusions are for the population behaviour. The stock has revived during the period 2015-16 with the index value more than 3. This indicates that the stock has finite mean and variance. Log-logistic distribution is the distribution extracted by the algorithm, which is not significant. Again, during the period 2017-19, the stock has faced the turbulence and the same is reflected in the index value, less than 3. This indicates that the variance of the stock is high, and the tail is heavy. In the year 2020, the stock has an index value which is very high and Johnson SB distribution best fits the stock price random variable. But the sample size is not high, and one has to observe the behaviour of the stock for more days, to come to a conclusion.

From table-11, one can observe the behaviour of the axis bank stock prices. One can note the changes in the distribution with the change in the time point. The stock has faced more turbulence during the periods 2007-09, 2011-14. It has revived during the periods 2010, 2015-16, and 2017-19. Again, in the year 2020, it has faced the turbulence and is evident from the index value and the graph. Interestingly, except for the year 2010, no distribution could fit the prices.

Baja Auto has faced turbulence during the time period 2007-09 and the same can be seen from the tail index value (1.1175). The tail is very heavy and has infinite variance. Even the mean doesn't exist for the stock. Log-logistic (3P), Gen Gamma (4P), and Beta distributions best fit the stock prices, during the periods 2010, 2011-14, and 2015-16 respectively.

During the period 2017-19, the stock has high tail index value, and this indicates that during this period it has low turbulence. Similar behaviour can be seen during the period 2015-16 with the index value more than 3. From the respective graphs, one can see that the performance has improved during this period and again had entered into turbulence during the period 2020. Though the index value is more than 3, the tails are heavier than the other two periods.

Table-13 gives the analysis related to Bajaj FinSv. The stock has high turbulence during the period 2007-2009 and is very evident from the tail index. It has high variance and mean also doesn't exist. Also, during the periods 2011-14, 2015-16, 2017-19 the stock has faced the turbulence due to the market crashes. During the periods 2010 and 2020 the tail behaviour has improved, and the value is more than 3. But one can see that the distributions have changed drastically with the change in the time periods.

Table-14 gives the analysis related to Bajaj Finance. Generalized extreme value distribution best fits during the period 2010 and Pearson 5 during the period 2020. During other periods the stock has faced turbulence, which has led to heavy tail behaviour during these periods. Period 2015-16 has heavy tail as compared to other time periods and the same is reflected in the graph.

Bharathi Airtel has less turbulence during the market crashes, expect for the period 2007-09. This can be inferred from the tail index value and the corresponding graphs. All the tail index values are more than 3 and this indicates that the variance is finite. From this one can conclude that this stock hasn't faced much turbulence due to market crashes.

On similar lines one can draw appropriate conclusions related to each of the stocks. Mainly one has to look at two points. The first is one observing the distribution and noting the changes in the distribution with the change in the events. That is, whether the market crashes have affected the stock price behaviour or not? The second point is the tail index value. Noting down the number of times the index value has gone below 3. Based on the value one can draw inferences on the level of turbulence the stock has faced during the time period. Also, the number of times the stock has faced the turbulence. The tail index value also gives one an idea on the thickness of the tail and information on the existence of the mean and variance.

We now present the frequency of the crossings of the stocks. Based on the number of times the index value is less than 3, we classify the stock as riskier or volatile and rank them. We classify the stocks into high riskier (if the frequency is between 4 and 6), medium riskier (if the frequency is between 2 and 3), low riskier (if the frequency is between 0 and 1).

From the above table, one can list those stocks that are having high, medium and low risk, respectively. Note that, this classification was done based on the index values. This will help one to understand the process of identifying the stocks with high risk, based on the level of index value.

Part-2: Tail Behaviour of the stock price random variable and classification of extremes

We now present the tail index estimation and classification of the extremes (maximum stock price and Minimum stock price). As indicated earlier, extremes belong to one of the three extreme value distributions. That is, extremes belong to either to the domain of attraction of Fréchet or Weibull or Gumbel. This is decided based on the size of the index. We fit a generalized extreme value distribution (GEV) to the stock prices and then, based on the index value, we identify the domains. The following gives the discussion on the same.

Table-A : Crossings of the stocks

Symbol	<1	1<alpha<=2	2<alpha<=3	Total	3<alpha<=a	Risk
TATAMOTORS	2	2	2	6	0	High
KOTAKBANK	1	2	3	6	0	High
YESBANK	2	2	1	5	1	High
JSWSTEEL	1	1	3	5	1	High
TATASTEEL	1	1	3	5	1	High
ZEEL	0	5	0	5	1	High
TITAN	0	3	2	5	2	High
INDUSINDBK	0	3	2	5	1	High
M&M	0	2	3	5	1	High
INFY	0	1	4	5	1	High
ICICIBANK	2	0	2	4	2	High
BAJAJFINSV	1	2	1	4	2	High
BRITANNIA	1	2	1	4	2	High
EICHERMOT	1	2	1	4	2	High
HINDALCO	1	2	1	4	2	High
LT	1	1	2	4	2	High
SBIN	1	1	2	4	2	High
TECHM	1	1	2	4	2	High
BPCL	0	3	1	4	2	High
UPL	0	2	2	4	0	High
HDFC	0	2	2	4	2	High
HDFCBANK	0	2	2	4	2	High
IOC	0	1	3	4	2	High
ADANIPORTS	0	1	3	4	2	High
NTPC	0	0	4	4	2	High
ASIANPAINT	1	2	0	3	3	medium
BAJFINANCE	1	2	0	3	2	medium
HCLTECH	1	2	0	3	3	medium
AXISBANK	1	1	1	3	3	medium
GAIL	1	1	1	3	3	medium
GRASIM	1	1	1	3	3	medium
SUNPHARMA	1	0	2	3	3	medium
VEDL	0	3	0	3	0	medium
ITC	0	1	2	3	3	medium
ONGC	0	1	2	3	3	medium
RELIANCE	0	1	2	3	3	medium
WIPRO	0	1	2	3	3	medium
INFRATEL	0	1	2	3	1	medium
ULTRACEMCO	1	1	0	2	4	medium
MARUTI	0	2	0	2	4	medium
TCS	0	2	0	2	4	medium
HINDUNILVR	0	2	0	2	4	medium
BAJAJ-AUTO	0	1	1	2	4	medium
DRREDDY	0	1	1	2	4	medium
NESTLEIND	0	0	2	2	3	medium
HEROMOTOCO	0	0	2	2	2	medium
POWERGRID	0	1	0	1	5	Low
BHARTIARTL	0	1	0	1	5	Low
COALINDIA	0	0	1	1	4	Low
CIPLA	0	0	0	0	6	Low

Source: From researcher's analysis

Stock-1: Adaniports

Table-59 : Tail Index estimation and classification-Maximum stock price

S.No.	Year	Parameters				Domain for Maximum
		ξ	α	σ	μ	
1	2007-2009	0.0329742	-------	26.776984	84.30949812	Gumbel
2	2010	-0.2822806	3.542574304	13.448771	133.3316943	Weibull
3	2011-2014	0.4066978	2.458828152	21.184833	131.8190492	Fréchet
4	2015-2016	-0.4677488	2.137899659	49.472445	257.9511569	Weibull
5	2017-2019	-0.421747	2.371089777	35.750593	357.786772	Weibull
6	2020	-0.8899874	1.123611413	29.981476	354.08371.4	Weibull

Source: From researcher's data analysis

Table-60 : Tail Index estimation and classification-Minimum stock price

S.No.	Year	Parameters				Domain for Minimum
		ξ	α	σ	μ	
1	2007-2009	-0.6222562	1.6070551	38.753476	-107.083179	Weibull
2	2010	-0.2643228	3.783252901	13.2407	-142.8428384	Weibull
3	2011-2014	-0.7347404	1.361024928	53.850226	-177.1602761	Weibull
4	2015-2016	-0.2068748	4.833841531	43.05969	-288.2159157	Weibull
5	2017-2019	-0.0802993	------------	28.617774	-381.9311938	Gumbel
6	2020	0.4169405	2.398423756	13.317164	-374.2768429	Fréchet

Source: From researcher's data analysis

Stock-2: Asian Paint

Table-61 : Tail Index estimation and classification-Maximum stock price

S.No.	Year	Parameters				Domain for Maximum
		ξ	α	σ	μ	
1	2007-2009	0.0666	--------	190.9313	940.0785	Gumbel
2	2010	-0.5423	1.8439	380.6566	2280.4590	Weibull
3	2011-2014	-0.5525	1.8099	1714.7020	2168.8349	Weibull
4	2015-2016	0.1105	9.0464	82.2235	843.9771	Fréchet
5	2017-2019	-0.0300	-------	169.1877	1204.7622	Gumbel
6	2020	-0.6755	1.4805	57.3684	1811.2215	Weibull

Source: From researcher's data analysis

Table-62 : Tail Index estimation and classification-Minimum stock price

S.No.	Year	Parameters				Domain for Minimum
		ξ	α	σ	μ	
1	2007-2009	-0.5514	1.8135	280.3440	-1159.1034	Weibull
2	2010	-0.4398	2.2736	371.0406	-2450.4087	Weibull
3	2011-2014	-1.0587	0.9446	2769.0245	-3007.5469	Weibull
4	2015-2016	-0.5505	1.8165	127.2447	-927.9633	Weibull
5	2017-2019	-0.4596	2.1759	221.5450	-1366.0445	Weibull
6	2020	-0.0337	-------	47.7721	-1842.2830	Gumbel

Source: From researcher's data analysis

Stock-3: Axis Bank

Table-63 : Tail Index estimation and classification-Maximum stock price

S.No.	Year	Parameters				Domain for Maximum
		ξ	α	σ	μ	
1	2007-2009	-0.3590	2.7856	213.4036	690.5828	Weibull
2	2010	-0.2990	3.3445	151.3232	1229.4936	Weibull
3	2011-2014	-0.3130	3.1953	347.0897	1047.5140	Weibull
4	2015-2016	-0.3955	2.5282	63.0741	493.0177	Weibull
5	2017-2019	0.1904	5.2527	69.6448	545.5278	Fréchet
6	2020	-1.0831	0.9233	52.3056	708.7020	Weibull

Source: From researcher's data analysis

Table-64 : Tail Index estimation and classification-Minimum stock price

S.No.	Year	Parameters				Domain for Minimum
		ξ	α	σ	μ	
1	2007-2009	-0.1792	5.5809	187.2052	-837.5279	Weibull
2	2010	-0.3793	2.6367	157.9687	-1328.9057	Weibull
3	2011-2014	-0.2006	4.9838	315.5746	-1282.1864	Weibull
4	2015-2016	-0.1737	5.7582	54.9858	-535.1672	Weibull
5	2017-2019	-0.6257	1.5982	108.6050	-617.7041	Weibull
6	2020	0.5221	1.9154	18.0671	-736.5282	Fréchet

Source: From researcher's data analysis

Stock-4: Bajaj Auto

Table-65 : Tail Index estimation and classification-Maximum stock price

S.No.	Year	Parameters				Domain for Maximum
		ξ	α	σ	μ	
1	2007-2009	0.4414	2.2653	233.8749	574.2357	Fréchet
2	2010	0.2055	4.8671	294.6793	1731.1205	Fréchet
3	2011-2014	-0.1454	6.8757	288.0887	1681.5135	Weibull
4	2015-2016	-0.2509	3.9857	231.9244	2380.5325	Weibull
5	2017-2019	-0.1386	7.2136	176.8959	2819.4816	Weibull
6	2020	-0.7111	1.4063	247.4540	2940.2574	Weibull

Source: From researcher's data analysis

Table-66 : Tail Index estimation and classification-Minimum stock price

S.No.	Year	Parameters				Domain for Minimum
		ξ	α	σ	μ	
1	2007-2009	-0.8175	1.2233	460.9728	-864.9484	Weibull
2	2010	-0.9562	1.0458	675.1199	-2146.3124	Weibull
3	2011-2014	-0.4667	2.1426	341.3964	-1896.0250	Weibull
4	2015-2016	-0.3366	2.9713	240.7734	-2548.7926	Weibull
5	2017-2019	-0.4059	2.4639	209.8838	-2960.0717	Weibull
6	2020	0.2589	3.8621	118.4076	-3094.5408	Fréchet

Source: From researcher's data analysis

Stock-5: Bajaj FinSV

Table-67 : Tail Index estimation and classification-Maximum stock price

S.No.		Parameters				Domain for Maximum
		ξ	α	σ	μ	
1	2007-2009	-0.078	-------	121.745	245.768	Gumbel
2	2010	-0.523	1.913	73.108	408.996	Weibull
3	2011-2014	-0.030	-------	159.634	621.609	Gumbel
4	2015-2016	0.232	4.319	358.982	1704.195	Fréchet
5	2017-2019	-0.171	5.855	1360.409	5362.630	Weibull
6	2020	-0.823	1.216	650.782	9107.093	Weibull

Source: From researcher's data analysis

Table-68 : Tail Index estimation and classification-Minimum stock price

S.No.	Year	Parameters				Domain for Minimum
		ξ	α	σ	μ	
1	2007-2009	-0.6546	1.5276	161.5801	-332.1828	Weibull
2	2010	-0.1896	5.2741	61.3905	-451.3977	Weibull
3	2011-2014	-0.6090	1.6421	216.2921	-746.7012	Weibull
4	2015-2016	-0.6896	1.4501	716.2322	-2261.9455	Weibull
5	2017-2019	-0.4084	2.4488	1580.7732	-6411.9171	Weibull
6	2020	0.3862	2.5892	264.3942	-9542.4535	Fréchet

Source: From researcher's data analysis

Stock-6: Bharathi ARTL

Table-69 : Tail Index estimation and classification-Maximum stock price

S.No.	Year	Parameters				Domain for Maximum
		ξ	α	σ	μ	
1	2007-2009	-0.41228	2.42554	190.96179	668.09093	Weibull
2	2010	-0.37216	2.68701	29.83840	303.28573	Weibull
3	2011-2014	-0.25903	3.86051	37.79926	322.30665	Weibull
4	2015-2016	-0.07803	-------	30.34354	338.35488	Gumbel
5	2017-2019	0.04561	-------	42.08398	351.14512	Gumbel
6	2020	-0.45578	2.19404	35.04473	495.96447	Weibull

Source: From researcher's data analysis

Table-70 : Tail Index estimation and classification-Minimum stock price

S.No.	Year	Parameters				Domain for Minimum
		ξ	α	σ	μ	
1	2007-2009	0.01534	-------	138.34912	-814.81772	Gumbel
2	2010	-0.27951	3.57769	28.14100	-322.42011	Weibull
3	2011-2014	-0.32192	3.10634	39.48094	-349.29614	Weibull
4	2015-2016	-0.51895	1.92697	38.59498	-362.58767	Weibull
5	2017-2019	-0.65642	1.52341	74.91162	-398.82195	Weibull
6	2020	-0.23125	4.32431	30.98144	-517.39467	Weibull

Source: From researcher's data analysis

Stock-7: BPCL

Table-71: Tail Index estimation and classification-Maximum stock price

S.No.	Year	Parameters				Domain for Maximum
		ξ	α	σ	μ	
1	2007-2009	0.0106		63.9629	351.2439	Gumbel
2	2010	-0.3473	2.8794	89.3458	604.9252	Weibull
3	2011-2014	-0.4675	2.1389	153.8679	472.7537	Weibull
4	2015-2016	-0.3206	3.1195	134.6728	756.5712	Weibull
5	2017-2019	0.0938		88.9921	403.1302	Gumbel
6	2020	-0.6716	1.4890	36.3035	448.5539	Weibull

Source: From researcher's data analysis

Table-72 : Tail Index estimation and classification-Minimum stock price

S.No.	Year	Parameters				Domain for Minimum
		ξ	α	σ	μ	
1	2007-2009	-0.4488	2.2280	88.9419	-412.0424	Weibull
2	2010	-0.6197	1.6136	101.3345	-650.0360	Weibull
3	2011-2014	-0.5613	1.7816	159.7358	-542.1154	Weibull
4	2015-2016	-0.3009	3.3231	129.9849	-846.6982	Weibull
5	2017-2019	-0.5614	1.7812	131.4205	-489.8178	Weibull
6	2020	0.1831	5.4624	20.9517	-470.5936	Fréchet

Source: From researcher's data analysis

Stock-8: Britannia

Table-73 : Tail Index estimation and classification-Maximum stock price

S.No.	Year	Parameters				Domain for Maximum
		ξ	α	σ	μ	
1	2007-2009	-0.3269	3.0586	172.4633	1386.4237	Weibull
2	2010	-0.6356	1.5734	689.2272	1221.7163	Weibull
3	2011-2014	0.4472	2.2362	149.8267	509.6939	Fréchet
4	2015-2016	-0.4936	2.0261	438.8555	2685.5644	Weibull
5	2017-2019	0.3245	3.0816	754.7877	3368.6084	Fréchet
6	2020	-0.6144	1.6276	132.3300	3051.7767	Weibull

Source: From researcher's data analysis

Table-74 : Tail Index estimation and classification-Minimum stock price

S.No.	Year	Parameters				Domain for Minimum
		ξ	α	σ	μ	
1	2007-2009	-0.2963	3.3754	168.4575	-1502.0108	Weibull
2	2010	0.2693	3.7131	404.6266	-1691.4549	Fréchet
3	2011-2014	-0.6723	1.4875	327.3983	-821.6670	Weibull
4	2015-2016	-0.1041	9.6084	352.4226	-2958.5997	Weibull
5	2017-2019	-0.7016	1.4254	1301.6572	-4236.1676	Weibull
6	2020	0.0086		93.0070	-3127.5570	Gumbel

Source: From researcher's data analysis

Stock-9: Cipla

Table-75 : Tail Index estimation and classification-Maximum stock price

S.No.	Year	Parameters				Domain for Maximum
		ξ	α	σ	μ	
1	2007-2009	0.11483	8.70846	27.12372	204.19299	Frechet
2	2010	-0.13682	7.30897	14.60304	324.32708	Weibull
3	2011-2014	0.18873	5.29867	51.20492	343.34274	Frechet
4	2015-2016	-0.41941	2.38431	72.48772	584.71062	Weibull
5	2017-2019	-0.41090	2.43366	55.77420	544.27648	Weibull
6	2020	-0.60871	1.64281	26.64072	443.11569	Weibull

Source: From researcher's data analysis

Table-76 : Tail Index estimation and classification-Minimum stock price

S.No.	Year	Parameters				Domain for Minimum
		ξ	α	σ	μ	
1	2007-2009	0.70529	1.41785	52.56835	-234.49931	Frechet
2	2010	-0.50632	1.97504	17.70544	-335.04443	Weibull
3	2011-2014	-0.67007	1.49238	86.01097	-402.61559	Weibull
4	2015-2016	-0.30489	3.27985	68.25294	-628.26962	Weibull
5	2017-2019	-0.16085	6.21701	48.10044	-580.85282	Weibull
6	2020	-0.10888	9.18457	20.76967	-457.79451	Weibull

Source: From researcher's data analysis

Stock-10: Coal India

Table-77 : Tail Index estimation and classification-Maximum stock price

S.No.	Year	Parameters				Domain for Maximum
		ξ	α	σ	μ	
1	2010	-0.0316		7.3578	316.2024	Gumbel
2	2011-2014	-0.3835	2.6075	39.4295	320.6948	Weibull
3	2015-2016	-0.0292		31.4606	321.4725	Gumbel
4	2017-2019	-0.4070	2.4571	35.6982	248.7241	Weibull
5	2020	-0.4272	2.3409	18.4361	179.4647	Weibull

Source: From researcher's data analysis

Table-78 : Tail Index estimation and classification-Minimum stock price

S.No.	Year	Parameters				Domain for Minimum
		ξ	α	σ	μ	
1	2010	-0.4942	2.0235	9.8835	-322.4707	Weibull
2	2011-2014	-0.2150	4.6518	35.6709	-346.8016	Weibull
3	2015-2016	-0.5657	1.7676	42.2278	-347.1086	Weibull
4	2017-2019	-0.1821	5.4913	31.1627	-271.9497	Weibull
5	2020	-0.2566	3.8977	17.1871	-190.7985	Weibull

Source: From researcher's data analysis

Stock-11: Dr Reddy

Table-79 : Tail Index estimation and classification-Maximum stock price

S.No.	Year	Parameters				Domain for Maximum
		ξ	α=-1/ ξ	σ	μ	
1	2007-2009	-0.0280		133.1382	588.2361	Gumbel
2	2010	-0.0185		167.8813	1306.9175	Gumbel
3	2011-2014	0.5739	1.7423	261.3634	1721.5505	Fréchet
4	2015-2016	0.2544	3.9301	234.7823	3154.9828	Fréchet
5	2017-2019	-0.3602	2.7763	279.2601	2435.9760	Weibull
6	2020	-0.4058	2.4642	146.6931	3021.1927	Weibull

Source: From researcher's data analysis

Table-80 : Tail Index estimation and classification-Minimum stock price

S.No.	Year	Parameters				Domain for Minimum
		ξ	α	σ	μ	
1	2007-2009	-0.5489	1.8219	180.3270	-697.2717	Weibull
2	2010	-0.6384	1.5663	262.2644	-1487.9073	Weibull
3	2011-2014	-0.7095	1.4095	527.0921	-2154.3754	Weibull
4	2015-2016	-0.6725	1.4870	489.0098	-3482.5449	Weibull
5	2017-2019	-0.2244	4.4565	255.0301	-2623.2700	Weibull
6	2020	-0.3251	3.0764	140.0695	-3109.9175	Weibull

Source: From researcher's data analysis

Stock-12: Eichermot

Table-81 : Tail Index estimation and classification-Maximum stock price

S.No.	Year	Parameters				Domain for Maximum
		ξ	α	σ	μ	
1	2007-2009	0.1355	7.3803	74.8156	277.9234	Fréchet
2	2010	-0.4668	2.1424	279.3538	874.0287	Weibull
3	2011-2014	0.7305	1.3689	1104.2846	2018.7141	Fréchet
4	2015-2016	-0.0585		84.6950	116.8964	Gumbel
5	2017-2019	-0.4161	2.4031	4680.5236	23035.0609	Weibull
6	2020	-0.2977	3.3588	1328.5801	18710.7667	Weibull

Source: From researcher's data analysis

Table-82 : Tail Index estimation and classification-Minimum stock price

S.No.	Year	Parameters				Domain for Minimum
		ξ	α	σ	μ	
1	2007-2009	-0.4982	2.0072	109.9769	-367.3427	Weibull
2	2010	-0.5945	1.6821	296.8899	-995.0558	Weibull
3	2011-2014	-0.5540	1.8050	2589.2786	-5370.4247	Weibull
4	2015-2016	-0.5475	1.8265	2918.5050	-19545.7000	Weibull
5	2017-2019	-0.1434	6.9754	3932.6960	-27108.3300	Weibull
6	2020	-0.1701	5.8788	1400.5600	-20015.5000	Weibull

Source: From researcher's data analysis

Stock-13: Gail :

Table-83 : Tail Index estimation and classification-Maximum stock price

S.No.	Year	Parameters				Domain for Maximum
		ξ	α	σ	μ	
1	2007-2009	-0.2431	4.1128	78.5967	304.6956	Weibull
2	2010	-0.4472	2.2359	35.9909	443.7869	Weibull
3	2011-2014	-0.1032	9.6912	46.6169	361.9463	Weibull
4	2015-2016	-0.4597	2.1753	42.3317	362.2067	Weibull
5	2017-2019	-0.5717	1.7492	116.6922	324.3209	Weibull
6	2020	-0.9100	1.0989	12.2906	118.1501	Weibull

Source: From researcher's data analysis

Table-84 : Tail Index estimation and classification-Minimum stock price

S.No.	Year	Parameters				Domain for Minimum
		ξ	α	σ	μ	
1	2007-2009	-0.3642	2.7457	85.8675	-371.4189	Weibull
2	2010	-0.4474	2.2351	35.9783	-462.3281	Weibull
3	2011-2014	-0.4239	2.3593	54.2968	-404.9232	Weibull
4	2015-2016	-0.1569	6.3747	35.8972	-388.7139	Weibull
5	2017-2019	0.0248		81.9003	-396.3113	Gumbel
6	2020	0.4535	2.2051	6.5223	-124.5025	Fréchet

Source: From researcher's data analysis

Stock-14: Grasim

Table-85 : Tail Index estimation and classification-Maximum stock price

S.No.	Year	Parameters				Domain for Maximum
		ξ	α	σ	μ	
1	2007-2009	-0.3141	3.1839	708.1534	2135.6665	Weibull
2	2010	-0.5733	1.7443	406.9115	2260.5143	Weibull
3	2011-2014	-0.0967		354.4496	2587.4517	Gumbel
4	2015-2016	-0.4843	2.0647	1046.5565	3148.5513	Weibull
5	2017-2019	-0.4129	2.4220	170.3862	929.0799	Weibull
6	2020	-0.6935	1.4420	67.0474	726.9189	Weibull

Source: From researcher's data analysis

Table-86 : Tail Index estimation and classification-Minimum stock price

S.No.	Year	Parameters				Domain for Minimum
		ξ	α	σ	μ	
1	2007-2009	-0.2770	3.6095			Weibull
2	2010	-0.4619	2.1648	386.3372	-2431.8598	Weibull
3	2011-2014	-0.2798	3.5744	331.7213	-2947.9458	Weibull
4	2015-2016	-0.0800		706.4117	-3979.5360	Gumbel
5	2017-2019	-0.3636	2.7505	165.3892	-1027.7930	Weibull
6	2020	0.1580	6.3294	40.6952	-766.6404	Fréchet

Source: From researcher's data analysis

Stock-15: HCL Tech

Table-87 : Tail Index estimation and classification-Maximum stock price

S.No.	Year	Parameters				Domain for Maximum
		ξ	α	σ	μ	
1	2007-2009	0.0068		94.0212	222.2053	Gumbel
2	2010	-0.1103	9.0629	26.0407	376.4257	Weibull
3	2011-2014	0.7331	1.3640	189.2702	550.5946	Fréchet
4	2015-2016	0.5047	1.9812	90.7169	813.3258	Fréchet
5	2017-2019	-0.4498	2.2234	128.6023	903.4625	Weibull
6	2020	-0.8197	1.2199	39.5300	573.6854	Weibull

Source: From researcher's data analysis

Table-88 : Tail Index estimation and classification-Minimum stock price

S.No.	Year	Parameters				Domain for Minimum
		ξ	α	σ	μ	
1	2007-2009	-0.6404	1.5616	134.8729	-297.3523	Weibull
2	2010	-0.4596	2.1759	31.7753	-397.1673	Weibull
3	2011-2014	-0.8412	1.1887	370.0792	-802.6060	Weibull
4	2015-2016	-0.8540	1.1709	285.9868	-1043.5082	Weibull
5	2017-2019	-0.0875		99.3603	-1003.4877	Gumbel
6	2020	0.3282	3.0470	18.7811	-596.5656	Fréchet

Source: From researcher's data analysis

Stock-16: HDFC

Table-89 : Tail Index estimation and classification-Maximum stock price

S.No.	Year	Parameters				Domain for Maximum
		ξ	α	σ	μ	
1	2007-2009	-0.3881	2.5764	496.2177	2011.1912	Weibull
2	2010	-0.9744	1.0263	1129.3881	1956.6105	Weibull
3	2011-2014	0.2370	4.2186	87.1274	715.6541	Fréchet
4	2015-2016	-0.3193	3.1320	90.0354	1218.7055	Weibull
5	2017-2019	-0.3198	3.1271	251.8052	1766.3789	Weibull
6	2020	-1.0230	0.9775	223.7730	2273.6739	Weibull

Source: From researcher's data analysis

Table-90 : Tail Index estimation and classification-Minimum stock price

S.No.	Year	Parameters				Domain for Minimum
		ξ	α	σ	μ	
1	2007-2009	-0.2516	3.9740	438.6607	-2349.2711	Weibull
2	2010	0.0838		38.8988	35.0003	Gumbel
3	2011-2014	-0.7024	1.4236	172.4760	-834.3968	Weibull
4	2015-2016	-0.2991	3.3438	89.4850	-1279.6024	Weibull
5	2017-2019	-0.2310	4.3284	238.3886	-1940.2897	Weibull
6	2020	0.5644	1.7718	74.2925	-2416.0942	Fréchet

Source: From researcher's data analysis

Stock-17: HDFC Bank

Table-91 : Tail Index estimation and classification-Maximum stock price

S.No.	Year	Parameters	Domain for Maximum
1	2007-2009	xi sigma mu -0.1868696 245.3323638 1167.2130353	Weibull
2	2010	xi sigma mu -0.4031521 261.2971683 1969.5001526	Weibull
3	2011-2014	xi sigma mu 0.5843595 160.7617704 593.5865967	Fréchet
4	2015-2016	xi sigma mu -3.622662e-03 7.289375e+01 1.061741e+03	Gumbel
5	2017-2019	xi sigma mu -0.4978421 372.5511483 1781.8255239	Weibull
6	2020	xi sigma mu -0.9644091 89.6169764 1196.6257608	Weibull

Source: From researcher's data analysis

Table-92 : Tail Index estimation and classification-Minimum stock price

S.No.	Year	Parameters	Domain for Minimum
1	2007-2009	xi sigma mu -0.4465495 264.9900369 -1345.9497485	Weibull
2	2010	xi sigma mu -0.36736 257.88539 -2122.23340	Weibull
3	2011-2014	xi sigma mu -0.8113799 396.3750498 -894.4057286	Weibull
4	2015-2016	xi sigma mu -0.5231738 98.3268232 -1125.6065970	Weibull
5	2017-2019	xi sigma mu -0.1118205 300.6273559 -2013.5580141	Weibull
6	2020	xi sigma mu 0.3072065 41.0957204 -1245.1830260	Fréchet

Source: From researcher's data analysis

Stock-18: Hero Moto Co

Table-93 : Tail Index estimation and classification-Maximum stock price

S.No.	Year	Parameters	Domain for Maximum
3	2011-2014	xi sigma mu 8.626491e-02 2.598543e+02 1.908020e+03	Gumbel
4	2015-2016	xi sigma mu 2.160821e-02 2.628220e+02 2.669263e+03	Gumbel
5	2017-2019	xi sigma mu -0.5205451 517.5785303 3078.0220853	Weibull
6	2020	xi sigma mu -0.5374569 180.0877004 2188.8049019	Weibull

Source: From researcher's data analysis

Table-94 : Tail Index estimation and classification-Minimum stock price

S.No.	Year	Parameters	Domain for Minimum
3	2011-2014	xi sigma mu -0.531726 401.554004 -2188.630856	Weibull
4	2015-2016	xi sigma mu -0.5854264 365.0590902 -2895.9609058	Weibull
5	2017-2019	xi sigma mu -0.3526144 478.2066244 -3342.7747078	Weibull
6	2020	xi sigma mu 0.5553984 97.1397957 -2400.3574926	Fréchet

Source: From researcher's data analysis

Stock-19: HindalCo

Table-95 : Tail Index estimation and classification-Maximum stock price

S.No.	Year	Parameters	Domain for Maximum
1	2007-2009	xi sigma mu -0.5015288 57.1975939 112.4300040	Weibull
2	2010	xi sigma mu 0.02560984 22.09847969 164.28413565	Gumbel
3	2011-2014	xi sigma mu 0.1641867 23.7594237 120.5057113	Fréchet
4	2015-2016	xi sigma mu -0.3557065 33.1712044 106.1276784	Weibull
5	2017-2019	xi sigma mu -0.125949 22.424974 204.937978	Weibull
6	2020	xi sigma mu -0.7790246 30.8172270 180.9232794	Weibull

Source: From researcher's data analysis

Table-96 : Tail Index estimation and classification-Minimum stock price

S.No.	Year	Parameters	Domain for Minimum
1	2007-2009	xi sigma mu -0.3875948 54.0725393 -141.3412160	Weibull
2	2010	xi sigma mu -0.5910047 30.7978744 -183.3716081	Weibull
3	2011-2014	xi sigma mu -0.6404073 37.9252855 -144.5952914	Weibull
4	2015-2016	xi sigma mu -0.5757248 36.5935707 -123.4184409	Weibull
5	2017-2019	xi sigma mu -0.3900031 26.6680963 -223.3200919	Weibull
6	2020	xi sigma mu 0.3109108 16.7740567 -199.5074983	Fréchet

Source: From researcher's data analysis

Stock-20: Hindunil VR

Table-97 : Tail Index estimation and classification-Maximum stock price

S.No.	Year	Parameters	Domain for Maximum
1	2007-2009	xi sigma mu -0.2953649 24.0132404 230.2536669	Weibull
2	2010	xi sigma mu -0.2056306 24.7654834 253.4922347	Weibull
3	2011-2014	xi sigma mu -0.2621113 134.7592684 448.6022195	Weibull
4	2015-2016	xi sigma mu -0.2994604 45.0310285 847.0272965	Weibull
5	2017-2019	xi sigma mu -0.3899352 347.0081177 1385.8107389	Weibull
6	2020	xi sigma mu -0.4560117 117.7333947 2069.2036428	Weibull

Source: From researcher's data analysis

Table-98 : Tail Index estimation and classification-Minimum stock price

S.No.	Year	Parameters				Domain for Minimum
		ξ	α=-1/ ξ	σ	μ	
1	2007-2009	xi sigma mu -0.3473109 24.5831727 -246.4083466				Weibull
2	2010	xi sigma mu -0.5813582 29.7208412 -269.3963108				Weibull
3	2011-2014	xi sigma mu -0.4797965 149.0810181 -534.3638470				Weibull
4	2015-2016	xi sigma mu -0.3365435 46.0429282 -877.6269681				Weibull
5	2017-2019	xi sigma mu -0.1972801 322.7420391 -1630.4537331				Weibull
6	2020	xi sigma mu -0.3754029 112.8970105 -2133.3770207				Weibull

Source: From researcher's data analysis

Stock-21: ICICI Bank

Table-99 : Tail Index estimation and classification-Maximum stock price

S.No.	Year	Parameters				Domain for Maximum
		ξ	α=-1/ ξ	σ	μ	
1	2007-2009	xi sigma mu -0.3230101 255.9556145 711.2158985				Weibull
2	2010	xi sigma mu 0.1069927 93.4879171 912.7463336				Fréchet
3	2011-2014	xi sigma mu -0.2097991 233.6629487 971.5734482				Weibull
4	2015-2016	xi sigma mu -0.1881431 36.9540446 258.3718014				Weibull
5	2017-2019	xi sigma mu 0.2870099 39.9926349 305.9670730				Fréchet
6	2020	xi sigma mu -0.998223 31.949314 517.311406				Weibull

Source: From researcher's data analysis

Table-100 : Tail Index estimation and classification-Minimum stock price

S.No.	Year	Parameters				Domain for Minimum
		ξ	α=-1/ ξ	σ	μ	
1	2007-2009	xi sigma mu -0.2670645 243.7766754 -884.6547675				Weibull
2	2010	xi sigma mu -0.6473106 138.4759643 -998.5445478				Weibull
3	2011-2014	xi sigma mu -0.265885 253.408738 -1147.361677				Weibull
4	2015-2016	xi sigma mu -0.3704216 41.4574173 -286.3615556				Weibull
5	2017-2019	xi sigma mu -0.6994177 70.2677963 -351.3995165				Weibull
6	2020	xi sigma mu 0.5490263 12.7677791 -535.2336516				Fréchet

Source: From researcher's data analysis

Stock-22: IndusIndBK

Table-101 : Tail Index estimation and classification-Maximum stock price

S.No.	Year	Parameters				Domain for Maximum
		ξ	α=-1/ ξ	σ	μ	
1	2007-2009	xi sigma mu 0.1712496 21.6360727 54.3400230				Fréchet
2	2010	xi sigma mu -0.2217885 42.9757263 193.5672038				Weibull
3	2011-2014	xi sigma mu 0.1316228 92.4278955 328.4745599				Fréchet
4	2015-2016	xi sigma mu 0.1273785 92.1661637 912.5591862				Fréchet
5	2017-2019	xi sigma mu -0.2410999 188.4422450 1516.8526890				Weibull
6	2020	xi sigma mu -0.6945927 265.4029084 1167.0032622				Weibull

Source: From researcher's data analysis

Table-102 : Tail Index estimation and classification-Minimum stock price

S.No.	Year	Parameters				Domain for Minimum
		ξ	α=-1/ ξ	σ	μ	
1	2007-2009	xi sigma mu -0.7200186 34.1772663 -74.7562901				Weibull
2	2010	xi sigma mu -0.593395 51.559149 -220.173899				Weibull
3	2011-2014	xi sigma mu -0.728302 157.685528 -425.894173				Weibull
4	2015-2016	xi sigma mu -0.6768174 139.9581520 -997.4780700				Weibull
5	2017-2019	xi sigma mu -0.3290748 201.5707710 -1655.1113550				Weibull
6	2020	xi sigma mu 4.459516e-02 1.727651e+02 -1.319575e+03				Gumbel

Source: From researcher's data analysis

Stock-23: Infratel

Table-103 : Tail Index estimation and classification-Maximum stock price

S.No.	Year	Parameters				Domain for Maximum
		ξ	α=-1/ ξ	σ	μ	
1	2011-2014	xi sigma mu 0.2829474 33.5614509 177.4457377				Fréchet
2	2015-2016	xi sigma mu 0.01480121 24.68383069 369.44571252				Gumbel
3	2017-2019	xi sigma mu -0.1202732 47.6538402 291.5354251				Weibull
4	2020	xi sigma mu -0.7774402 19.1984935 229.9844569				Weibull

Source: From researcher's data analysis

Table-104 : Tail Index estimation and classification-Minimum stock price

S.No.	Year	Parameters				Domain for Minimum
		ξ	α=-1/ ξ	σ	μ	
1	2011-2014	xi sigma mu -0.6953942 59.6078454 -216.1583506				Weibull
2	2015-2016	xi sigma mu -0.4685537 36.0178443 -397.8300845				Weibull
3	2017-2019	xi sigma mu -0.3730201 56.5988060 -331.4461798				Weibull
4	2020	xi sigma mu 0.267786 10.646427 -241.274737				Fréchet

Source: From researcher's data analysis

Stock-24: Infy

Table-105 : Tail Index estimation and classification-Maximum stock price

S.No.	Year	Parameters				Domain for Maximum
		ξ	α=-1/ ξ	σ	μ	
1	2007-2009	xi sigma mu -0.4366311 1034.9049535 4123.3415052				Weibull
2	2010	xi sigma mu -0.1104543 361.0996367 5282.5988428				Weibull
3	2011-2014	xi sigma mu -0.0543729 425.2064862 2645.8142189				Weibull
4	2015-2016	xi sigma mu 0.596329 148.896450 1085.291955				Fréchet
5	2017-2019	xi sigma mu 0.0931269 152.0597608 815.5173218				Gumbel
6	2020	xi sigma mu -1.02785 51.70549 750.18438				Weibull

Source: From researcher's data analysis

Table-106 : Tail Index estimation and classification-Minimum stock price

S.No.	Year	Parameters				Domain for Minimum
		ξ	α=-1/ ξ	σ	μ	
1	2007-2009	xi sigma mu -0.1831875 884.7030041 -4780.9906585				Weibull
2	2010	xi sigma mu -0.516714 449.821697 -5559.020301				Weibull
3	2011-2014	xi sigma mu -0.4871286 548.2917793 -3005.2526173				Weibull
4	2015-2016	xi sigma mu -0.8102249 495.9065823 -1522.7636674				Weibull
5	2017-2019	xi sigma mu -0.675823 224.188413 -949.523513				Weibull
6	2020	xi sigma mu 0.4659412 21.7028188 -777.1269313				Fréchet

Source: From researcher's data analysis

Stock-25: IOC

Table-107 : Tail Index estimation and classification-Maximum stock price

S.No.	Year	Parameters				Domain for Maximum
		ξ	α=-1/ ξ	σ	μ	
1	2007-2009	xi sigma mu -0.04035887 76.16870802 417.46709100				Gumbel
2	2010	xi sigma mu -0.3177675 46.6461340 339.8673112				Weibull
3	2011-2014	xi sigma mu -0.3040273 46.9782454 269.1738743				Weibull
4	2015-2016	xi sigma mu 0.0437423 55.5558681 369.9473934				Gumbel
5	2017-2019	xi sigma mu 0.977521 45.052215 157.061145				Weibull
6	2020	xi sigma mu -0.7953899 12.2656469 111.9325578				Fréchet

Source: From researcher's data analysis

Table-108 : Tail Index estimation and classification-Minimum stock price

S.No.	Year	Parameters				Domain for Minimum
		ξ	α=-1/ ξ	σ	μ	
1	2007-2009	xi sigma mu -0.5000793 101.2943915 -481.4285686				Weibull
2	2010	xi sigma mu -0.538165 51.840962 -366.481607				Weibull
3	2011-2014	xi sigma mu -0.3445848 47.7251778 -300.4855442				Weibull
4	2015-2016	xi sigma mu -0.5790216 80.5823706 -423.3358641				Weibull
5	2017-2019	xi sigma mu -0.9342023 148.9231508 -276.6384358				Weibull
6	2020	xi sigma mu 0.02740226 8.09013856 -117.83409240				Gumbel

Source: From researcher's data analysis

Stock-26: ITC

Table-109 : Tail Index estimation and classification-Maximum stock price

S.No.	Year	Parameters				Domain for Maximum
		ξ	α=-1/ ξ	σ	μ	
1	2007-2009	xi sigma mu 0.02589755 22.15151398 177.80068557				Gumbel
2	2010	xi sigma mu -0.5950367 58.7402157 217.1568855				Weibull
3	2011-2014	xi sigma mu -0.4984481 70.0417624 260.2349474				Weibull
4	2015-2016	xi sigma mu -0.426819 45.059231 297.797252				Weibull
5	2017-2019	xi sigma mu -0.1492043 17.7656092 267.4011931				Weibull
6	2020	xi sigma mu -0.9892282 30.1895916 212.7544820				Weibull

Source: From researcher's data analysis

Table-110 : Tail Index estimation and classification-Minimum stock price

S.No.	Year	Parameters				Domain for Minimum
		ξ	α=-1/ ξ	σ	μ	
1	2007-2009	xi sigma mu -0.5780766 33.2388276 -197.9883534				Weibull
2	2010	xi sigma mu -0.811728 64.523481 -232.247540				Weibull
3	2011-2014	xi sigma mu -0.2449561 61.5042322 -300.6788983				Weibull
4	2015-2016	xi sigma mu -0.07196241 35.65504795 -328.45574823				Gumbel
5	2017-2019	xi sigma mu -0.4158566 20.6536727 -280.8822465				Weibull
6	2020	xi sigma mu 0.5710577 14.5285170 -229.9747279				Fréchet

Source: From researcher's data analysis

Stock-27: JswSteel

Table-111 :Tail Index estimation and classification-Maximum stock price

<table>
<tr><th rowspan="2">S.No.</th><th rowspan="2">Year</th><th colspan="4">Parameters</th><th rowspan="2">Domain for Maximum</th></tr>
<tr><th>ξ</th><th>α=-1/ ξ</th><th>σ</th><th>μ</th></tr>
<tr><td>1</td><td>2007-2009</td><td colspan="4">xi sigma mu
-0.2937012 285.6438899 570.5372293</td><td>Weibull</td></tr>
<tr><td>2</td><td>2010</td><td colspan="4">xi sigma mu
-0.2580408 96.3850304 1129.3748213</td><td>Weibull</td></tr>
<tr><td>3</td><td>2011-2014</td><td colspan="4">xi sigma mu
3.360995e-03 1.663338e+02 7.445017e+02</td><td>Gumbel</td></tr>
<tr><td>4</td><td>2015-2016</td><td colspan="4">xi sigma mu
0.6129225 158.2232426 981.8444714</td><td>Fréchet</td></tr>
<tr><td>5</td><td>2017-2019</td><td colspan="4">xi sigma mu
0.06053713 48.06320390 242.10485205</td><td>Gumbel</td></tr>
<tr><td>6</td><td>2020</td><td colspan="4">xi sigma mu
-0.7577826 29.2939898 255.5955363</td><td>Weibull</td></tr>
</table>

Source: From researcher's data analysis

Table-112 : Tail Index estimation and classification-Minimum stock price

<table>
<tr><th rowspan="2">S.No.</th><th rowspan="2">Year</th><th colspan="4">Parameters</th><th rowspan="2">Domain for Minimum</th></tr>
<tr><th>ξ</th><th>α=-1/ ξ</th><th>σ</th><th>μ</th></tr>
<tr><td>1</td><td>2007-2009</td><td colspan="4">xi sigma mu
-0.3851725 296.5112157 -757.3706040</td><td>Weibull</td></tr>
<tr><td>2</td><td>2010</td><td colspan="4">xi sigma mu
-0.3735986 102.8130389 -1196.2208544</td><td>Weibull</td></tr>
<tr><td>3</td><td>2011-2014</td><td colspan="4">xi sigma mu
-0.5141997 241.4499776 -934.5665283</td><td>Weibull</td></tr>
<tr><td>4</td><td>2015-2016</td><td colspan="4">xi sigma mu
-0.8760665 351.1243057 -1210.3651943</td><td>Weibull</td></tr>
<tr><td>6</td><td>2020</td><td colspan="4">xi sigma mu
0.1937217 16.8351090 -272.1518135</td><td>Fréchet</td></tr>
</table>

Source: From researcher's data analysis

Stock-28: Kotak Bank

Table-113 : Tail Index estimation and classification-Maximum stock price

<table>
<tr><th rowspan="2">S.No.</th><th rowspan="2">Year</th><th colspan="4">Parameters</th><th rowspan="2">Domain for Maximum</th></tr>
<tr><th>ξ</th><th>α=-1/ ξ</th><th>σ</th><th>μ</th></tr>
<tr><td>1</td><td>2007-2009</td><td colspan="4">xi sigma mu
-0.07830656 204.47872153 538.70995262</td><td>Gumbel</td></tr>
<tr><td>2</td><td>2010</td><td colspan="4">xi sigma mu
-0.7338255 154.7327887 665.1184900</td><td>Weibull</td></tr>
<tr><td>3</td><td>2011-2014</td><td colspan="4">xi sigma mu
0.08791689 142.04295327 562.98839185</td><td>Gumbel</td></tr>
<tr><td>4</td><td>2015-2016</td><td colspan="4">xi sigma mu
0.6770115 99.2240793 711.4112393</td><td>Fréchet</td></tr>
<tr><td>5</td><td>2017-2019</td><td colspan="4">xi sigma mu
-0.2123073 223.7939812 1091.9942638</td><td>Weibull</td></tr>
<tr><td>6</td><td>2020</td><td colspan="4">xi sigma mu
-0.9683786 120.0679245 1591.0259407</td><td>Weibull</td></tr>
</table>

Source: From researcher's data analysis

Stock-29: L&T

Table-114 : Tail Index estimation and classification-Minimum stock price

S.No.	Year	Parameters				Domain for Minimum
		ξ	α=-1/ ξ	σ	μ	
1	2007-2009	xi sigma mu -0.4447218 243.4191090 -723.0760909				Weibull
2	2010	xi sigma mu 0.3222351 84.9754289 -764.7178259				Fréchet
3	2011-2014	xi sigma mu -0.5257368 207.2995586 -730.2502676				Weibull
4	2015-2016	xi sigma mu -0.9394243 267.3912948 -885.1934192				Weibull
5	2017-2019	xi sigma mu -0.38959 252.29249 -1267.15709				Weibull
6	2020	xi sigma mu 0.4182747 32.7977169 -1673.1378715				Fréchet

Source: From researcher's data analysis

Table-115 : Tail Index estimation and classification-Maximum stock price

S.No.	Year	Parameters				Domain for Maximum
		ξ	α=-1/ ξ	σ	μ	
1	2007-2009	xi sigma mu -0.04102701 836.45548998 1603.11287426				Gumbel
2	2010	xi sigma mu -0.353723 202.793286 1714.300305				Weibull
3	2011-2014	xi sigma mu -0.4556464 313.5148476 1298.8078990				Weibull
4	2015-2016	xi sigma mu -0.3935438 208.9711912 1425.3118003				Weibull
5	2017-2019	xi sigma mu -0.01791794 120.44654577 1307.86202945				Gumbel
6	2020	xi sigma mu -0.8868243 123.5852520 1230.9561689				Weibull

Source: From researcher's data analysis

Table-116 : Tail Index estimation and classification-Minimum stock price

S.No.	Year	Parameters				Domain for Minimum
		ξ	α=-1/ ξ	σ	μ	
1	2007-2009	xi sigma mu -0.6849284 1155.8701111 -2213.3250587				Weibull
2	2010	xi sigma mu -0.4113353 208.6934872 -1836.4810809				Weibull
3	2011-2014	xi sigma mu -1.890228e-02 2.109653e+02 -1.513390e+03				Gumbel
4	2015-2016	xi sigma mu -0.2953737 198.5765770 -1555.1227299				Weibull
5	2017-2019	xi sigma mu -0.5498893 164.6872186 -1408.4998430				Weibull
6	2020	xi sigma mu 0.350772 52.546764 -1309.765330				Fréchet

Source: From researcher's data analysis

Stock-30: M&M

Table-117 : Tail Index estimation and classification-Maximum stock price

S.No.	Year	Parameters				Domain for Maximum
		ξ	α=-1/ ξ	σ	μ	
1	2007-2009	xi sigma mu -0.3961314 208.6341430 609.1263554				Weibull
2	2010	xi sigma mu 0.2706583 121.9966425 638.9455503				Fréchet
3	2011-2014	xi sigma mu 0.2471599 126.2255959 774.8978670				Fréchet
4	2015-2016	xi sigma mu -0.05944181 74.59622517 1241.92275747				Gumbel
5	2017-2019	xi sigma mu 0.2127469 217.9956094 749.1464299				Fréchet
6	2020	xi sigma mu -0.861558 58.877015 516.294238				Weibull

Source: From researcher's data analysis

Table-118 : Tail Index estimation and classification-Minimum stock price

S.No.	Year	Parameters				Domain for Minimum
		ξ	α=-1/ ξ	σ	μ	
1	2007-2009	xi sigma mu -0.1861614 183.1306582 -745.9331899				Weibull
2	2010	xi sigma mu -0.8468606 217.6159904 -759.3106098				Weibull
3	2011-2014	xi sigma mu -0.6533286 209.0821021 -914.7473827				Weibull
4	2015-2016	xi sigma mu -0.5098718 105.2193619 -1312.3199339				Weibull
5	2017-2019	xi sigma mu -0.8073121 360.0307966 -950.1877199				Weibull
6	2020	xi sigma mu 0.3310075 30.9592524 -549.9329884				Fréchet

Source: From researcher's data analysis

Stock-31: Maruthi

Table-119 : Tail Index estimation and classification-Maximum stock price

S.No.	Year	Parameters				Domain for Maximum
		ξ	α=-1/ ξ	σ	μ	
1	2007-2009	xi sigma mu 0.1189136 200.6383046 762.9829341				Fréchet
2	2010	xi sigma mu -0.3905532 93.6475864 1349.2119921				Weibull
3	2011-2014	xi sigma mu 0.3553578 288.0800445 1294.3655694				Fréchet
4	2015-2016	xi sigma mu 0.1335078 461.5044192 3944.3600390				Fréchet
5	2017-2019	xi sigma mu -0.2130236 1049.9749832 7051.4808737				Weibull
6	2020	xi sigma mu -0.730326 590.346608 6723.968349				Weibull

Source: From researcher's data analysis

Table-120 : Tail Index estimation and classification-Minimum stock price

S.No.	Year	Parameters				Domain for Minimum
		ξ	α=-1/ ξ	σ	μ	
1	2007-2009	xi sigma mu -0.6058499 350.4305040 -1036.0292926				Weibull
2	2010	xi sigma mu -0.2144546 84.0259303 -1410.3679724				Weibull
3	2011-2014	xi sigma mu -0.6577007 579.0635056 -1792.8569612				Weibull
4	2015-2016	xi sigma mu -0.5871017 688.8630880 -4403.8478644				Weibull
5	2017-2019	xi sigma mu -0.4739236 1190.3220610 -7813.5253546				Weibull
6	2020	xi sigma mu 0.1643099 359.0689868 -7071.5874699				Fréchet

Source: From researcher's data analysis

Stock-32: NestleIND

Table-121: Tail Index estimation and classification-Maximum stock price

S.No.	Year	Parameters				Domain for Minimum
		ξ	α=-1/ ξ	σ	μ	
1	2007-2009	xi sigma mu -0.714853 427.169861 -3081.852778				Weibull
2	2010	xi sigma mu -0.4128126 769.9517088 -4972.1681771				Weibull
3	2011-2014	xi sigma mu -0.2132161 513.9577687 -6507.3851984				Weibull
4	2015-2016	xi sigma mu -0.7133911 2845.3188015 -9783.1522121				Weibull
5	2017-2019	xi sigma mu 1.251065e-01 5.708618e+02 -1.604003e+04				Fréchet
6	2020	xi sigma mu 0.1643099 359.0689868 -7071.5874699				Fréchet

Source: From researcher's data analysis

Stock-33: NTPC

Table-123 : Tail Index estimation and classification-Maximum stock price

S.No.	Year	Parameters				Domain for Maximum
		ξ	α=-1/ ξ	σ	μ	
1	2007-2009	xi sigma mu -0.1233625 26.8272669 173.4948277				Weibull
2	2010	xi sigma mu -0.1433455 9.1658795 198.6577319				Weibull
3	2011-2014	xi sigma mu -0.3247251 18.3916270 149.9333498				Weibull
4	2015-2016	xi sigma mu -0.3747628 12.6124101 138.3266488				Weibull
5	2017-2019	xi sigma mu -0.5610665 20.9529147 149.1881249				Weibull
6	2020	xi sigma mu -0.6763304 9.3947804 110.2915014				Weibull

Source: From researcher's data analysis

Stock-34: ONGC

Table-125 : Tail Index estimation and classification-Maximum stock price

S.No.	Year	Parameters				Domain for Maximum
		ξ	α=-1/ ξ	σ	μ	
1	2007-2009	xi sigma mu -0.3417753 173.3655727 908.8194253				Weibull
2	2010	xi sigma mu -0.4027902 122.7611694 1182.4490838				Weibull
3	2011-2014	xi sigma mu 0.5224299 26.7352166 277.7533493				Fréchet
4	2015-2016	xi sigma mu 0.1059258 34.3407335 235.9827184				Fréchet
5	2017-2019	xi sigma mu -0.4057405 21.7670614 159.3217435				Weibull
6	2020	xi sigma mu -0.8858495 21.7940165 103.9406507				Weibull

Source: From researcher's data analysis

Table-126 : Tail Index estimation and classification-Minimum stock price

S.No.	Year	Parameters				Domain for Minimum
		ξ	α=-1/ ξ	σ	μ	
1	2007-2009	xi sigma mu -0.3255437 171.6951044 -1021.1923227				Weibull
2	2010	xi sigma mu -0.3728778 119.8557046 -1253.8285844				Weibull
3	2011-2014	xi sigma mu -1.040053 153.655700 -391.186974				Weibull
4	2015-2016	xi sigma mu -0.6355402 50.4127295 -267.6601139				Weibull
5	2017-2019	xi sigma mu -0.2199333 19.5992177 -173.3560863				Weibull
6	2020	xi sigma mu 0.1687951 13.0769559 -114.7811791				Fréchet

Source: From researcher's data analysis

Stock-35: PowerGrid

Table-127 : Tail Index estimation and classification-Maximum stock price

S.No.	Year	Parameters				Domain for Maximum
		ξ	α=-1/ ξ	σ	μ	
1	2007-2009	xi sigma mu -0.06585517 16.51142516 94.90486875				Gumbel
2	2010	xi sigma mu -0.2075088 4.6779994 103.1120397				Weibull
3	2011-2014	xi sigma mu 0.2656298 7.9844036 103.2017107				Fréchet
4	2015-2016	xi sigma mu 0.1752499 11.8708499 141.2843313				Fréchet
5	2017-2019	xi sigma mu -0.2398448 9.7125611 194.7307826				Weibull
6	2020	xi sigma mu -0.5943826 11.2907302 186.1257730				Weibull

Source: From researcher's data analysis

Table-128 : Tail Index estimation and classification-Minimum stock price

S.No.	Year	Parameters				Domain for Minimum
		ξ	α=-1/ ξ	σ	μ	
1	2007-2009	xi sigma mu -0.4050505 21.1252105 -109.3167174				Weibull
2	2010	xi sigma mu -0.3679934 5.1208661 -106.5440892				Weibull
3	2011-2014	xi sigma mu -0.6541295 13.7597675 -112.3553831				Weibull
4	2015-2016	xi sigma mu -0.5960175 18.9502293 -153.9351081				Weibull
5	2017-2019	xi sigma mu -0.3510143 10.3251415 -201.6891073				Weibull
6	2020	xi sigma mu 0.08922681 6.90616063 -192.87858255				Gumbel

Source: From researcher's data analysis

Stock-36: Reliance

Table-129 : Tail Index estimation and classification-Maximum stock price

S.No.	Year	Parameters				Domain for Maximum
		ξ	α=-1/ ξ	σ	μ	
1	2007-2009	xi sigma mu -0.265903 501.048322 1736.395095				Weibull
2	2010	xi sigma mu -0.3679699 45.1394555 1023.5657587				Weibull
3	2011-2014	xi sigma mu -0.1444895 85.4751958 826.1257785				Weibull
4	2015-2016	xi sigma mu -0.3973527 72.9365578 943.7831746				Weibull
5	2017-2019	xi sigma mu -0.2595239 204.9793511 1108.7794184				Weibull
6	2020	xi sigma mu -0.8350581 152.6574660 1399.0686041				Weibull

Source: From researcher's data analysis

Table-130 : Tail Index estimation and classification-Minimum stock price

S.No.	Year	Parameters				Domain for Minimum
		ξ	α=-1/ ξ	σ	μ	
1	2007-2009	xi sigma mu -0.4616945 548.7133750 -2058.0965141				Weibull
2	2010	xi sigma mu -0.2310384 41.8859158 -1053.6130817				Weibull
3	2011-2014	xi sigma mu -0.1444895 85.4751958 826.1257785				Weibull
4	2015-2016	xi sigma mu -0.3973527 72.9365578 943.7831746				Weibull
5	2017-2019	xi sigma mu -0.2595239 204.9793511 1108.7794184				Weibull
6	2020	xi sigma mu -0.8350581 152.6574660 1399.0686041				Weibull

Source: From researcher's data analysis

Stock-37: SBIN

Table-131 : Tail Index estimation and classification-Maximum stock price

S.No.	Year	Parameters				Domain for Maximum
		ξ	α=-1/ ξ	σ	μ	
1	2007-2009	xi sigma mu -0.0600003 358.5743219 1397.7535695				Gumbel
2	2010	xi sigma mu 9.629893e-03 3.503036e+02 2.315166e+03				Gumbel
3	2011-2014	xi sigma mu -0.4957346 534.4532411 1881.8961244				Weibull
4	2015-2016	xi sigma mu -0.3650722 40.4140841 230.7209762				Weibull
5	2017-2019	xi sigma mu -0.09351696 24.80163846 277.57038846				Fréchet
6	2020	xi sigma mu -0.8518904 30.8114750 303.2788651				Weibull

Source: From researcher's data analysis

Table-132 : Tail Index estimation and classification-Minimum stock price

S.No.	Year	Parameters				Domain for Minimum
		ξ	α=-1/ ξ	σ	μ	
1	2007-2009	xi sigma mu -0.5704734 522.2231184 -1787.9323197				Weibull
2	2010	xi sigma mu -0.7140053 499.4062640 -2583.5083327				Weibull
3	2011-2014	xi sigma mu -6.406734e-03 3.606435e+02 -2.293181e+03				Gumbel
4	2015-2016	xi sigma mu -0.1882572 35.8418925 -258.1154554				Weibull
5	2017-2019	xi sigma mu -0.4709614 30.7932151 -297.4520390				Weibull
6	2020	xi sigma mu 0.3811402 13.7102311 -321.2099002				Fréchet

Source: From researcher's data analysis

Stock-38: Sun Pharma

Table-133 : Tail Index estimation and classification-Maximum stock price

S.No.	Year	Parameters				Domain for Maximum
		ξ	α=-1/ ξ	σ	μ	
1	2007-2009	xi sigma mu -0.04383202 142.75568753 1104.23504022				Gumbel
2	2010	xi sigma mu -0.5081098 475.9039695 1439.3277204				Weibull
3	2011-2014	xi sigma mu 0.09190445 114.49117868 563.61032456				Gumbel
4	2015-2016	xi sigma mu -0.1492387 88.2051930 794.1823592				Weibull
5	2017-2019	xi sigma mu -0.1328509 75.7616375 481.6959738				Weibull
6	2020	xi sigma mu -0.8348774 32.0401572 416.4486815				Weibull

Source: From researcher's data analysis

Table-134: Tail Index estimation and classification-Minimum stock price

S.No.	Year	Parameters				Domain for Minimum
		ξ	α=-1/ ξ	σ	μ	
1	2007-2009	xi sigma mu -0.5777769 188.4235194 -1218.2855955				Weibull
2	2010	xi sigma mu 3.958955e-02 3.177326e+02 -1.823897e+03				Gumbel
3	2011-2014	xi sigma mu -0.6223775 170.2186296 -669.6988687				Weibull
4	2015-2016	xi sigma mu -0.363972 101.638164 -863.079796				Weibull
5	2017-2019	xi sigma mu -0.5412033 93.0560890 -536.8369137				Weibull
6	2020	xi sigma mu 0.255474 18.941785 -434.417661				Fréchet

Source: From researcher's data analysis

Stock-39: Tata Motors

Table-135 : Tail Index estimation and classification-Maximum stock price

S.No.	Year	Parameters				Domain for Maximum
		ξ	α=-1/ ξ	σ	μ	
1	2007-2009	xi sigma mu -0.4876763 244.7419019 482.2239697				Weibull
2	2010	xi sigma mu 0.373614 122.621366 808.167558				Fréchet
3	2011-2014	xi sigma mu 0.4540639 126.9085774 299.0540071				Fréchet
4	2015-2016	xi sigma mu -0.3956556 84.4674590 421.6568474				Weibull
5	2017-2019	xi sigma mu -0.3406356 125.7023598 257.2234805				Weibull
6	2020	xi sigma mu -0.9115259 38.2720565 158.4572004				Weibull

Source: From researcher's data analysis

Table-136 : Tail Index estimation and classification-Minimum stock price

S.No.	Year	Parameters				Domain for Minimum
		ξ	α=-1/ ξ	σ	μ	
1	2007-2009	xi sigma mu -0.06028525 191.13684875 -643.57043052				Gumbel
2	2010	xi sigma mu -0.8115581 227.9523824 -947.6108919				Weibull
3	2011-2014	xi sigma mu -0.682244 323.659546 -613.219845				Weibull
4	2015-2016	xi sigma mu -0.3894023 84.4489952 -470.7814966				Weibull
5	2017-2019	xi sigma mu -0.6935232 146.2378754 -317.1084863				Weibull
6	2020	xi sigma mu 0.4406527 18.4858439 -180.9966653				Fréchet

Source: From researcher's data analysis

Stock-40: Tata Steel

Table-137 : Tail Index estimation and classification-Maximum stock price

S.No.	Year	Parameters				Domain for Maximum
		ξ	α=-1/ ξ	σ	μ	
1	2007-2009	xi sigma mu -0.4126935 226.1127542 479.7260767				Weibull
2	2010	xi sigma mu -0.5269916 68.3062522 570.4086984				Weibull
3	2011-2014	xi sigma mu -0.2009087 93.8156671 394.1799235				Weibull
4	2015-2016	xi sigma mu -0.4651045 66.0465427 303.1131322				Weibull
5	2017-2019	xi sigma mu -0.2307244 96.8924297 499.7603354				Weibull
6	2020	xi sigma mu -0.714213 64.034957 412.464419				Weibull

Source: From researcher's data analysis

Table-138 : Tail Index estimation and classification-Minimum stock price

S.No.	Year	Parameters				Domain for Minimum
		ξ	α=-1/ ξ	σ	μ	
1	2007-2009	xi sigma mu -0.295189 212.424799 -617.123596				Weibull
2	2010	xi sigma mu -0.1419323 55.8953744 -611.2595130				Weibull
3	2011-2014	xi sigma mu -0.3640362 104.4048094 -464.4311138				Weibull
4	2015-2016	xi sigma mu -0.3524908 62.2066565 -339.2213412				Weibull
5	2017-2019	xi sigma mu -0.3703254 105.0172123 -568.9838539				Weibull
6	2020	xi sigma mu 0.3582556 34.3458253 -464.2013640				Fréchet

Source: From researcher's data analysis

Stock-41: TCS

Table-139 : Tail Index estimation and classification-Maximum stock price

S.No.	Year	Parameters				Domain for Maximum
		ξ	α=-1/ ξ	σ	μ	
1	2007-2009	xi sigma mu -0.3554998 273.4039280 751.7980824				Weibull
2	2010	xi sigma mu 0.3888266 70.4551378 790.3456462				Fréchet
3	2011-2014	xi sigma mu 0.4800385 279.0987206 1281.2864521				Fréchet
4	2015-2016	xi sigma mu -0.3981819 137.6619751 2439.5317952				Weibull
5	2017-2019	xi sigma mu 0.1200929 272.6926815 2142.9150554				Fréchet
6	2020	xi sigma mu -0.8615818 131.6758936 2102.9871057				Weibull

Source: From researcher's data analysis

Table-140 : Tail Index estimation and classification-Minimum stock price

S.No.	Year	Parameters				Domain for Minimum
		ξ	α=-1/ ξ	σ	μ	
1	2007-2009	xi sigma mu -0.517402 295.182090 -902.341148				Weibull
2	2010	xi sigma mu -0.7957886 148.9035213 -886.1175848				Weibull
3	2011-2014	xi sigma mu -0.6234046 503.5593299 -1724.0101524				Weibull
4	2015-2016	xi sigma mu -0.1175267 114.5813164 -2533.1962528				Weibull
5	2017-2019	xi sigma mu -0.5893836 419.6923326 -2428.3793831				Weibull
6	2020	xi sigma mu 0.3695446 58.3209499 -2177.9996568				Fréchet

Source: From researcher's data analysis

Stock-42: Titan

Table-141 : Tail Index estimation and classification-Maximum stock price

S.No.	Year	Parameters				Domain for Maximum
		ξ	α=-1/ ξ	σ	μ	
1	2007-2009	xi sigma mu -0.1840481 209.5906381 1041.5133732				Weibull
2	2010	xi sigma mu -0.2308554 689.0894329 2307.9289690				Weibull
3	2011-2014	xi sigma mu 0.779799 74.381350 241.006457				Fréchet
4	2015-2016	xi sigma mu -0.2208785 29.8136865 355.1862019				Weibull
5	2017-2019	xi sigma mu -0.3953728 281.3934494 741.5656095				Weibull
6	2020	xi sigma mu -0.5908878 86.7284879 1189.0073981				Weibull

Source: From researcher's data analysis

Table-142 : Tail Index estimation and classification-Minimum stock price

S.No.	Year	Parameters				Domain for Minimum
		ξ	α=-1/ ξ	σ	μ	
1	2007-2009	xi sigma mu -0.4553756 241.3118520 -1191.7563806				Weibull
2	2010	xi sigma mu -0.6153283 828.4792507 -2722.0433205				Weibull
3	2011-2014	xi sigma mu -0.9783071 1018.1298721 -1196.8959059				Weibull
4	2015-2016	xi sigma mu -0.4263794 33.3894507 -376.2021457				Weibull
5	2017-2019	xi sigma mu -0.2513074 248.8426715 -954.2389293				Weibull
6	2020	xi sigma mu -1.861389e-03 6.200649e+01 -1.240039e+03				Gumbel

Source: From researcher's data analysis

Stock-43: Ultra Cemco

Table-143 : Tail Index estimation and classification-Maximum stock price

S.No.	Year	Parameters				Domain for Maximum
		ξ	α=-1/ ξ	σ	μ	
1	2007-2009	xi sigma mu -0.381823 211.050582 662.249532				Weibull
2	2010	xi sigma mu -0.608515 104.857245 994.440768				Weibull
3	2011-2014	xi sigma mu -0.2219761 477.6287766 1515.9013762				Weibull
4	2015-2016	xi sigma mu 0.213447 252.497073 2945.335427				Fréchet
5	2017-2019	xi sigma mu -0.3054916 292.9080174 3968.9245192				Weibull
6	2020	xi sigma mu -0.693272 290.820017 4263.368095				Weibull

Source: From researcher's data analysis

Table-144 : Tail Index estimation and classification-Minimum stock price

S.No.	Year	Parameters				Domain for Minimum
		ξ	α=-1/ ξ	σ	μ	
1	2007-2009	xi sigma mu -0.1725231 189.9036836 -823.8864271				Weibull
2	2010	xi sigma mu -0.2184596 87.2541115 -1048.2280726				Weibull
3	2011-2014	xi sigma mu -0.6309914 579.2613611 -1798.2570070				Weibull
4	2015-2016	xi sigma mu -0.6058179 410.5238863 -3277.1479169				Weibull
5	2017-2019	xi sigma mu -0.2281582 278.4179204 -4173.3555157				Weibull
6	2020	xi sigma mu 0.1937264 158.6216857 -4436.9530808				Fréchet

Source: From researcher's data analysis

Stock-44: UPL

Table-145 : Tail Index estimation and classification-Maximum stock price

S.No.	Year	Parameters				Domain for Maximum
		ξ	α=-1/ ξ	σ	μ	
3	2011-2014	xi sigma mu -0.5760633 79.2025007 250.6087663				Weibull
4	2015-2016	xi sigma mu -0.203967 88.826094 478.780433				Weibull
5	2017-2019	xi sigma mu -0.2034375 108.1035405 696.3087337				Weibull
6	2020	xi sigma mu -0.8679316 63.8686285 531.0140850				Weibull

Source: From researcher's data analysis

Table-146 : Tail Index estimation and classification-Minimum stock price

S.No.	Year	Parameters				Domain for Minimum
		ξ	α=-1/ ξ	σ	μ	
3	2011-2014	xi sigma mu -0.680573 85.848496 -276.935797				Weibull
4	2015-2016	xi sigma mu -0.4346092 101.0109314 -542.6811051				Weibull
5	2017-2019	xi sigma mu -0.2281582 278.4179204 -4173.3555157				Weibull
6	2020	xi sigma mu 0.1937264 158.6216857 -4436.9530808				Fréchet

Source: From researcher's data analysis

Stock-45: VEDL

Table-147 : Tail Index estimation and classification-Maximum stock price

S.No.	Year	Parameters				Domain for Maximum
		ξ	α=-1/ ξ	σ	μ	
4	2015-2016	xi sigma mu 0.1518909 36.8316439 108.4283202				Fréchet
5	2017-2019	xi sigma mu -0.2794255 58.8338326 209.4599830				Weibull
6	2020	xi sigma mu -0.8438032 26.4406187 133.8580177				Weibull

Source: From researcher's data analysis

Table-148 : Tail Index estimation and classification-Minimum stock price

S.No.	Year	Parameters				Domain for Minimum
		ξ	α=-1/ ξ	σ	μ	
4	2015-2016	xi sigma mu -0.6888771 56.4610879 -142.9231128				Weibull
5	2017-2019	xi sigma mu -0.5814771 67.9105871 -243.3403525				Weibull
6	2020	xi sigma mu 0.2830008 14.3304352 -148.5207733				Fréchet

Source: From researcher's data analysis

Stock-46: Wipro

Table-149 : Tail Index estimation and classification-Maximum stock price

S.No.	Year	Parameters				Domain for Maximum
		ξ	α=-1/ ξ	σ	μ	
1	2007-2009	xi sigma mu -0.4426297 129.6104670 417.6629304				Weibull
2	2010	xi sigma mu 0.7110555 67.7039500 446.2340015				Fréchet
3	2011-2014	xi sigma mu -0.0690529 64.5654312 410.6413856				Gumbel
4	2015-2016	xi sigma mu -0.2816349 49.2067049 533.0278946				Weibull
5	2017-2019	xi sigma mu 0.423354 35.575855 277.681138				Fréchet
6	2020	xi sigma mu -0.8685007 18.8277447 235.5987020				Weibull

Source: From researcher's data analysis

Table-150 : Tail Index estimation and classification-Minimum stock price

S.No.	Year	Parameters				Domain for Minimum
		ξ	α=-1/ ξ	σ	μ	
1	2007-2009	xi sigma mu -0.1583752 110.0295554 -500.4776509				Weibull
2	2010	xi sigma mu -0.855307 149.630483 -549.913043				Weibull
3	2011-2014	xi sigma mu -0.5955443 84.4034558 -459.6626367				Weibull
4	2015-2016	xi sigma mu -0.5955443 84.4034558 -459.6626367				Weibull
5	2017-2019	xi sigma mu -0.8308301 101.4645153 -355.5778778				Weibull
6	2020	xi sigma mu 0.3663992 8.7639134 -246.3421433				Fréchet

Source: From researcher's data analysis

Stock-47: Yes Bank

Table-151 : Tail Index estimation and classification-Maximum stock price

S.No.	Year	Parameters				Domain for Maximum
		ξ	α=-1/ ξ	σ	μ	
1	2007-2009	xi sigma mu -0.333432 59.688599 137.327883				Weibull
2	2010	xi sigma mu -0.1241662 33.5561117 277.2062711				Weibull
3	2011-2014	xi sigma mu 0.2103727 76.6716875 334.5969990				Fréchet
4	2015-2016	xi sigma mu 0.2766623 125.0104401 806.6083781				Fréchet
5	2017-2019	xi sigma mu 0.7339357 194.8330696 209.0719284				Fréchet
6	2020	xi sigma mu -0.2617301 7.2602176 35.3576580				Weibull

Source: From researcher's data analysis

Table-152 : Tail Index estimation and classification-Minimum stock price

S.No.	Year	Parameters				Domain for Minimum
		ξ	α=-1/ ξ	σ	μ	
1	2007-2009	xi sigma mu -0.3460825 60.0958752 -175.6952652				Weibull
2	2010	xi sigma mu -0.5151017 41.2491988 -302.3739853				Weibull
3	2011-2014	xi sigma mu -0.5968005 118.3066502 -423.4388962				Weibull
4	2015-2016	xi sigma mu -0.6709353 214.8725192 -949.0790064				Weibull
5	2017-2019	xi sigma mu -0.9949741 626.2503144 -660.8868884				Weibull
6	2020	xi sigma mu -0.1978899 6.7452481 -40.4426757				Weibull

Source: From researcher's data analysis

Stock-48: Zeel

Table-153 : Tail Index estimation and classification-Maximum stock price

S.No.	Year	Parameters				Domain for Maximum
		ξ	α=-1/ ξ	σ	μ	
1	2007-2009	xi sigma mu -0.4795718 72.9694387 208.4446056				Weibull
2	2010	xi sigma mu -0.8872353 47.5271982 263.6674843				Weibull
3	2011-2014	xi sigma mu 0.02147263 59.28018741 167.62104716				Fréchet
4	2015-2016	xi sigma mu -0.08704208 50.75278690 386.13650033				Gumbel
5	2017-2019	xi sigma mu -0.645975 103.873718 453.050630				Weibull
6	2020	xi sigma mu -0.5830422 35.5818295 241.0865219				Weibull

Source: From researcher's data analysis

Table-154 : Tail Index estimation and classification-Minimum stock price

S.No.	Year	Parameters				Domain for Minimum
		ξ	α=-1/ ξ	σ	μ	
1	2007-2009	xi sigma mu -0.2223824 63.8715281 -251.6652596				Weibull
2	2010	xi sigma mu 0.4536444 19.3125766 -291.4550586				Fréchet
3	2011-2014	xi sigma mu -0.8764888 87.5286593 -207.8890014				Weibull
4	2015-2016	xi sigma mu -0.4931507 63.9080676 -426.4544923				Weibull
5	2017-2019	xi sigma mu 0.145268 66.256781 -518.541046				Fréchet
6	2020	xi sigma mu 0.08386724 23.16312376 -263.29823816				Gumbel

Source: From researcher's data analysis

Stock-49: TECHM

Table-155 : Tail Index estimation and classification-Maximum stock price

S.No.	Year	Parameters				Domain for Maximum
		ξ	α=-1/ ξ	σ	μ	
1	2007-2009	xi sigma mu -0.2591721 413.6061760 749.2528670				Weibull
2	2010	xi sigma mu 0.1798151 75.7064842 726.6453481				Fréchet
3	2011-2014	xi sigma mu 0.7527747 257.1932739 783.0003044				Fréchet
4	2015-2016	xi sigma mu 0.7473112 72.5095137 485.9472414				Fréchet
5	2017-2019	xi sigma mu -0.5944597 147.6699159 592.3386968				Weibull
6	2020	xi sigma mu -0.8313021 59.6053228 769.6146756				Weibull

Source: From researcher's data analysis

Table-156 : Tail Index estimation and classification-Minimum stock price

S.No.	Year	Parameters				Domain for Minimum
		ξ	α=-1/ ξ	σ	μ	
1	2007-2009	xi sigma mu -0.8313021 59.6053228 769.6146756				Weibull
2	2010	xi sigma mu -0.7489787 156.4541025 -828.7247486				Weibull
3	2011-2014	xi sigma mu -0.9324265 567.3566624 -1140.3726507				Weibull
4	2015-2016	xi sigma mu -0.8393979 553.3770107 -1067.7740940				Weibull
5	2017-2019	xi sigma mu -0.02514051 110.24459224 -681.39208427				Gumbel
6	2020	xi sigma mu 0.2579117 31.6151202 -802.4562397				Fréchet

Source: From researcher's data analysis

Stock-50: Bajaj Finance

Table-157 : Tail Index estimation and classification-Maximum stock price

S.No.	Year	Parameters				Domain for Maximum
		ξ	α=-1/ ξ	σ	μ	
1	2007-2009	xi sigma mu -0.7050124 51.2324711 744.4388401				Weibull
2	2010	xi sigma mu 0.4129311 359.2111629 910.2945066				Fréchet
3	2011-2014	xi sigma mu -0.2265128 2299.0428596 4062.9446865				Weibull
4	2015-2016	xi sigma mu -0.06448588 744.93985293 1927.76715640				Gumbel
5	2017-2019	xi sigma mu -0.4749594 350.6024142 4260.5121581				Weibull
6	2020	xi sigma mu -0.8313021 59.6053228 769.6146756				Weibull

Source: From researcher's data analysis

Table-158: Tail Index estimation and classification-Minimum stock price

S.No.	Year	Parameters				Domain for Minimum
		ξ	α=-1/ ξ	σ	μ	
1	2007-2009	xi sigma mu 0.05521209 35.19886491 -773.27014384				Gumbel
2	2010	xi sigma mu -0.7611518 555.5660888 -1273.7953390				Weibull
3	2011-2014	xi sigma mu -0.3192301 2453.8805516 -5964.8060686				Weibull
4	2015-2016	xi sigma mu -0.5670221 974.5161542 -2517.9433941				Weibull
5	2017-2019	sigma mu -0.209882 313.683874 -4470.734495				Weibull
6	2020	xi sigma mu 0.2579117 31.6151202 -802.4562397				Frechet

Source: From researcher's data analysis

Overall conclusion on the Extreme value distributions of the individual stocks

We now present the conclusion on the behaviour of the extreme stocks and the domain they belong to. Based on the index value, we classify the maximum and minimum stock price variables into one of the three types of the extreme value distributions. For each of the stocks, at different time points, we fit the generalized extreme value distribution and compute the value of xi. If the value of xi is equal to zero, then we classify the stock as the one belonging to the domain of Gumbel law. If the value of xi is >0, then we classify the stock as the one belonging to the domain of Fréchet law. If the value of xi is <0, then we classify the stock as the one belonging to the domain of Weibull law. We present the discussion for both maximum and minimum stock price random variables. The discussion will be presented for few stocks and on similar lines the other stocks can be interpreted. Note that the main objective of this part is to identify the domain the maximum and minimum belongs to and provide the extremal index value. It is more descriptive than to find the reasons for the change in the domains.

From table-59 one can note that, during the period 2007-09 the maximum stock price random variable belongs to Gumbel law, during the period 2010 it belongs to Weibull law and during the period 2011-14 it belongs to Fréchet law. During the periods 2015-16, 2017-19, and 2020 the maximum stock price belongs to a Weibull law. From this, one can conclude that the change in the events have changed the domain of attraction. But the change is not so frequent. In most of the time points, the domain of the maximum is Weibull and the same can be used to compute the probabilities related to the maximum stock prices. Similarly, from table-60 one can observe that the domain of the minimum is again Weibull. That is, the maximum and minimum stock prices can be modelled using a Weibull law.

From table 61 one can note that, the maximum belongs to Gumbel law during the financial crisis period 2007-09 and during the period 2017-19. During the periods 2010, 2011-2014, and 2020 the maximum belongs to the domain of Weibull. Only during the period 2015-16 the maximum stock price. belongs to the domain of Fréchet law. From table 62, one can note that the minimum stock price belongs to the domain of Gumbel law. Hence, Weibull and Gumbel laws play an important role in explain the behaviour of the extremes related to Asian Paint stock. The same can be used to compute the probabilities related to maximum and minimum stock prices.

On similar lines, one can note the domains for the maximum and minimum stock prices for the remaining stocks. One common aspect that can be seen in almost all the stocks is, the maximum or minimum stock price variable belongs to Weibull law in majority of the cases.

The second law that play an important role in explaining the behaviour of the extreme stock prices is, the Gumbel law. Based on these findings, one can compute the value at risk and other measures to draw inferences about the risk associated with the stocks.

Part-3: Behaviour of the Total Stock Price variable and the corresponding properties

We now present the discussion on the behaviour of the total stock price variable. According to the literature, the total or the sum (properly normalized) follows either a stable distribution or a normal distribution. This is decided based on the index value of the tail. If the tail index is equal to 2 then, the corresponding distribution is normal and if the tail index is less than 2, then the corresponding distribution is a stable distribution. In the current study, we make an attempt to estimate the index and classify the total stock price random variable. The following table gives the results of the same.

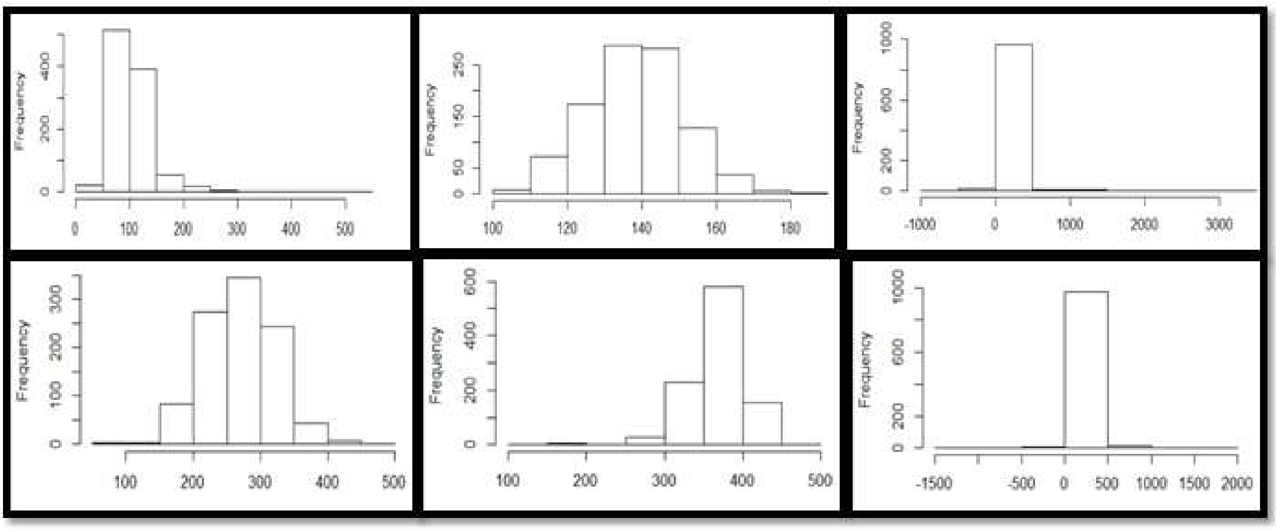
Stock-1: Adaniports

Table-159 : Tail index and classification of the total price random variable

S.No.	Year	Parameters				Domain for total
		α	β	σ	μ	
1	2007-2009	1.594723	1	19.18344	91.548908	Stable
2	2010	1.9785717	-0.6166991	9.3009124	138.2107789	Stable
3	2011-2014	1.027743	0	12.010896	241.216843	Stable
4	2015-2016	2	0	35.55631	269.90123	Normal
5	2017-2019	1.79221	-1	21.46978	372.83838	Stable
6	2020	1.013525	0	9.278602	320.017812	Stable

Source: From researcher's data analysis

Figure-62: Distribution of total stock prices



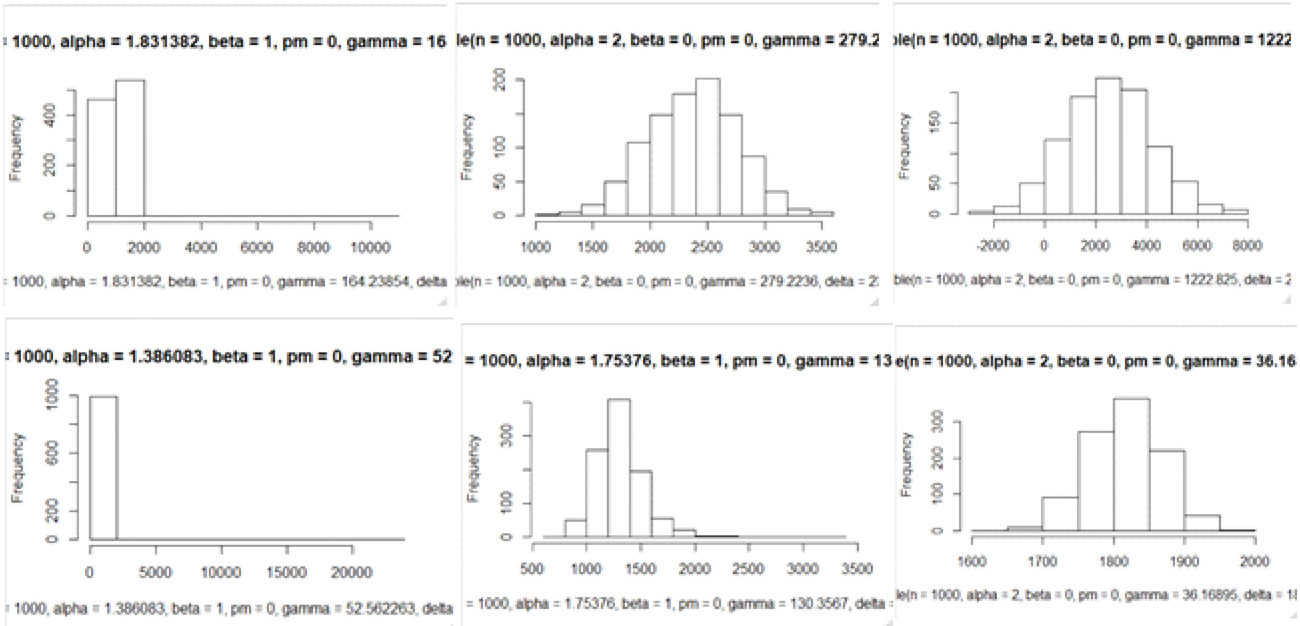
Stock-2: Asian Paint

Table-160 : Tail index and classification of the total price random variable

S.No.	Year	Parameters				Domain for total
		α	β	σ	μ	
1	2007-2009	1.831382	1	164.238540	1034.171230	Stable
2	2010	2	0	279.2236	2351.6029	Normal
3	2011-2014	2	0	1222.825	2501.742	Normal
4	2015-2016	1.386083	1	52.562263	917.466827	Stable
5	2017-2019	1.75376	1	130.35670	1263.50268	Stable
6	2020	2	0	36.16895	1818.39772	Normal

Source: From researcher's data analysis

Figure-63 : Distribution of total stock prices



Source: From researcher's data analysis

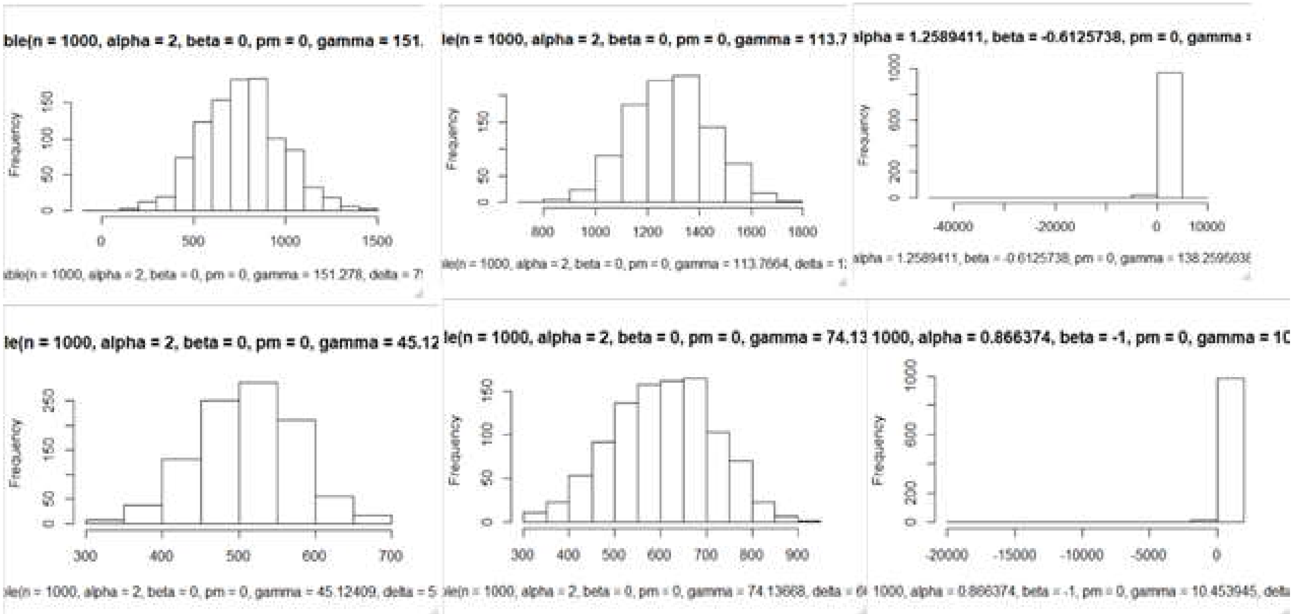
Stock-3: Axis Bank

Table-161 : Tail index and classification of the total price random variable

S.No.	Year	Parameters				Domain for total
		α	β	σ	μ	
1	2007-2009	2	0	151.2780	753.9889	Normal
2	2010	2	0	113.7664	1282.5617	Normal
3	2011-2014	1.2589411	-0.6125738	138.2595038	1219.1104090	Stable
4	2015-2016	2	0	45.12409	510.49205	Normal
5	2017-2019	2	0	74.13668	601.36336	Normal
6	2020	0.866374	-1	10.453945	759.183345	Stable

Source: From researcher's data analysis

Figure-64 : Distribution of total stock prices



Source: From researcher's data analysis

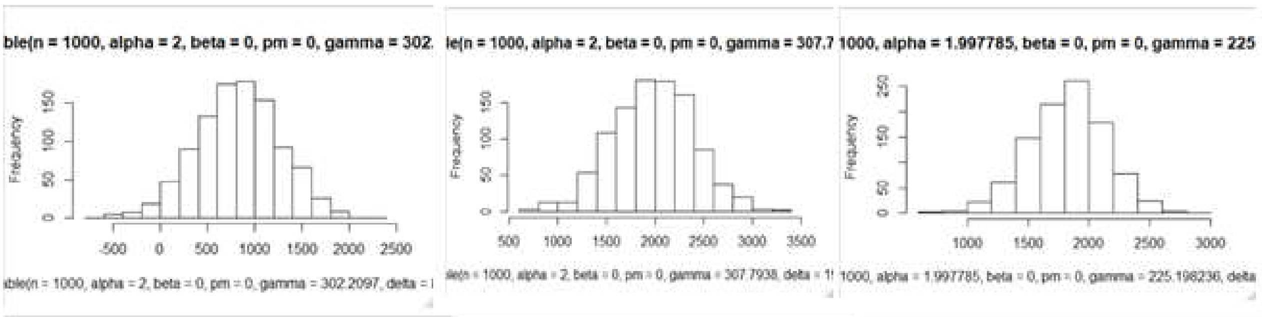
Stock-4: Bajaj Auto

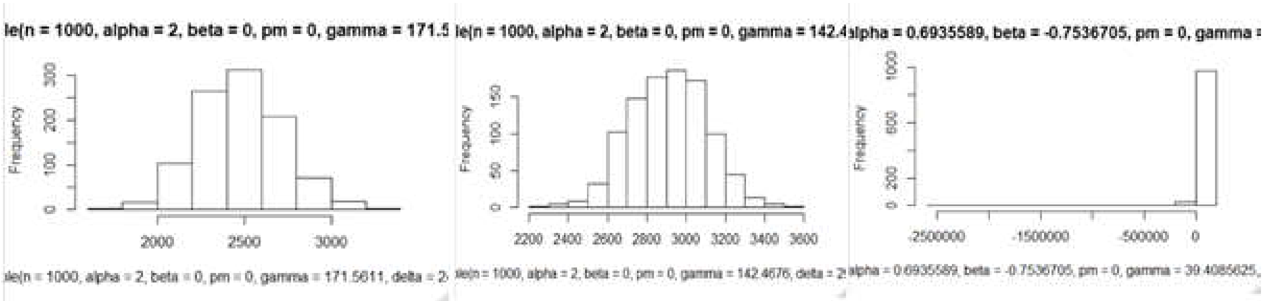
Table-162 : Tail index and classification of the total price random variable

S.No.	Year	Parameters				Domain for total
		α	β	σ	μ	
1	2007-2009	2	0	302.2097	837.8180	Normal
2	2010	2	0	307.7938	1968.9724	Normal
3	2011-2014	1.997785	0	225.198236	1816.666813	Normal
4	2015-2016	2	0	171.5611	2468.7155	Normal
5	2017-2019	2	0	142.4676	2904.6083	Normal
6	2020	0.6935589	-0.7536705	39.4085625	3108.2583082	Stable

Source: From researcher's data analysis

Figure-65 : Distribution of the total stock prices





Source: From researcher's data analysis

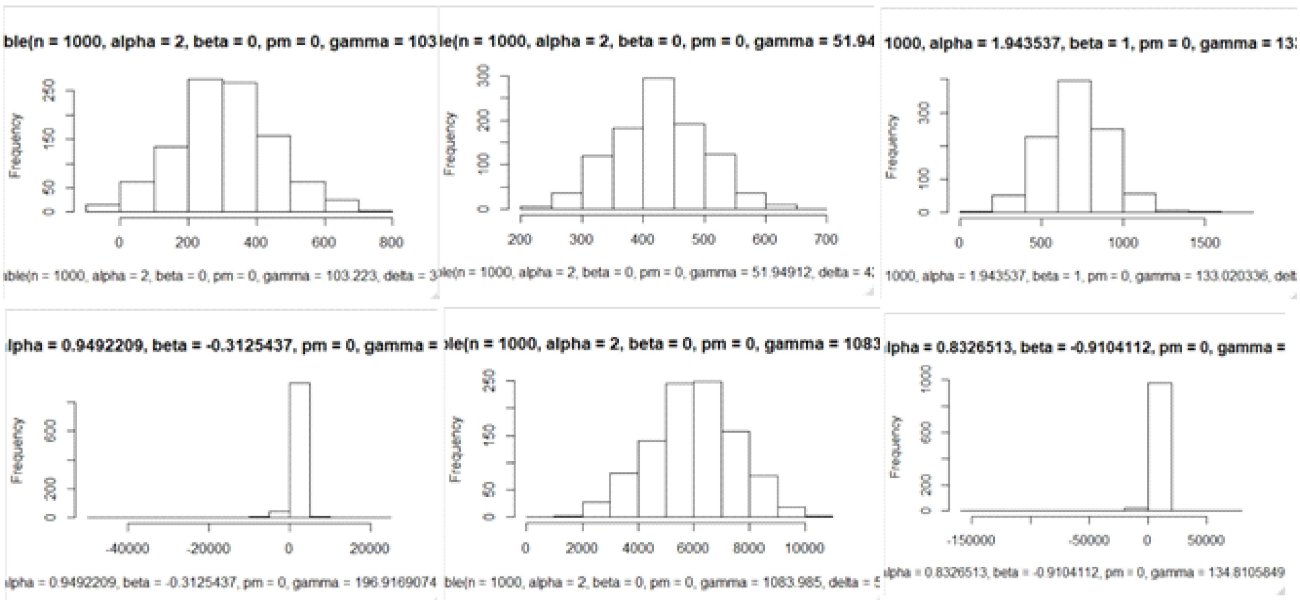
Stock-5: Bajaj FinSV

Table-163 : Tail index and classification of the total price random variable

S.No.	Year	Parameters				Domain for total
		α	β	σ	μ	
1	2007-2009	2	0	103.2230	310.3567	Normal
2	2010	2	0	51.94912	424.29786	Normal
3	2011-2014	1.943537	1	133.020336	703.184458	Stable
4	2015-2016	0.9492209	-0.3125437	196.9169074	1447.6979965	Stable
5	2017-2019	2	0	1083.985	5991.753	Normal
6	2020	0.8326513	-0.9104112	134.8105849	9569.3551405	Stable

Source: From researcher's data analysis

Figure-66 : Distribution of the stock prices



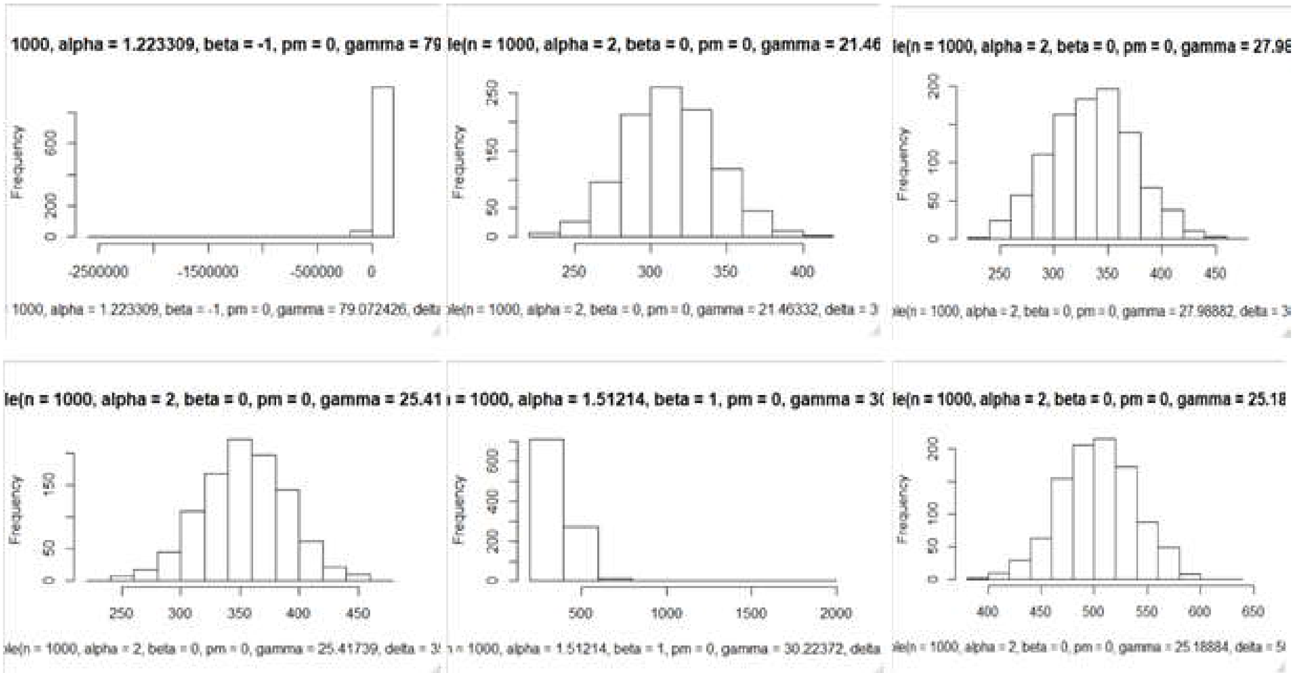
Stock-6: BharthiARTL

Table-164: Tail index and classification of the total price random variable

S.No.	Year	Parameters				Domain for total
		α	β	σ	μ	
1	2007-2009	1.223309	-1	79.072426	777.546841	Stable
2	2010	2	0	21.46332	312.10261	Normal
3	2011-2014	2	0	27.98882	336.53419	Normal
4	2015-2016	2	0	25.41739	354.51326	Normal
5	2017-2019	1.51214	1	30.22372	363.93475	Stable
6	2020	2	0	25.18884	504.77744	Normal

Source: From researcher's data analysis

Figure-67 : Distribution of the stock prices



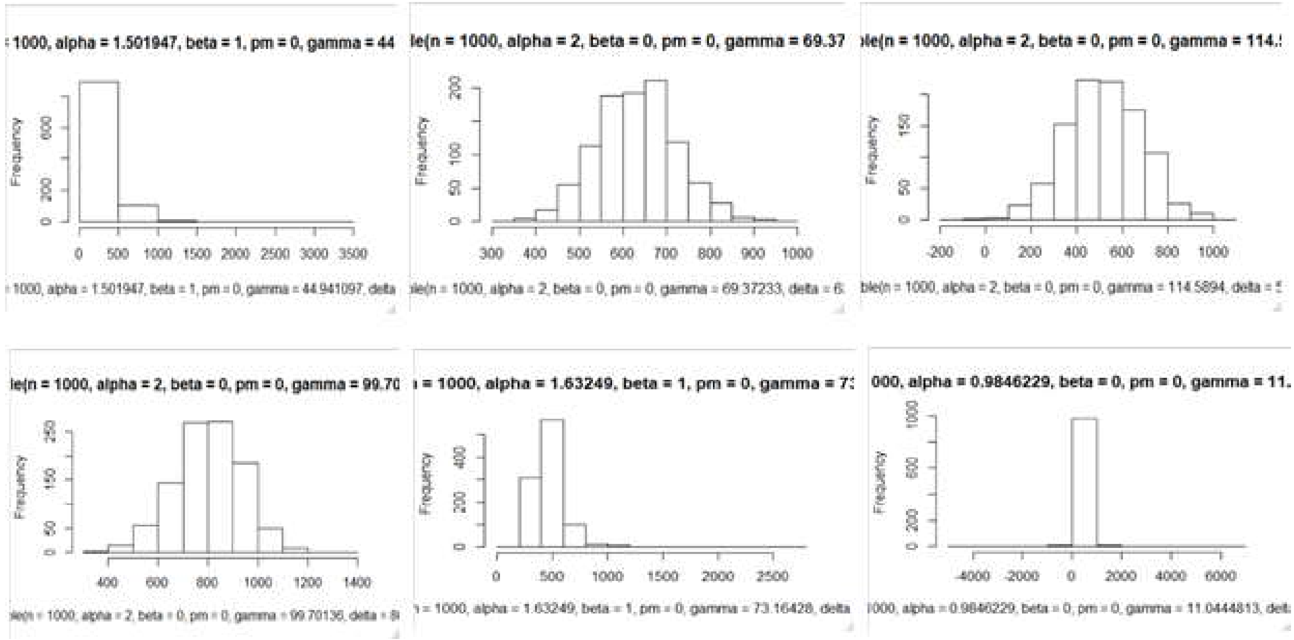
Stock-7: BPCL

Table-165 : Tail index and classification of the total price random variable

S.No.	Year	Parameters				Domain for total
		α	β	σ	μ	
1	2007-2009	1.501947	1	44.941097	364.932155	Stable
2	2010	2	0	69.37233	633.86455	Normal
3	2011-2014	2	0	114.5894	510.9103	Normal
4	2015-2016	2	0	99.70136	800.70507	Normal
5	2017-2019	1.63249	1	73.16428	433.44142	Stable
6	2020	0.9846229	0	11.0444813	498.4231216	Stable

Source: From researcher's data analysis

Figure-68 : Distribution of the stock prices



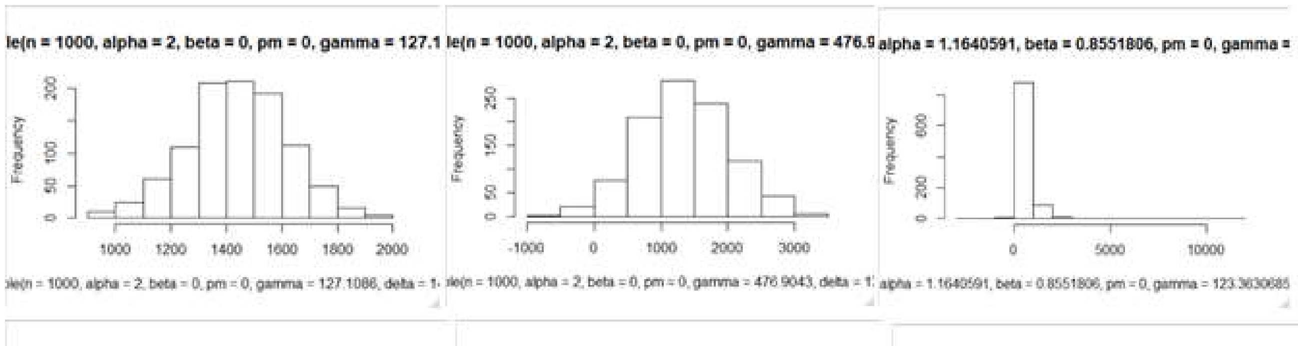
Stock-8: Britannia

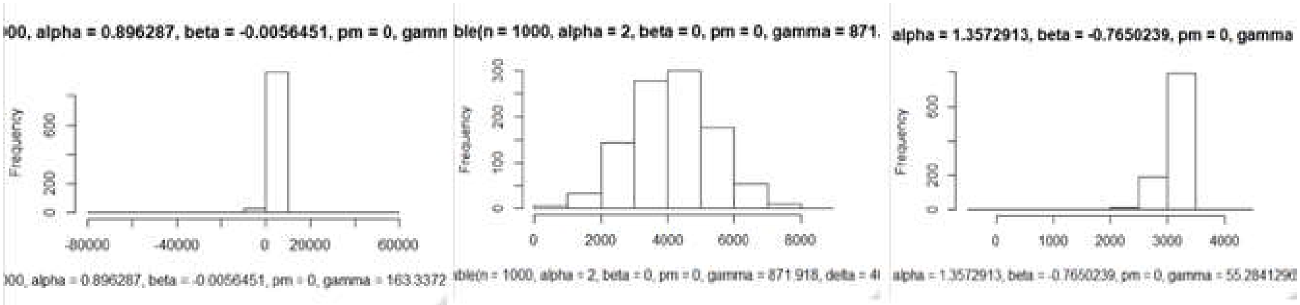
Table-166 : Tail index and classification of the total price random variable

S.No.	Year	Parameters				Domain for total
		α	β	σ	μ	
1	2007-2009	2	0	127.1086	1442.7041	Normal
2	2010	2	0	476.9043	1324.8122	Normal
3	2011-2014	1.1640591	0.8551806	123.3630685	506.4571067	Stable
4	2015-2016	0.8962870	-0.0056451	163.3372	2790.397	Stable
5	2017-2019	2	0	871.918	4089.631	Normal
6	2020	1.3572913	-0.7650239	55.2841296	3106.3156190	Stable

Source: From researcher's data analysis

Figure-69 : Distribution of the stock prices





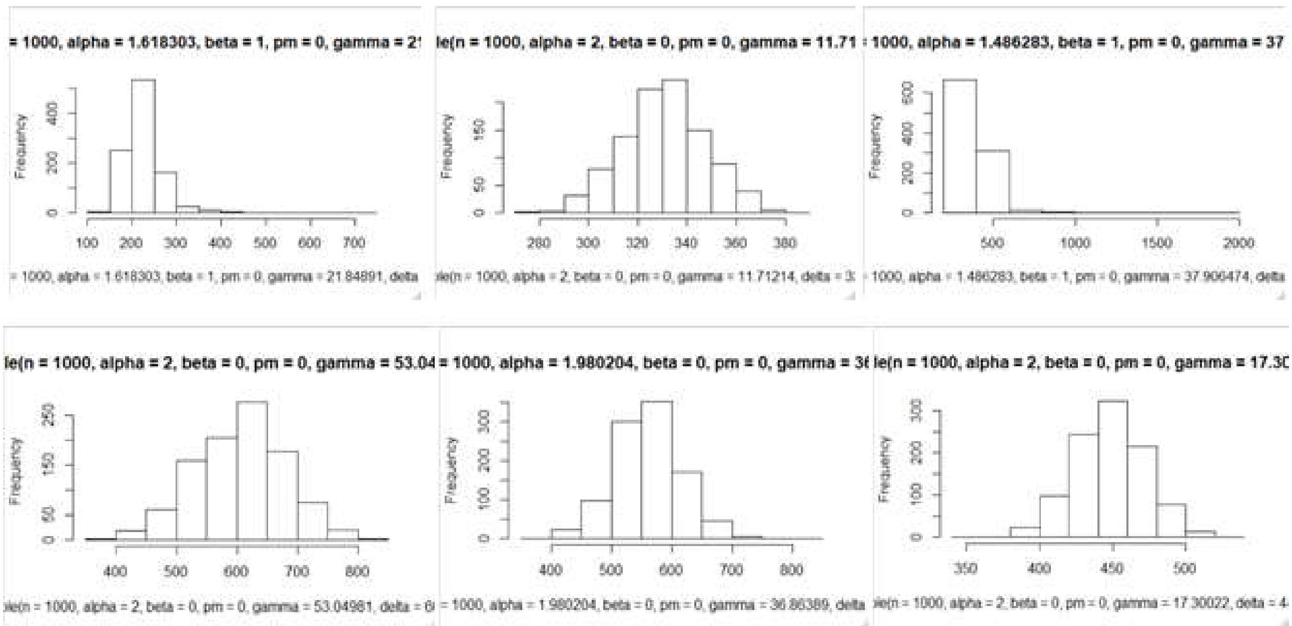
Stock-9: Cipla

Table-167 : Tail index and classification of the total price random variable

S.No.	Year	Parameters				Domain for total
		α	β	σ	μ	
1	2007-2009	1.618303	1	21.848910	213.946663	Stable
2	2010	2	0	11.71214	331.28051	Normal
3	2011-2014	1.486283	1	37.906474	360.197012	Stable
4	2015-2016	2	0	53.04981	604.36771	Normal
5	2017-2019	1.980204	0	36.863890	558.815907	Normal
6	2020	2	0	17.30022	447.35634	Normal

Source: From researcher's data analysis

Figure-70 : Distribution of the stock prices



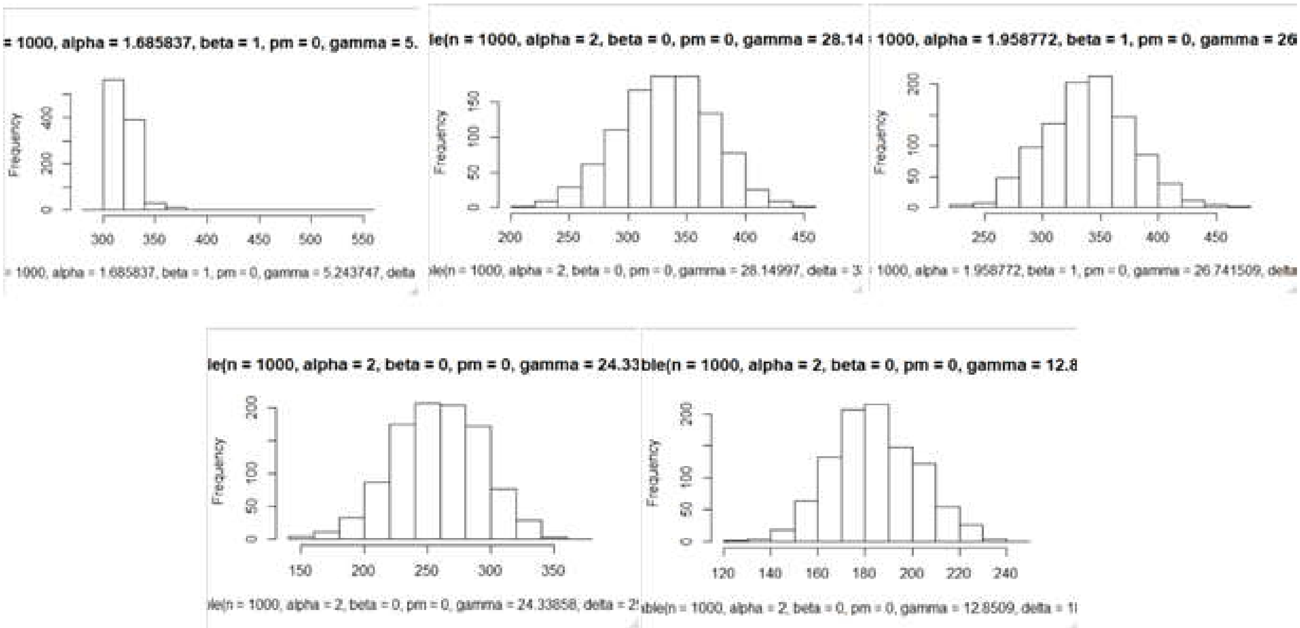
Stock-10: Coal India

Table-168 : Tail index and classification of the total price random variable

S.No.	Year	Parameters				Domain for total
		α	β	σ	μ	
1	2010	1.685837	1	5.243747	318.178413	Stable
2	2011-2014	2	0	28.14997	331.99133	Normal
3	2015-2016	1.958772	1	26.741509	338.063068	Stable
4	2017-2019	2	0	24.33858	258.16475	Normal
5	2020	2	0	12.8509	184.3708	Normal

Source: From researcher's data analysis

Figure-71 : Distribution of the stock prices



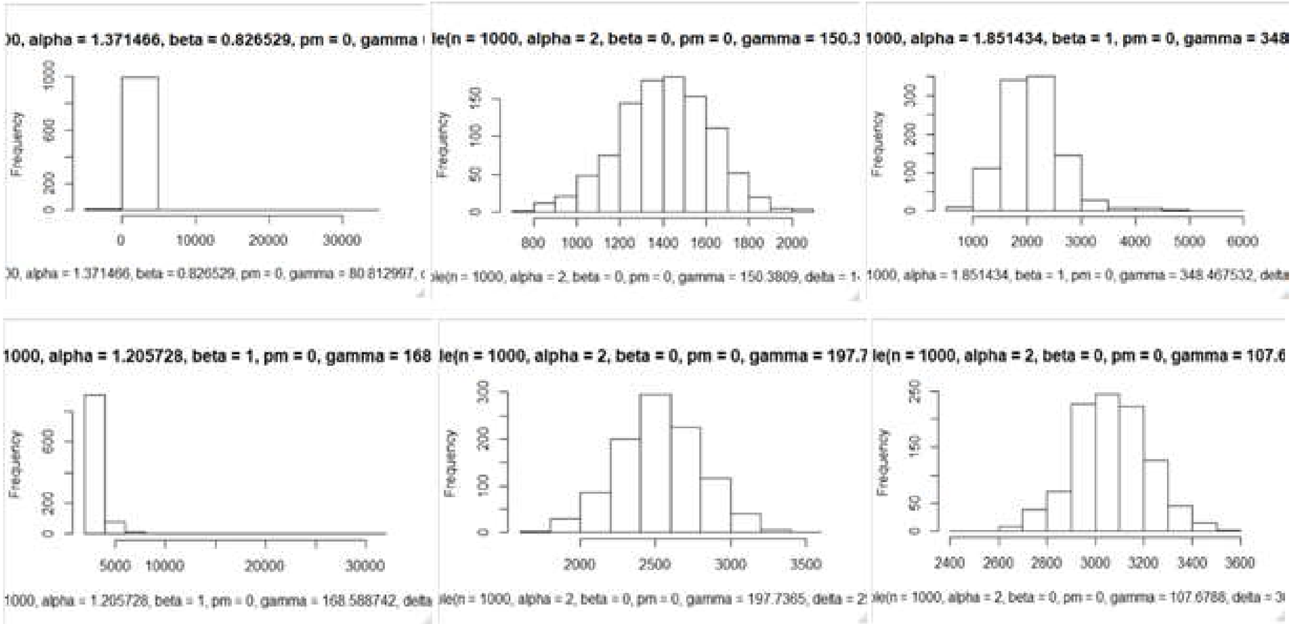
Stock-11: Dr Reddy

Table-169 : Tail index and classification of the total price random variable

S.No.	Year	Parameters				Domain for total
		α	β	σ	μ	
1	2007-2009	1.371466	0.826529	80.812997	620.485321	Stable
2	2010	2	0	150.3809	1405.4666	Normal
3	2011-2014	1.851434	1	348.467532	1996.696955	Stable
4	2015-2016	1.205728	1	168.588742	3289.549678	Stable
5	2017-2019	2	0	197.7365	2519.1425	Normal
6	2020	2	0	107.6788	3062.7955	Normal

Source: From researcher's data analysis

Figure-72 : Distribution of the stock prices



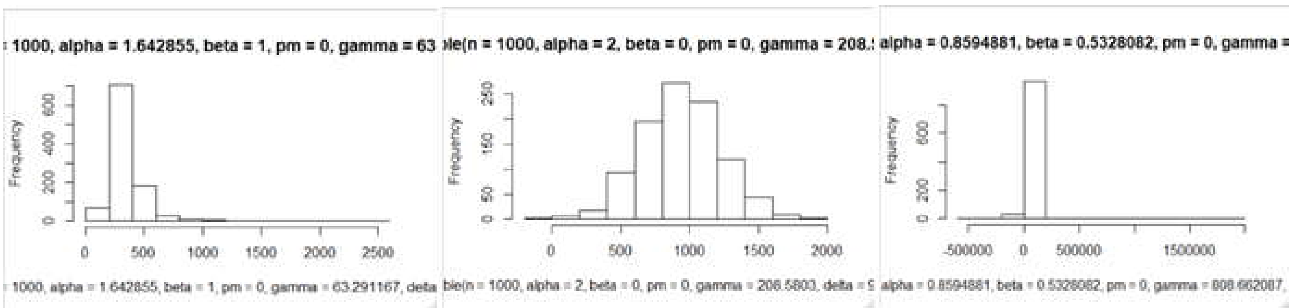
Stock-12: Eichermot

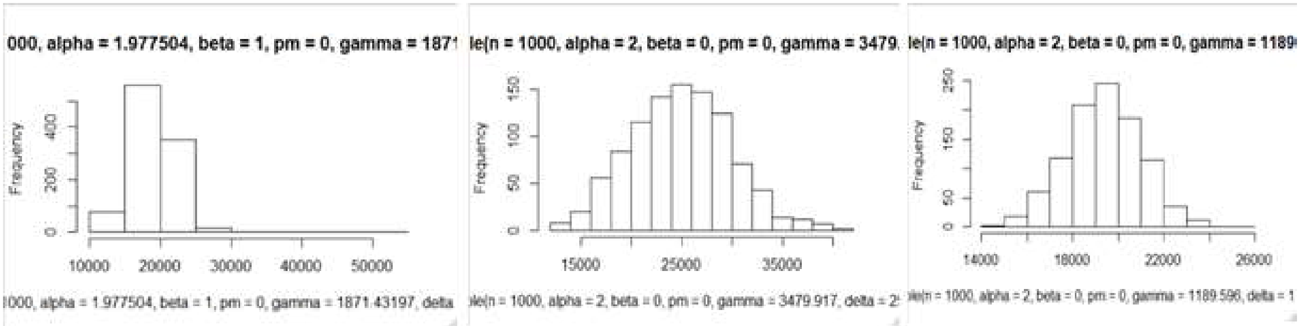
Table-170 : Tail index and classification of the total price random variable

S.No.	Year	Parameters				Domain for total
		α	β	σ	μ	
1	2007-2009	1.642855	1	63.291167	306.928231	Stable
2	2010	2	0	208.5803	943.1464	Normal
3	2011-2014	0.8594881	0.5328082	808.6620870	2979.7299841	Stable
4	2015-2016	1.977504	1	1871.431970	18932.769479	Stable
5	2017-2019	2	0	3479.917	25043.651	Normal
6	2020	2	0	1189.596	19377.845	Normal

Source: From researcher's data analysis

Figure-73 : Distribution of the stock prices





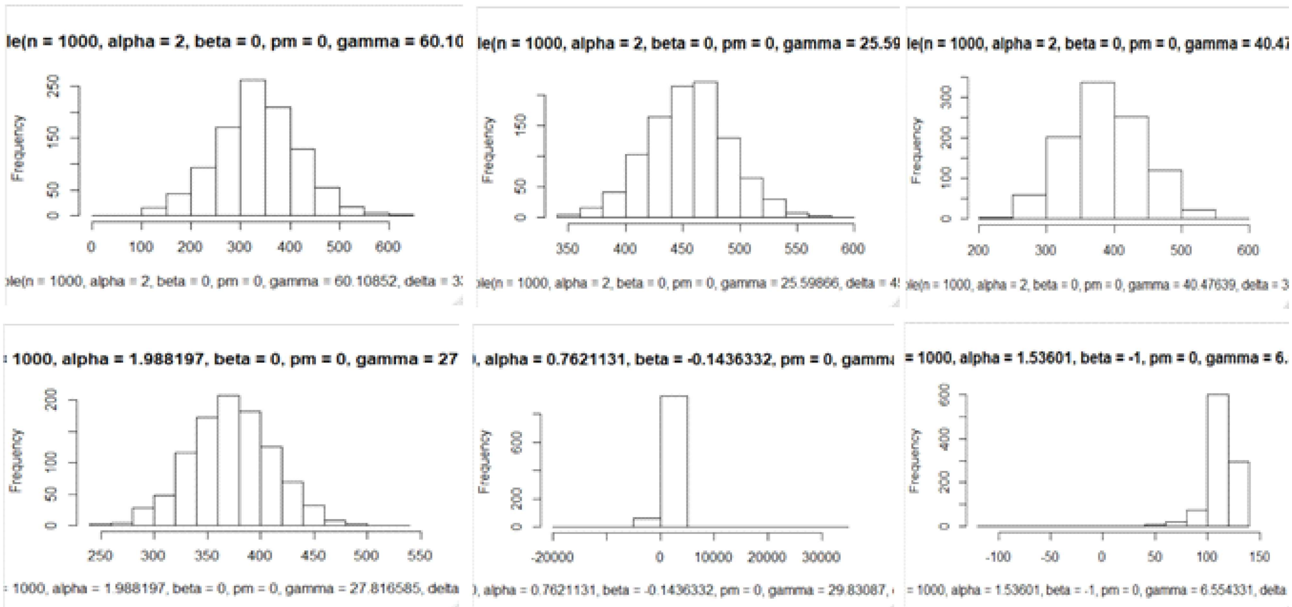
Stock-13: Gail

Table-171 : Tail index and classification of the total price random variable

S.No.	Year	Parameters				Domain for total
		α	β	σ	μ	
1	2007-2009	2	0	60.10852	335.06374	Normal
2	2010	2	0	25.59866	453.04519	Normal
3	2011-2014	2	0	40.47639	385.82242	Normal
4	2015-2016	1.988197	0	27.816585	372.212908	Normal
5	2017-2019	0.7621131	-0.1436332	29.8308700	359.9285713	Stable
6	2020	1.536010	-1	6.554331	117.072117	Stable

Source: From researcher's data analysis

Figure-74 : Distribution of the stock prices



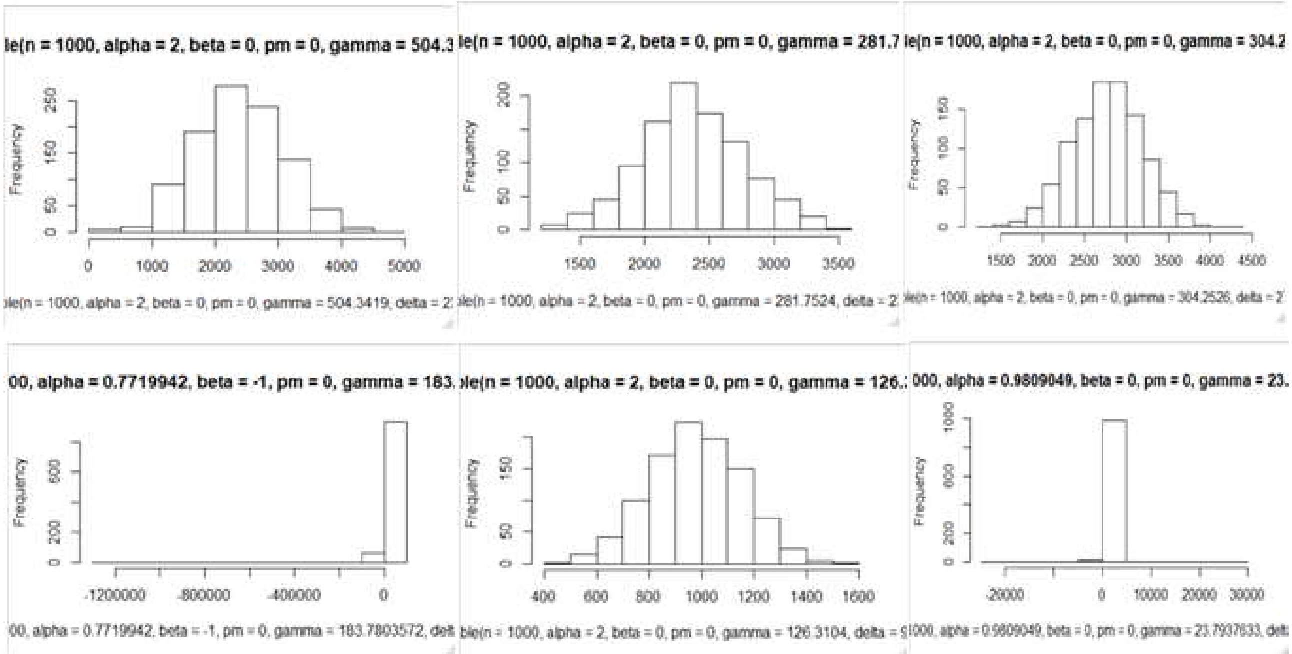
Stock-14: Grasim

Table-172 : Tail index and classification of the total price random variable

S.No.	Year	Parameters				Domain for total
		α	β	σ	μ	
1	2007-2009	2	0	504.3419	2371.0729	Normal
2	2010	2	0	281.7524	2335.3776	Normal
3	2011-2014	2	0	304.2526	2771.1362	Normal
4	2015-2016	0.7719942	-1	183.7803572	4214.6668591	Stable
5	2017-2019	2	0	126.3104	976.0383	Normal
6	2020	0.9809049	0	23.7937633	758.5277453	Stable

Source: From researcher's data analysis

Figure-75 : Distribution of the stock prices



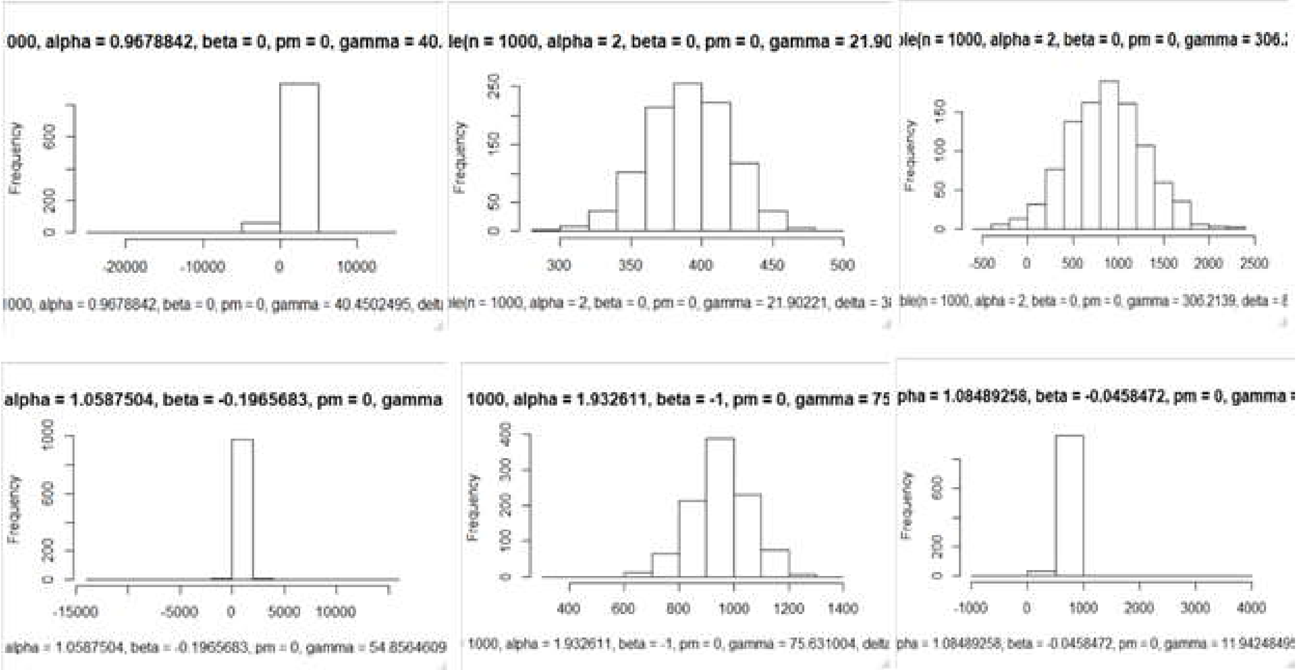
Stock-15: HCL Tech

Table-173 : Tail index and classification of the total price random variable

S.No.	Year	Parameters				Domain for total
		α	β	σ	μ	
1	2007-2009	0.9678842	0	40.4502495	237.8213452	Stable
2	2010	2	0	21.90221	389.50547	Normal
3	2011-2014	2	0	306.2139	848.7173	Normal
4	2015-2016	1.0587504	-0.1965683	54.8564609	835.0899021	Stable
5	2017-2019	1.932611	-1	75.631004	960.646567	Stable
6	2020	1.08489258	-0.0458472	11.94248495	577.72384602	Stable

Source: From researcher's data analysis

Figure-76 : Distribution of total stock prices



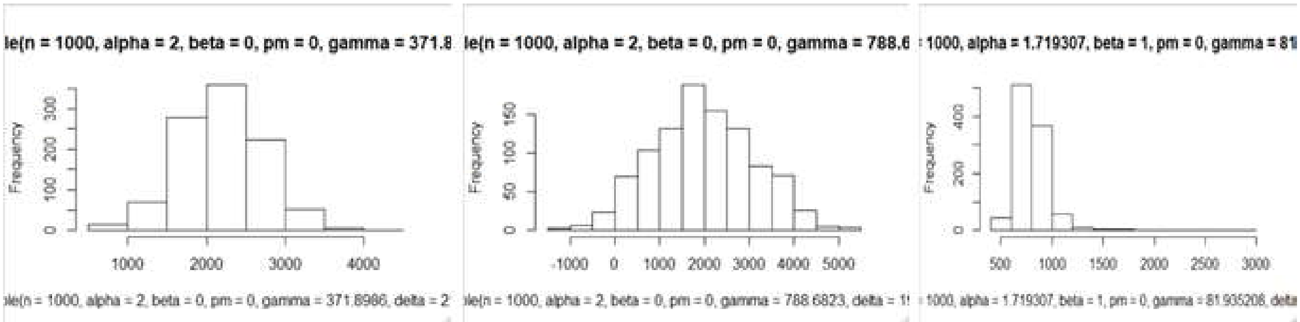
Stock-16: HDFC

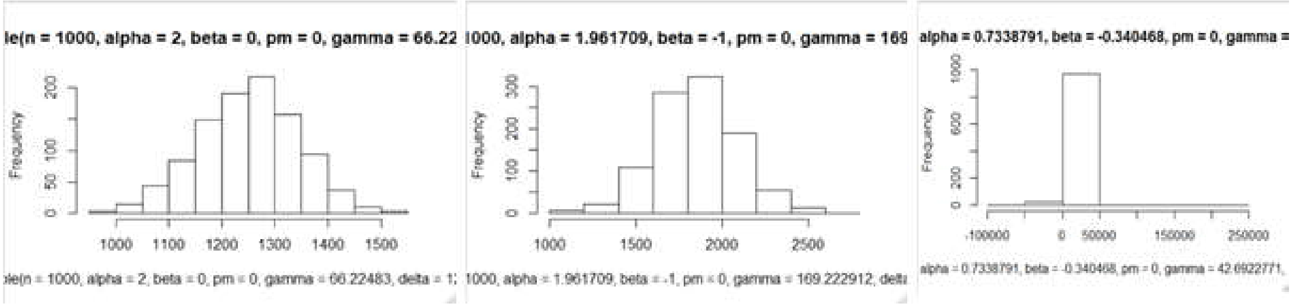
Table-174 : Tail index and classification of the total price random variable

S.No.	Year	Parameters				Domain for total
		α	β	σ	μ	
1	2007-2009	2	0	371.8986	2155.7298	Normal
2	2010	2	0	788.6823	1957.6017	Normal
3	2011-2014	1.719307	1	81.935208	763.660624	Stable
4	2015-2016	2	0	66.22483	1248.71240	Normal
5	2017-2019	1.961709	-1.000000	169.222912	1857.163419	Stable
6	2020	0.7338791	-0.3404680	42.6922771	2358.8274373	Stable

Source: From researcher's data analysis

Figure-77 : Distribution of the total stock prices





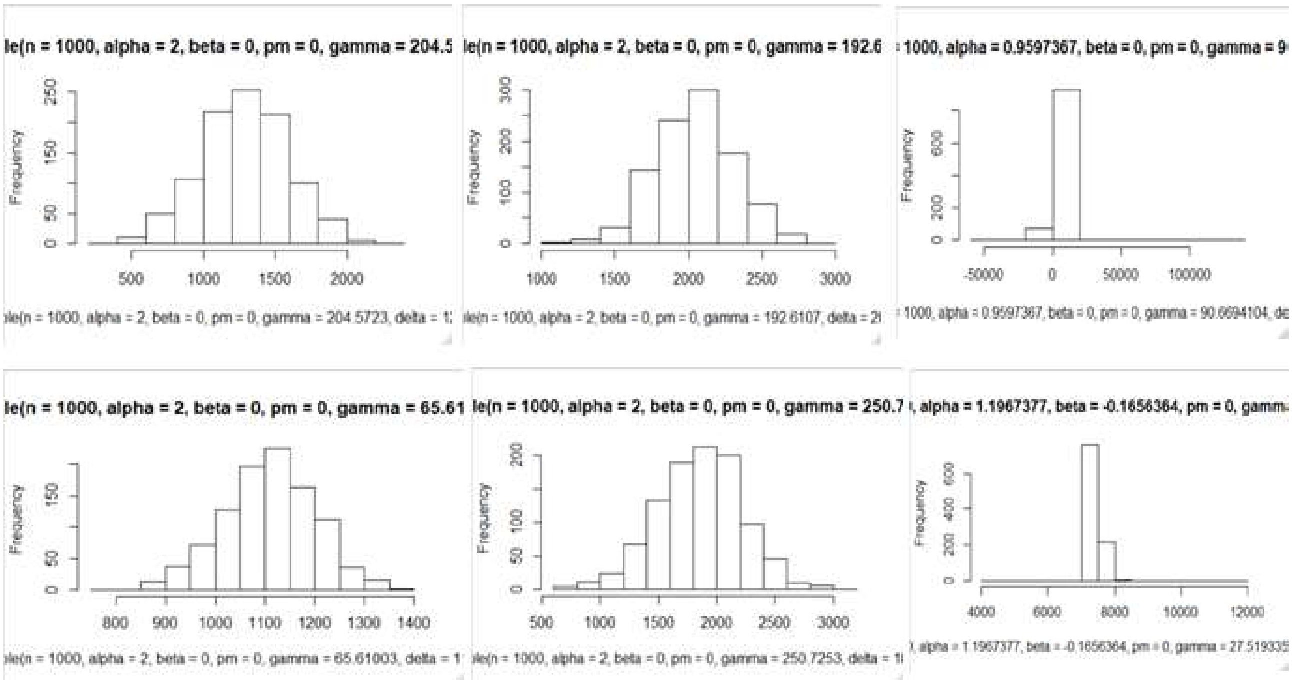
Stock-17: HDFC Bank

Table-175 : Tail index and classification of the total price random variable

S.No.	Year	Parameters				Domain for total
		α	β	σ	μ	
1	2007-2009	2	0	204.5723	1275.7931	Normal
2	2010	2	0	192.6107	2043.6865	Normal
3	2011-2014	0.9597367	0	90.6694104	487.6948	Stable
4	2015-2016	2	0	65.61003	1105.7487	Normal
5	2017-2019	2	0	250.7253	1861.3577	Normal
6	2020	1.1967377	-0.1656364	27.5193358	7474.9294	Stable

Source: From researcher's data analysis

Figure-78 : Distribution of the total stock prices



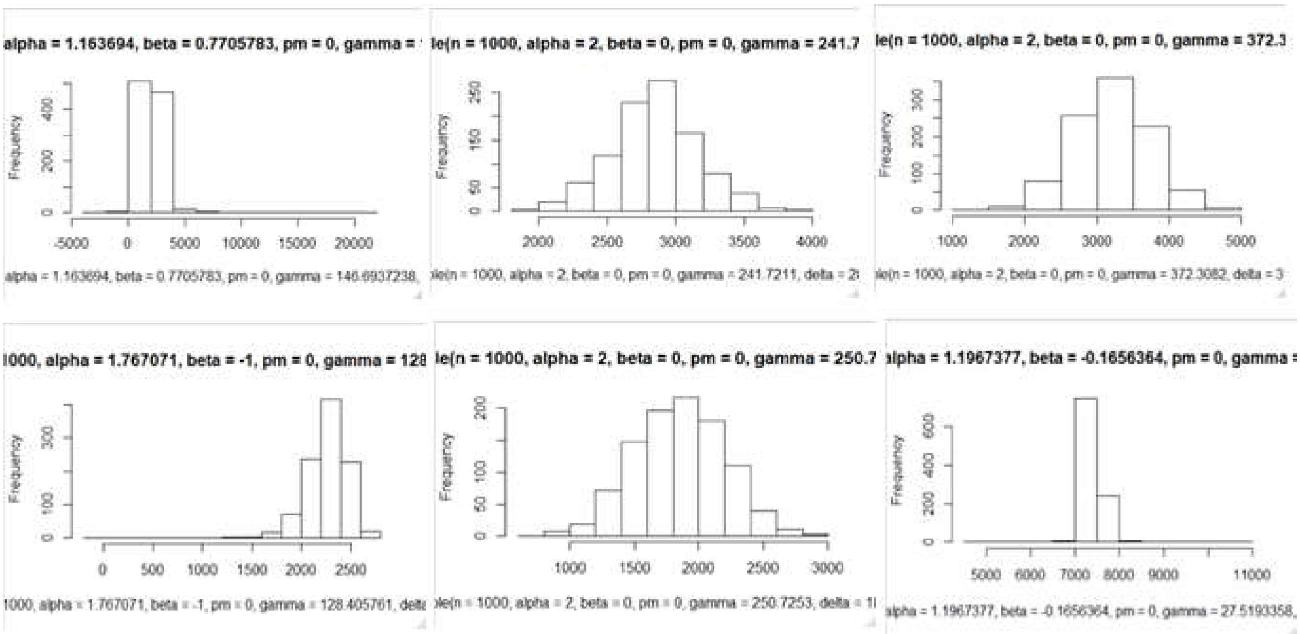
Stock-18: Hero Moto Co

Table-176 : Tail index and classification of the total price random variable

S.No.	Year	Parameters				Domain for total
		α	β	σ	μ	
1	2007-2009	1.1636940	0.7705783	146.6937238	1952.4642268	Stable
2	2010	2	0	241.7211	2833.9044	Normal
3	2011-2014	2	0	372.3082	3188.3665	Normal
4	2015-2016	1.767071	-1	128.405761	2306.825551	Stable
5	2017-2019	2	0	250.7253	1861.3577	Normal
6	2020	1.1967377	-0.1656364	27.5193358	7474.9294123	Stable

Source: From researcher's data analysis

Figure-79 : Distribution of total stock prices



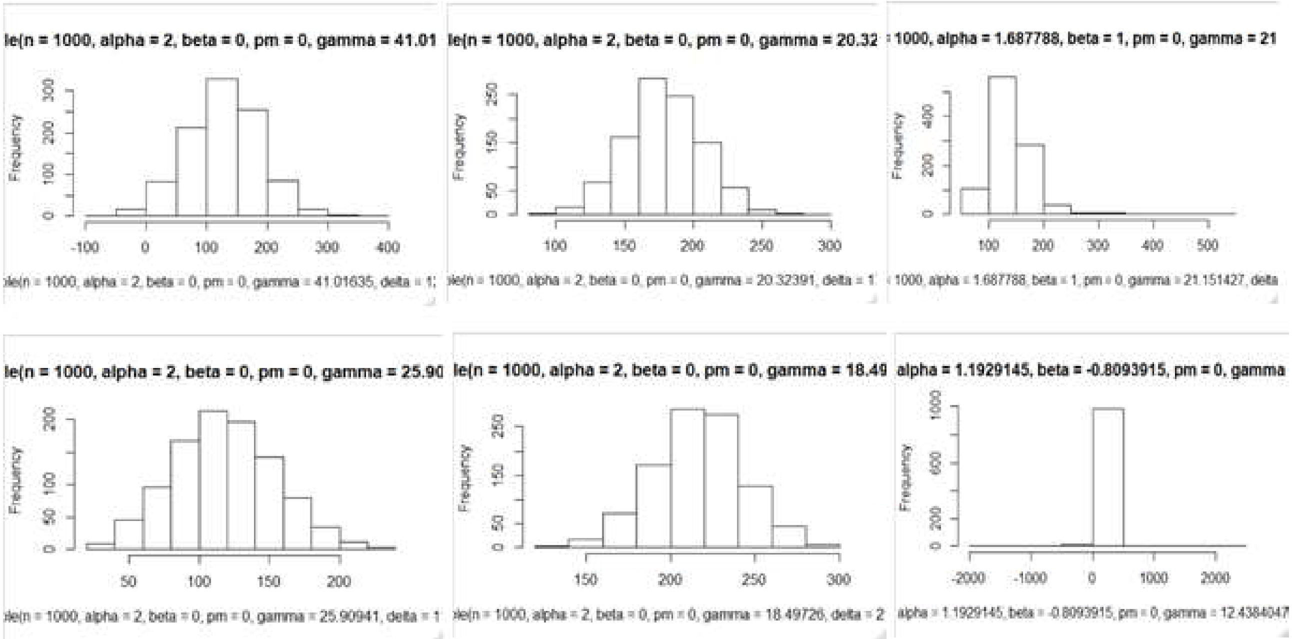
Stock-19: HindalCo

Table-177 : Tail index and classification of the total price random variable

S.No.	Year	Parameters				Domain for total
		α	β	σ	μ	
1	2007-2009	2	0	41.01635	125.16697	Normal
2	2010	2	0	20.32391	178.23004	Normal
3	2011-2014	1.687788	1	21.151427	131.407906	Stable
4	2015-2016	2	0	25.90941	116.63593	Normal
5	2017-2019	2	0	18.49726	215.95345	Normal
6	2020	1.1929145	-0.8093915	12.4384047	202.9935557	Stable

Source: From researcher's data analysis

Figure-80 : Distribution of total stock prices



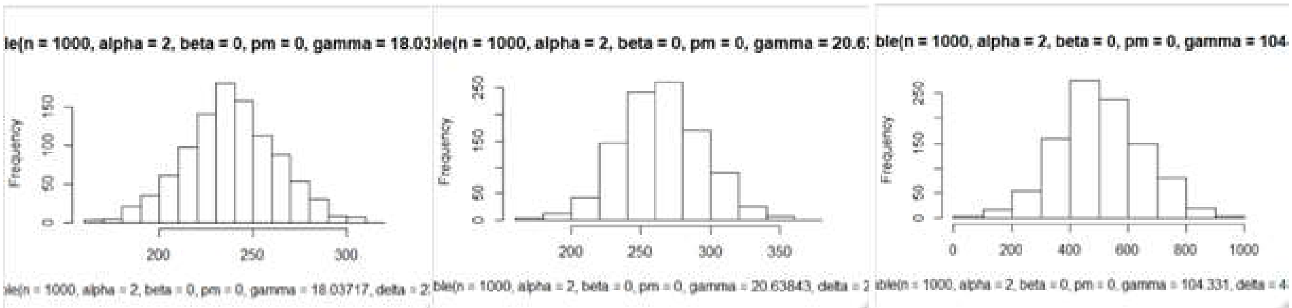
Stock-20: Hindunil VR

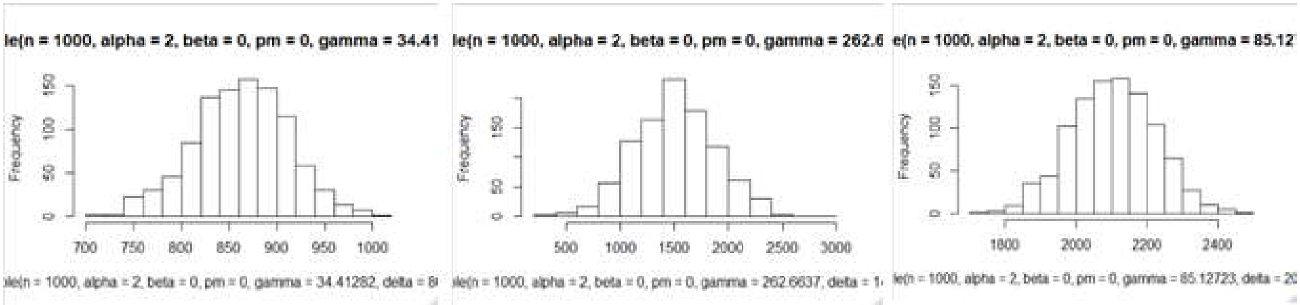
Table-178 : Tail index and classification of the total price random variable

S.No.	Year	Parameters				Domain for total
		α	β	σ	μ	
1	2007-2009	2	0	18.03717	238.65306	Normal
2	2010	2	0	20.63843	264.07970	Normal
3	2011-2014	2	0	104.3310	499.4013	Normal
4	2015-2016	2	0	34.41282	862.78896	Normal
5	2017-2019	2	0	262.6637	1490.4811	Normal
6	2020	2	0	85.12723	2099.14636	Normal

Source: From researcher's data analysis

Figure-81 : Distribution of total stock prices





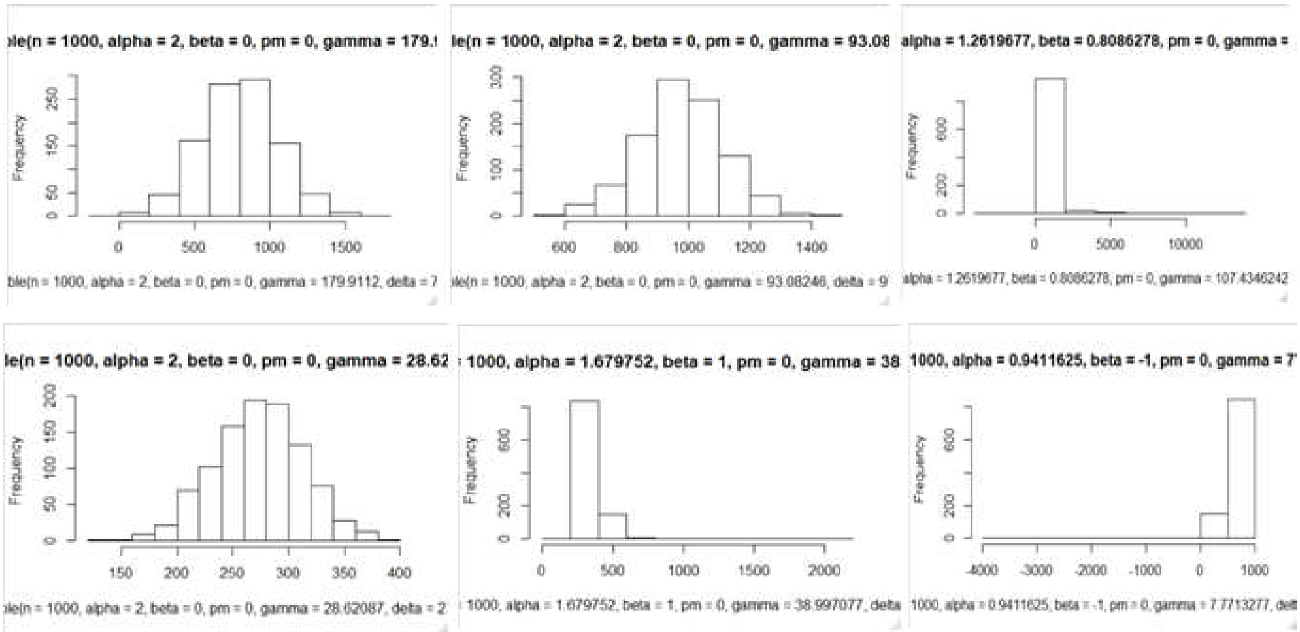
Stock-21: ICICI Bank

Table-179 : Tail index and classification of the total price random variable

S.No.	Year	Parameters				Domain for total
		α	β	σ	μ	
1	2007-2009	2	0	179.9112	793.3203	Normal
2	2010	2	0	93.08246	978.90624	Normal
3	2011-2014	1.2619677	0.8086278	107.4346242	991.2123442	Stable
4	2015-2016	2	0	28.62087	274.33027	Normal
5	2017-2019	1.679752	1	38.997077	327.215389	Stable
6	2020	0.9411625	-1	7.7713277	539.114787	Stable

Source: From researcher's data analysis

Figure-82 : Distribution of total stock prices



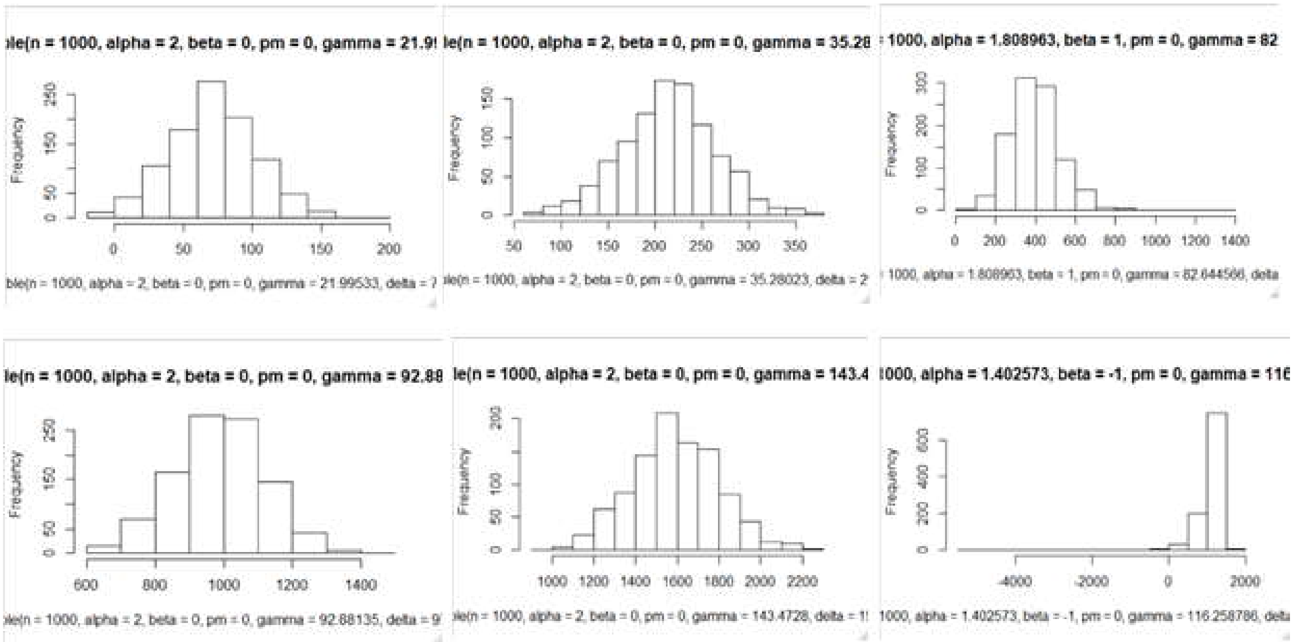
Stock-22: IndusIndBK

Table-180 : Tail index and classification of the total price random variable

S.No.	Year	Parameters				Domain for total
		α	β	σ	μ	
1	2007-2009	2	0	21.99533	71.37944	Normal
2	2010	2	0	35.28023	211.38333	Normal
3	2011-2014	1.808963	1	82.644566	377.179522	Stable
4	2015-2016	2	0	92.88135	979.90225	Normal
5	2017-2019	2	0	143.4728	1591.0822	Normal
6	2020	1.402573	-1	116.258786	1213.404599	Stable

Source: From researcher's data analysis

Figure-83 : Distribution of total stock prices



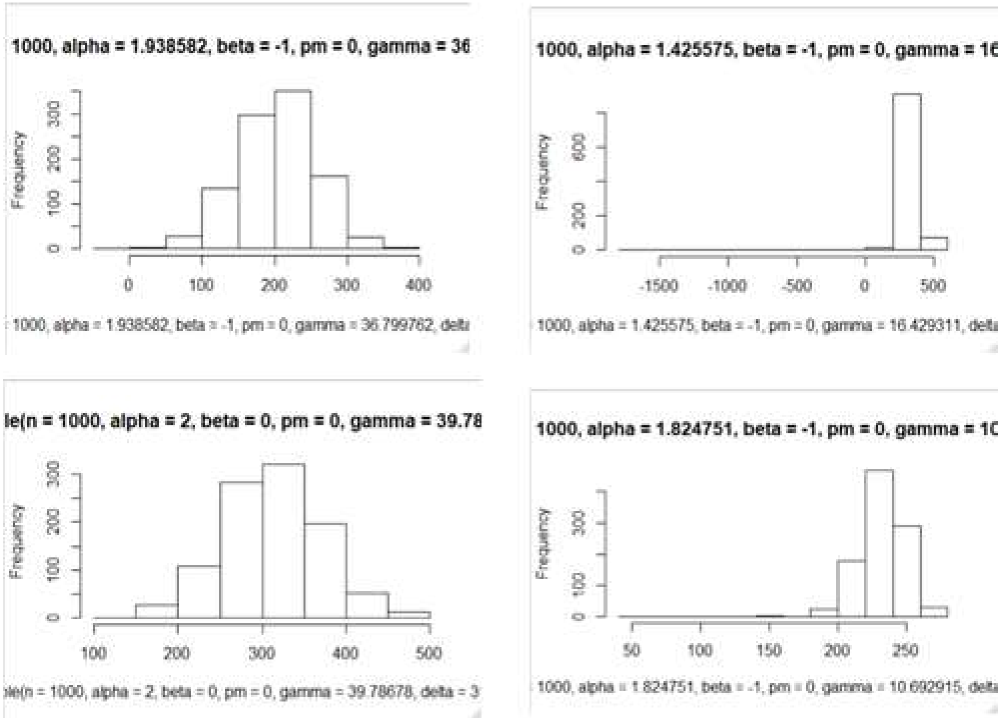
Stock-23: Infratel

Table-181 : Tail index and classification of the total price random variable

S.No.	Year	Parameters				Domain for total
		α	β	σ	μ	
1	2011-2014	1.938582	1	36.799762	205.121054	Stable
2	2015-2016	1.425575	1	16.429311	375.563172	Stable
3	2017-2019	2	0	39.78678	315.14452	Normal
4	2020	1.824751	-1	10.692915	234.007722	Stable

Source: From researcher's data analysis

Figure-84 : Distribution of total stock prices



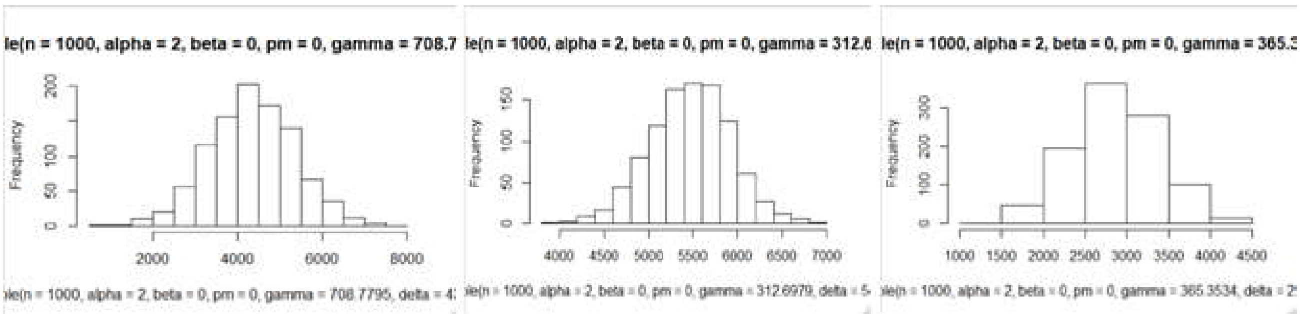
Stock-24: Infy

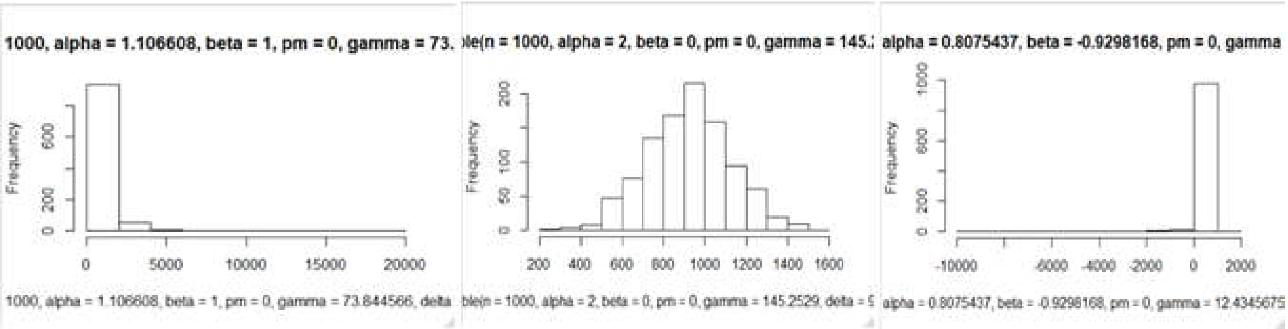
Table-182 : Tail index and classification of the total price random variable

S.No.	Year	Parameters				Domain for total
		α	β	σ	μ	
1	2007-2009	2	0	708.7795	4387.2354	Normal
2	2010	2	0	312.6979	5464.7407	Normal
3	2011-2014	2	0	365.3534	2885.3375	Normal
4	2015-2016	1.106608	1	73.844566	1496.815767	Stable
5	2017-2019	2	0	145.2529	922.0722	Normal
6	2020	0.8075437	-0.9298168	12.4345675	778.2807275	Stable

Source: From researcher's data analysis

Figure-85 : Distribution of total stock prices





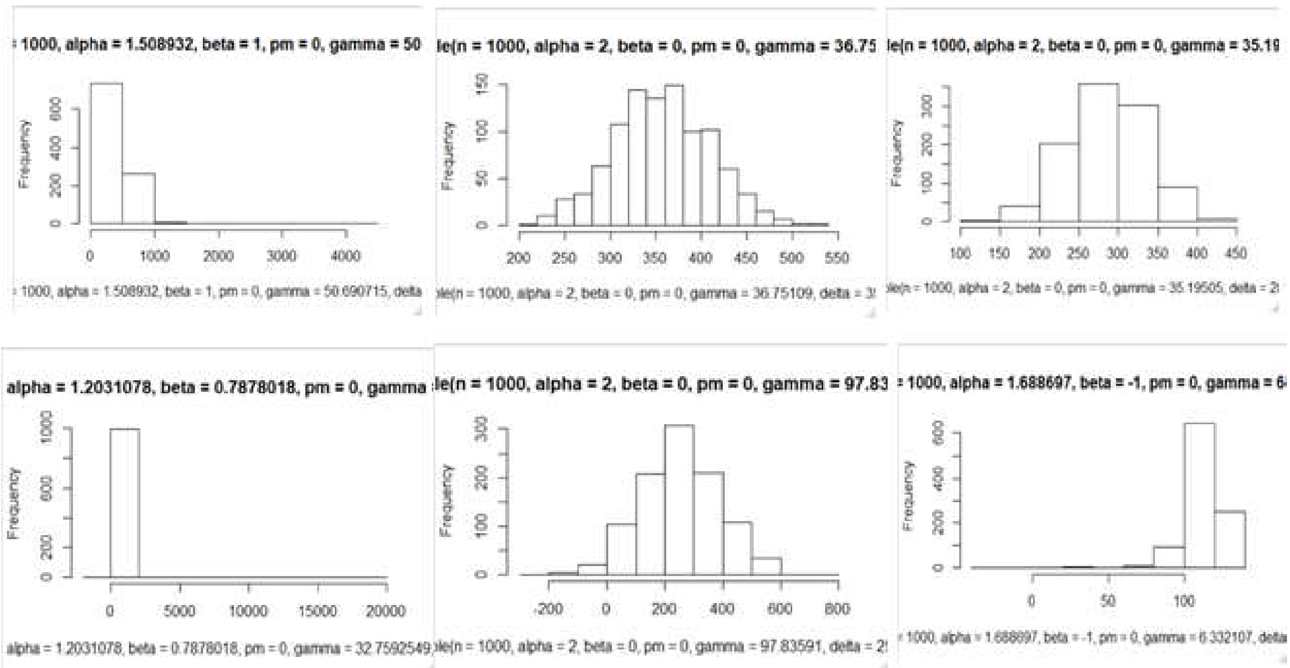
Stock-25: IOC

Table-183: Tail index and classification of the total price random variable

S.No.	Year	Parameters				Domain for total
		α	β	σ	μ	
1	2007-2009	1.508932	1	50.690715	432.584196	Stable
2	2010	2	0	36.75109	355.94141	Normal
3	2011-2014	2	0	35.19505	285.32491	Normal
4	2015-2016	1.2031078	0.7878018	32.7592549	376.2560009	Stable
5	2017-2019	2	0	97.83591	250.47705	Normal
6	2020	1.688697	-1	6.332107	115.262279	Stable

Source: From researcher's data analysis

Figure-86 : Distribution of total stock prices



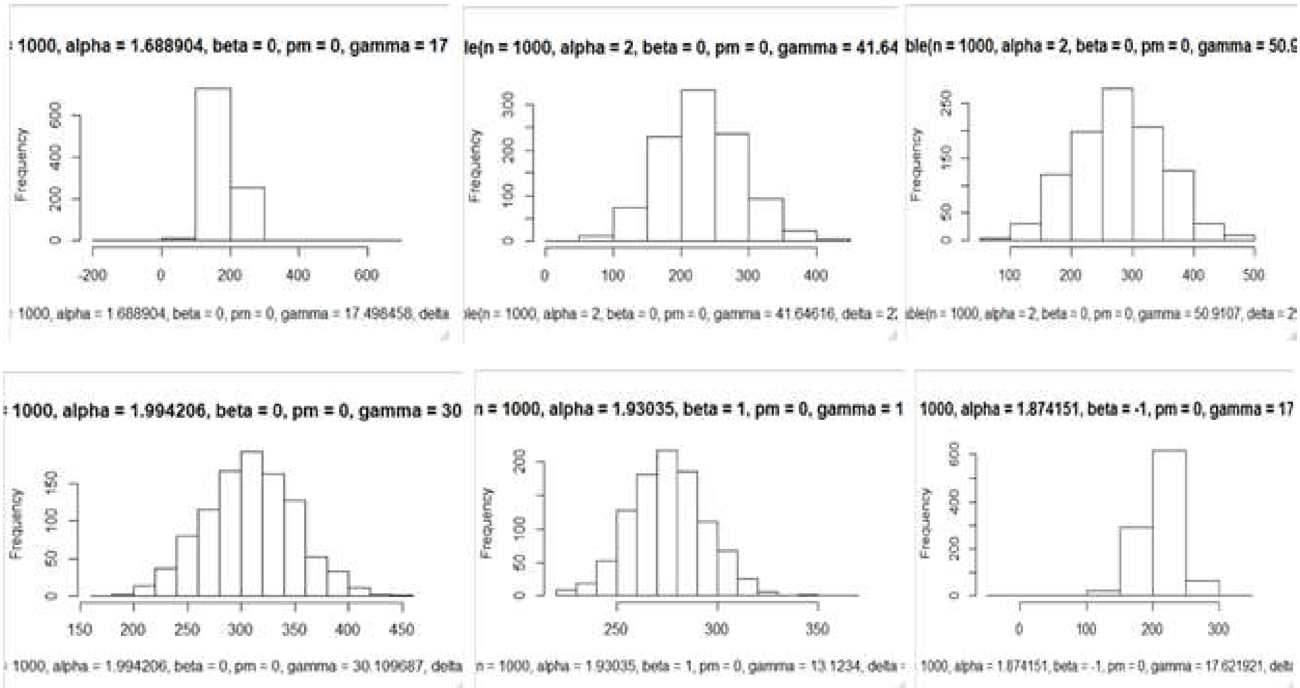
Stock-26: ITC

Table-184 : Tail index and classification of the total price random variable

S.No.	Year	Parameters				Domain for total
		α	β	σ	μ	
1	2007-2009	1.688904	0	17.498458	185.224248	Stable
2	2010	2	0	41.64616	227.38306	Normal
3	2011-2014	2	0	50.9107	276.0179	Normal
4	2015-2016	1.994206	0	30.109687	309.170505	Normal
5	2017-2019	1.93035	1	13.12340	274.20147	Stable
6	2020	1.874151	-1	17.621921	215.210029	Stable

Source: From researcher's data analysis

Figure-87 : Distribution of total stock prices



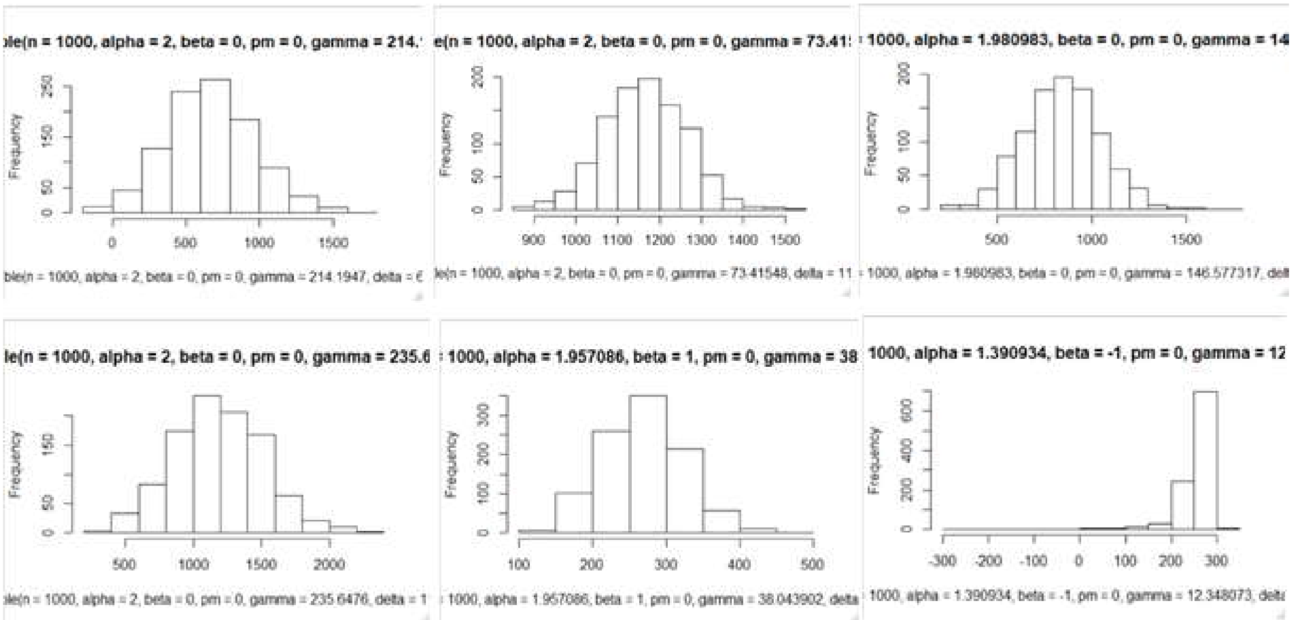
Stock-27: JswSteel

Table-185 : Tail index and classification of the total price random variable

S.No.	Year	Parameters				Domain for total
		α	β	σ	μ	
1	2007-2009	2	0	214.1947	670.6854	Normal
2	2010	2	0	73.41548	1165.90584	Normal
3	2011-2014	1.980983	0	146.577317	845.766410	Normal
4	2015-2016	2	0	235.6476	1197.9227	Normal
5	2017-2019	1.957086	1	38.043902	266.952012	Stable
6	2020	1.390934	-1	12.348073	266.531489	Stable

Source: From researcher's data analysis

Figure-88 : Distribution of total stock prices



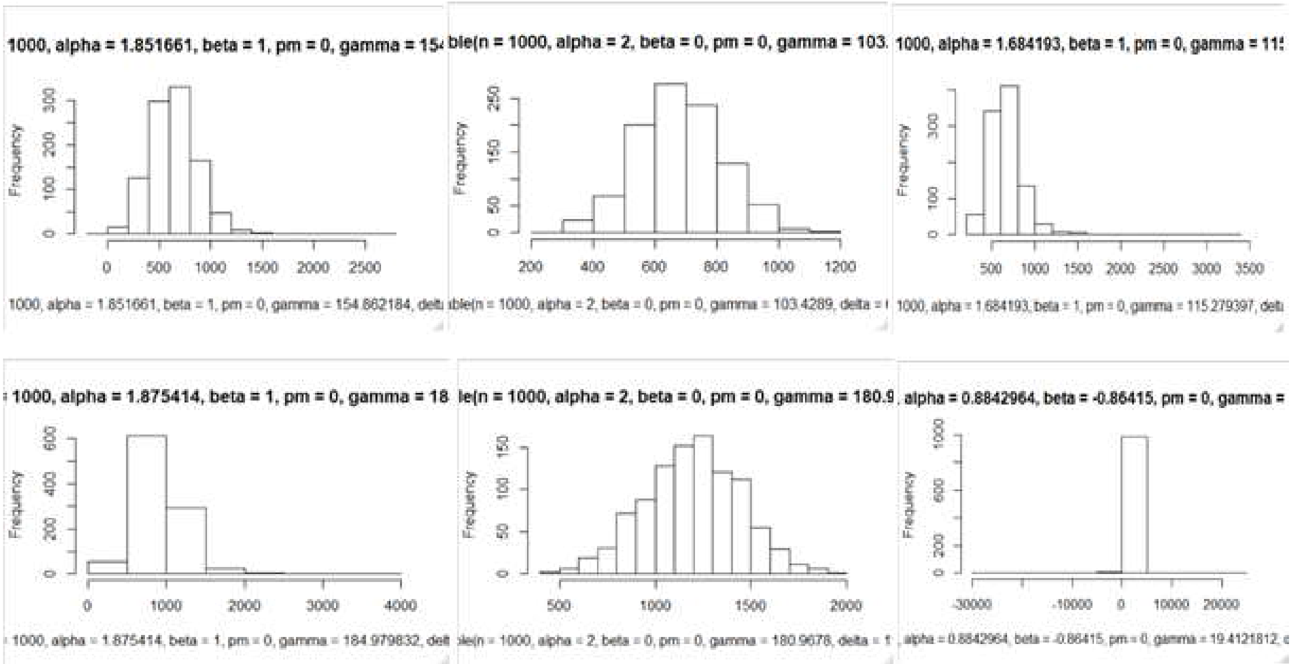
Stock-28: Kotak Bank

Table-186 : Tail index and classification of the total price random variable

S.No.	Year	Parameters				Domain for total
		α	β	σ	μ	
1	2007-2009	1.851661	1	154.862184	613.905126	Stable
2	2010	2	0	103.4289	681.8560	Normal
3	2011-2014	1.684193	1	115.279397	617.806801	Stable
4	2015-2016	1.875414	1	184.979832	861.138380	Stable
5	2017-2019	2	0	180.9678	1195.5046	Normal
6	2020	0.8842964	-0.8641500	19.4121812	1671.8083189	Stable

Source: From researcher's data analysis

Figure-89 : Distribution of total stock prices



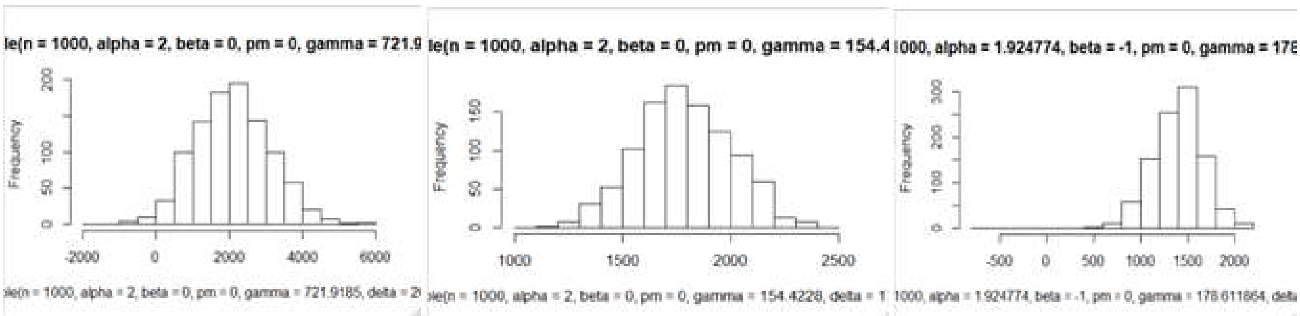
Stock-29: L&T

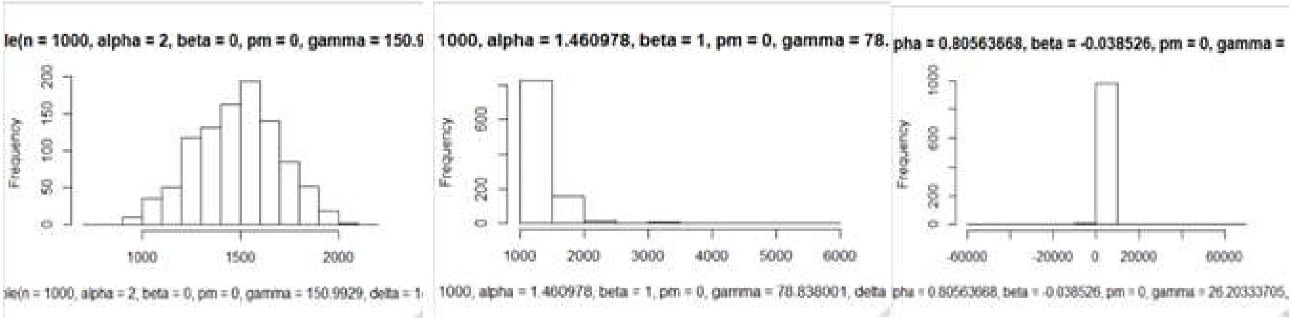
Table-187 : Tail index and classification of the total price random variable

S.No.	Year	Parameters				Domain for total
		α	β	σ	μ	
1	2007-2009	2	0	721.9185	2082.4108	Normal
2	2010	2	0	154.4228	1778.5119	Normal
3	2011-2014	1.924774	-1	178.611864	1406.851506	Stable
4	2015-2016	2	0	150.9929	1484.9362	Normal
5	2017-2019	1.460978	1	78.838001	1331.989073	Stable
6	2020	0.80563668	-0.0385260	26.20333705	1259.10265301	Stable

Source: From researcher's data analysis

Figure-90 : Distribution of total stock prices





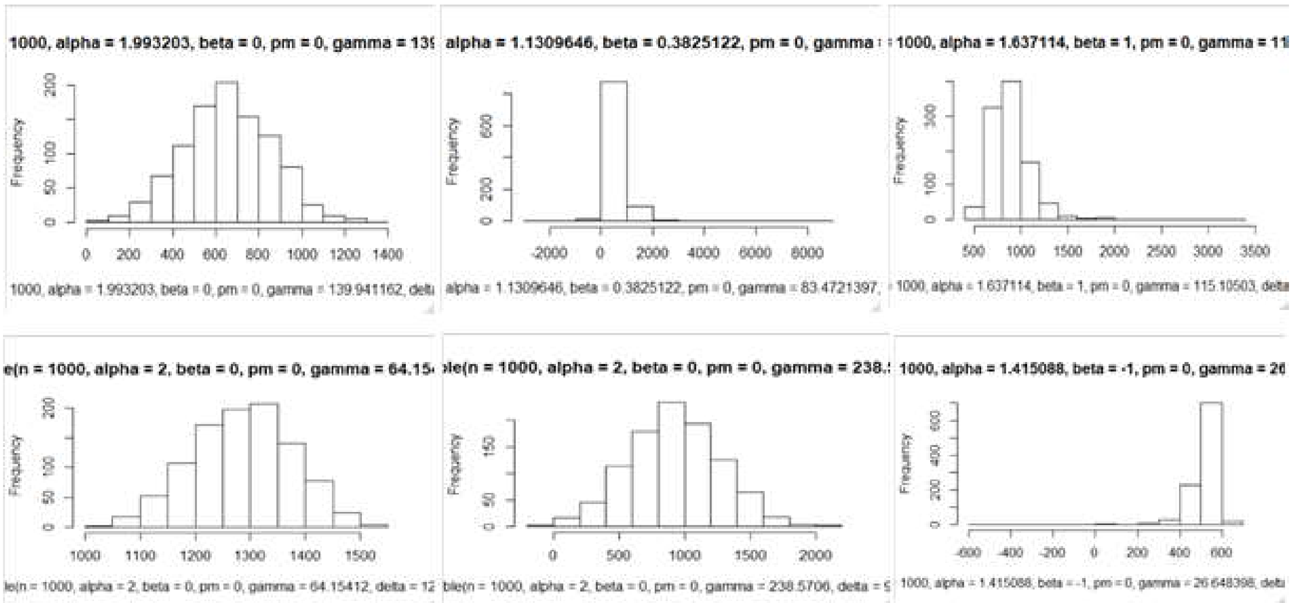
Stock-30: M&M

Table-188 : Tail index and classification of the total price random variable

S.No.	Year	Parameters				Domain for total
		α	β	σ	μ	
1	2007-2009	1.993203	0	139.941162	665.246522	Normal
2	2010	1.1309646	0.3825122	83.4721397	711.0715379	Stable
3	2011-2014	1.637114	1	115.105030	834.864911	Stable
4	2015-2016	2	0	64.15412	1282.88499	Normal
5	2017-2019	2	0	238.5706	926.7712	Normal
6	2020	1.415088	-1	26.648398	539.658694	Stable

Source: From researcher's data analysis

Figure-91 : Distribution of total stock prices



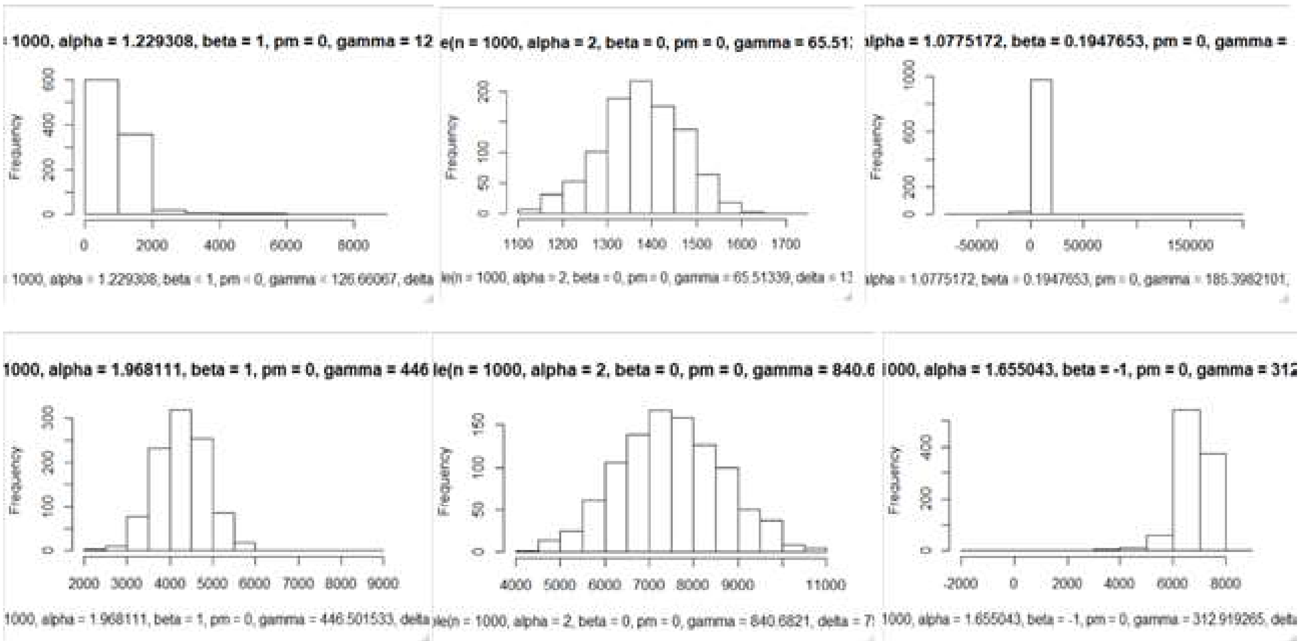
Stock-31: Maruthi

Table-189 : Tail index and classification of the total price random variable

S.No.	Year	Parameters				Domain for total
		α	β	σ	μ	
1	2007-2009	1.229308	1	126.66067	883.196854	Stable
2	2010	2	0	65.51339	1375.48089	Normal
3	2011-2014	1.0775172	0.1947653	185.3982101	1530.8137536	Stable
4	2015-2016	1.968111	1	446.501533	4266.082477	Stable
5	2017-2019	2	0	840.6821	7535.2303	Normal
6	2020	1.655043	-1	312.919265	6942.862946	Stable

Source: From researcher's data analysis

Figure-92 : Distribution of total stock prices



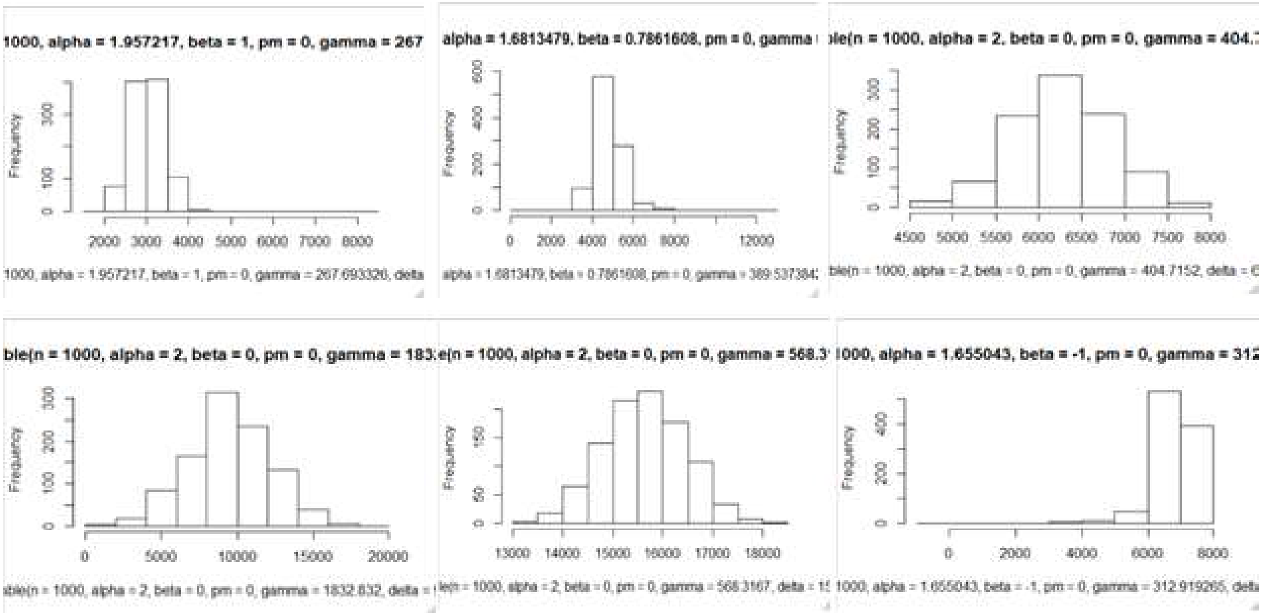
Stock-32: NestleIND

Table-190 : Tail index and classification of the total price random variable

S.No.	Year	Parameters				Domain for total
		α	β	σ	μ	
1	2007-2009	1.957217	1	267.693326	3021.032534	Stable
2	2010	1.6813479	0.7861608	389.5373842	4638.7546600	Stable
3	2011-2014	2	0	404.7152	6286.7360	Normal
4	2015-2016	2	0	1832.832	9478.520	Normal
5	2017-2019	2	0	568.3167	15625.6998	Normal
6	2020	1.655043	-1	312.919265	6942.862976	Stable

Source: From researcher's data analysis

Figure-93 : Distribution of total stock prices



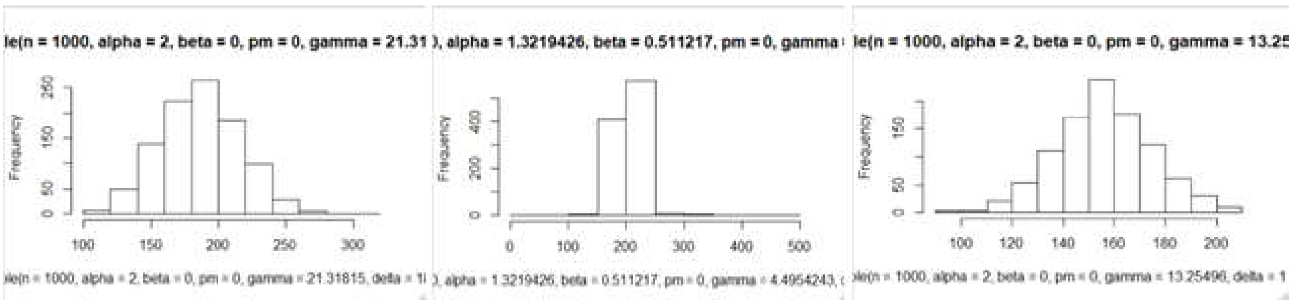
Stock-33: NTPC

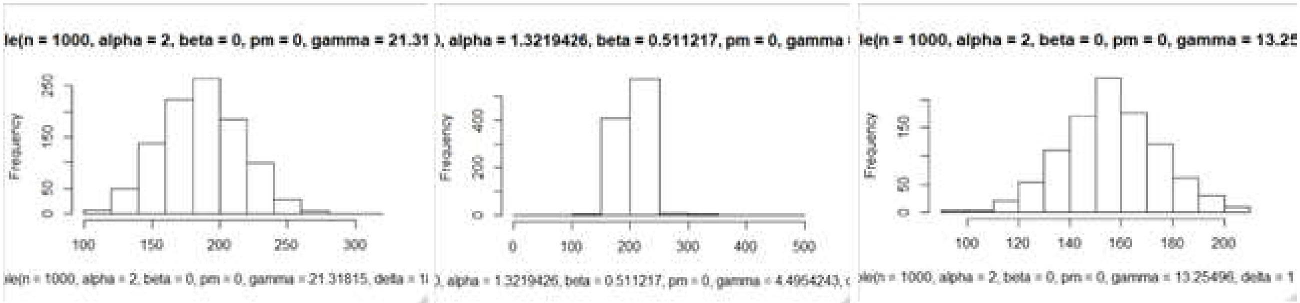
Table-191 : Tail index and classification of the total price random variable

S.No.	Year	Parameters				Domain for total
		α	β	σ	μ	
1	2007-2009	2	0	21.31815	186.56105	Normal
2	2010	1.3219426	0.511217	4.4954243	200.5073539	Stable
3	2011-2014	2	0	13.25496	155.91981	Normal
4	2015-2016	2	0	9.357005	142.126666	Normal
5	2017-2019	2	0	14.18062	152.98172	Normal
6	2020	1.591500	-1	4.492389	113.661150	Stable

Source: From researcher's data analysis

Figure-94 : Distribution of total stock prices





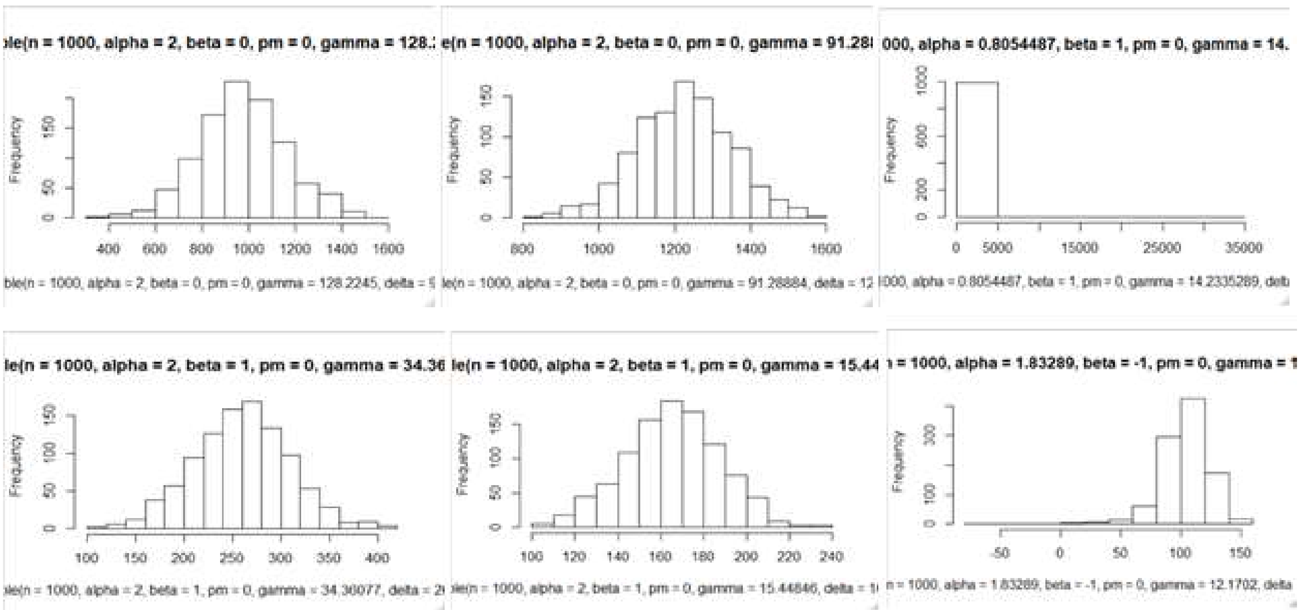
Stock-34: ONGC

Table-192 : Tail index and classification of the total price random variable

S.No.	Year	Parameters				Domain for total
		α	β	σ	μ	
1	2007-2009	2	0	128.2245	964.3138	Normal
2	2010	2	0	91.28884	1217.03955	Normal
3	2011-2014	0.8054487	1	14.2335289	287.6894569	Stable
4	2015-2016	2	0	34.36077	260.14022	Normal
5	2017-2019	2	0	15.44846	165.27753	Normal
6	2020	1.83289	-1	12.17020	107.48063	Stable

Source: From researcher's data analysis

Figure-95 : Distribution of total stock prices



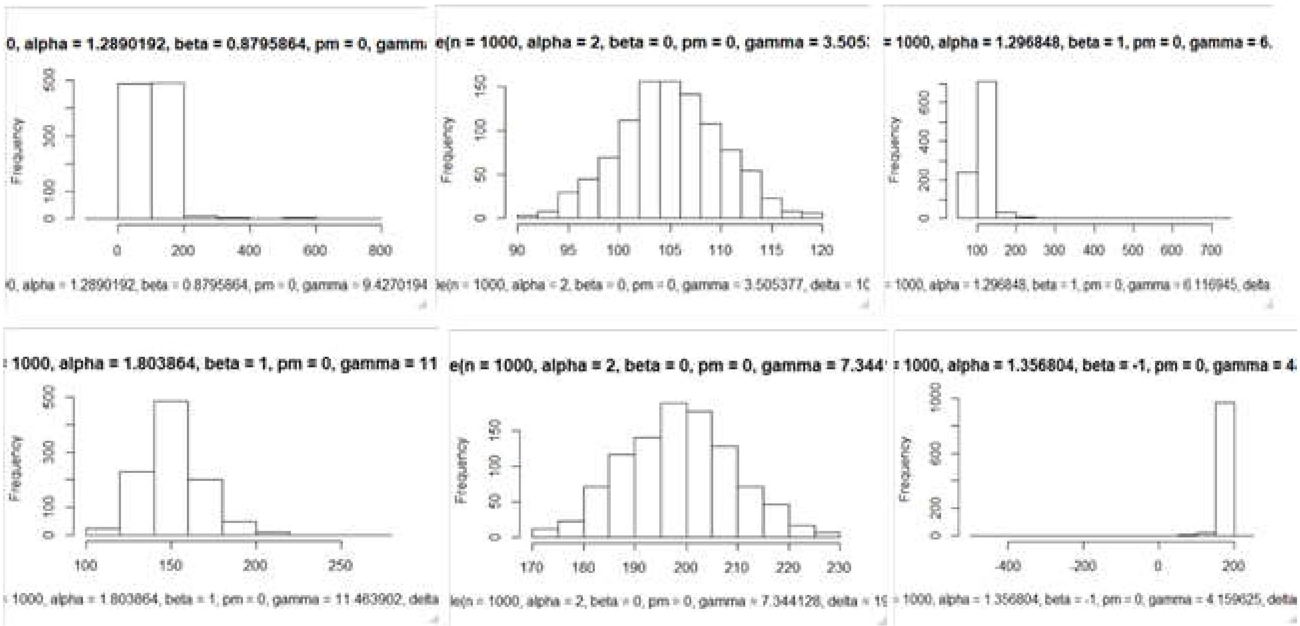
Stock-35: PowerGrid

Table-193 : Tail index and classification of the total price random variable

S.No.	Year	Parameters				Domain for total
		α	β	σ	μ	
1	2007-2009	1.2890192	0.8795864	9.4270194	96.8101110	Stable
2	2010	2	0	3.505377	105.039202	Normal
3	2011-2014	1.296848	1	6.116945	103.341677	Stable
4	2015-2016	1.803864	1	11.463902	147.799255	Stable
5	2017-2019	2	0	7.344128	198.514955	Normal
6	2020	1.356804	-1	4.159625	190.391632	Stable

Source: From researcher's data analysis

Figure-96 : Distribution of total stock prices



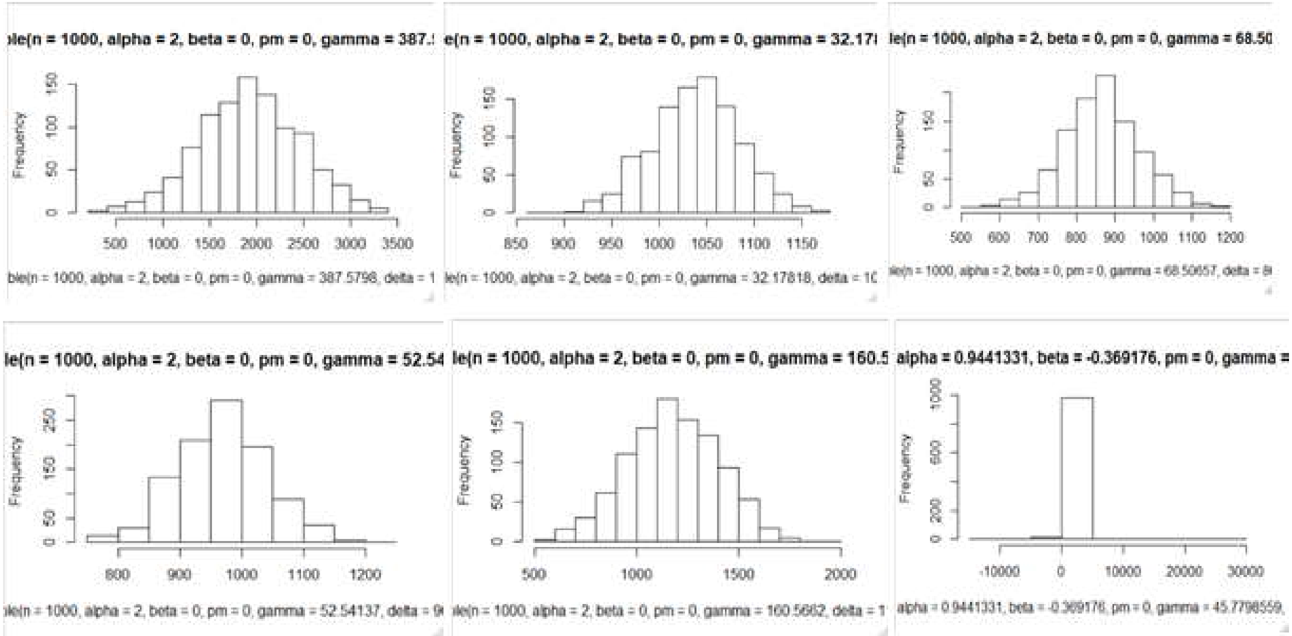
Stock-36: Reliance

Table-194 : Tail index and classification of the total price random variable

S.No.	Year	Parameters				Domain for total
		α	β	σ	μ	
1	2007-2009	2	0	387.5798	1923.7410	Normal
2	2010	2	0	32.17818	1037.00436	Normal
3	2011-2014	2	0	68.50657	866.30395	Normal
4	2015-2016	2	0	52.54137	964.22864	Normal
5	2017-2019	2	0	160.5662	1186.8232	Normal
6	2020	0.9441331	-0.369176	45.7798559	1428.9102599	Stable

Source: From researcher's data analysis

Figure-97 : Distribution of total stock prices



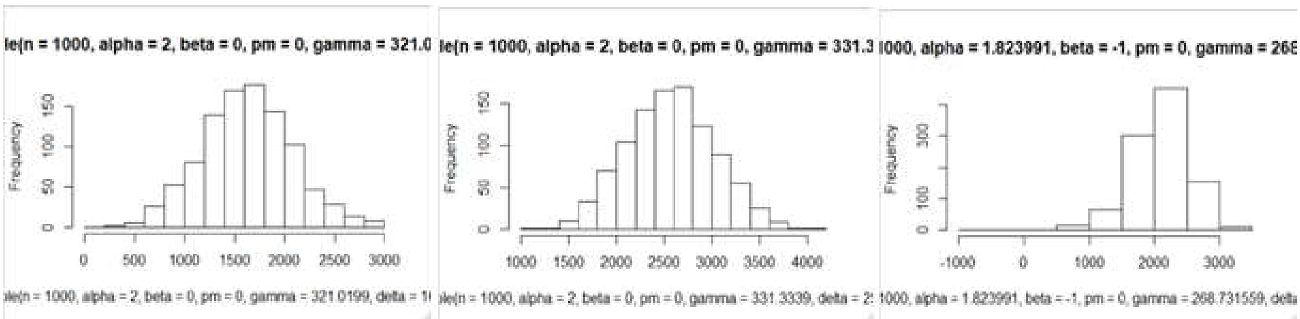
Stock-37: SBIN

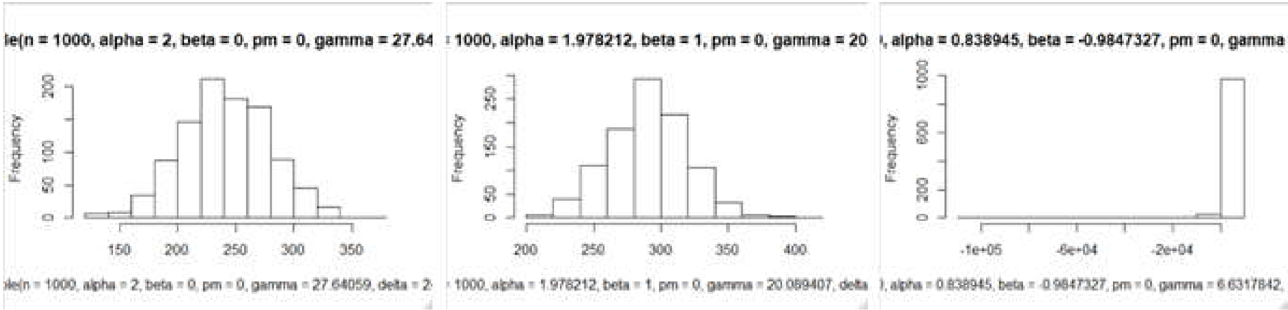
Table-195 : Tail index and classification of the total price random variable

S.No.	Year	Parameters				Domain for total
		α	β	σ	μ	
1	2007-2009	2	0	321.0199	1601.4541	Normal
2	2010	2	0	331.3339	2528.6453	Normal
3	2011-2014	1.823991	-1	268.731559	2152.599217	Stable
4	2015-2016	2	0	27.64059	242.53558	Normal
5	2017-2019	1.978212	1	20.089407	289.818833	Stable
6	2020	0.8389450	-0.9847327	6.6317842	322.7460972	Stable

Source: From researcher's data analysis

Figure-98 : Distribution of total stock prices





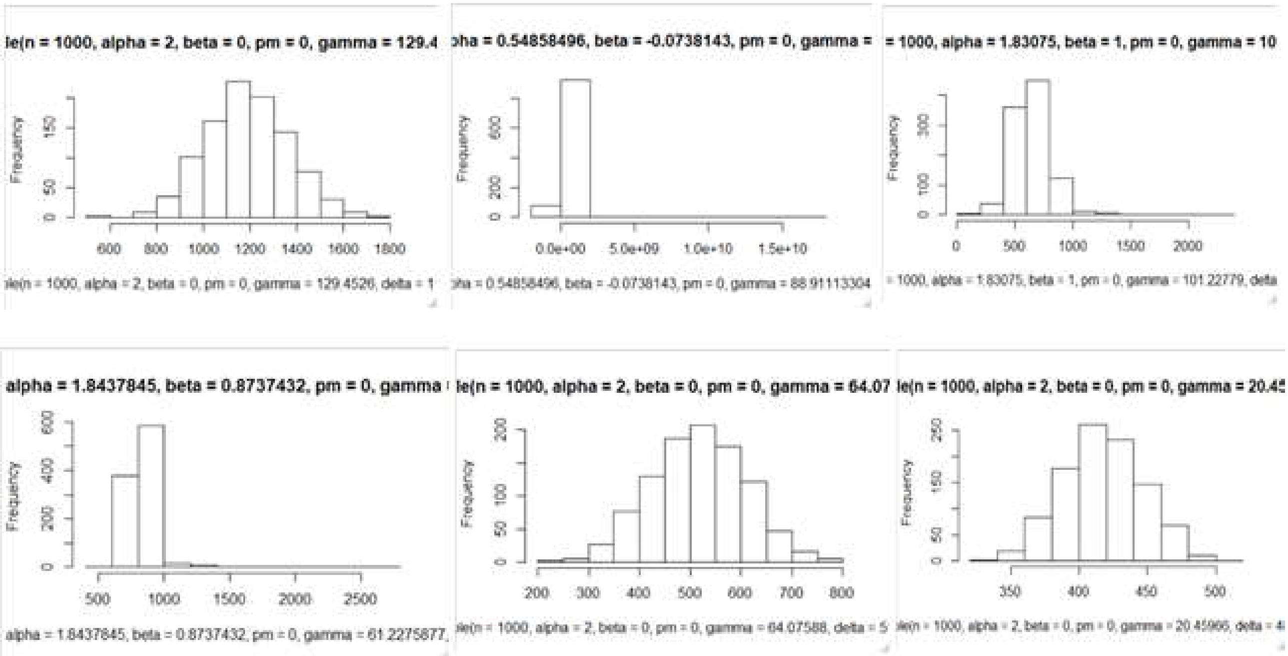
Stock-38: Sun Pharma

Table-196 : Tail index and classification of the total price random variable

S.No.	Year	Parameters				Domain for total
		α	β	σ	μ	
1	2007-2009	2	0	129.4526	1185.1925	Normal
2	2010	0.54858496	-0.0738143	88.91113304	1702.11052169	Stable
3	2011-2014	1.83075	1	101.22779	622.44391	Stable
4	2015-2016	1.8437845	0.8737432	61.2275877	821.8815693	Stable
5	2017-2019	2	0	64.07588	518.51172	Normal
6	2020	2	0	20.45966	418.16251	Normal

Source: From researcher's data analysis

Figure-99 : Distribution of total stock prices



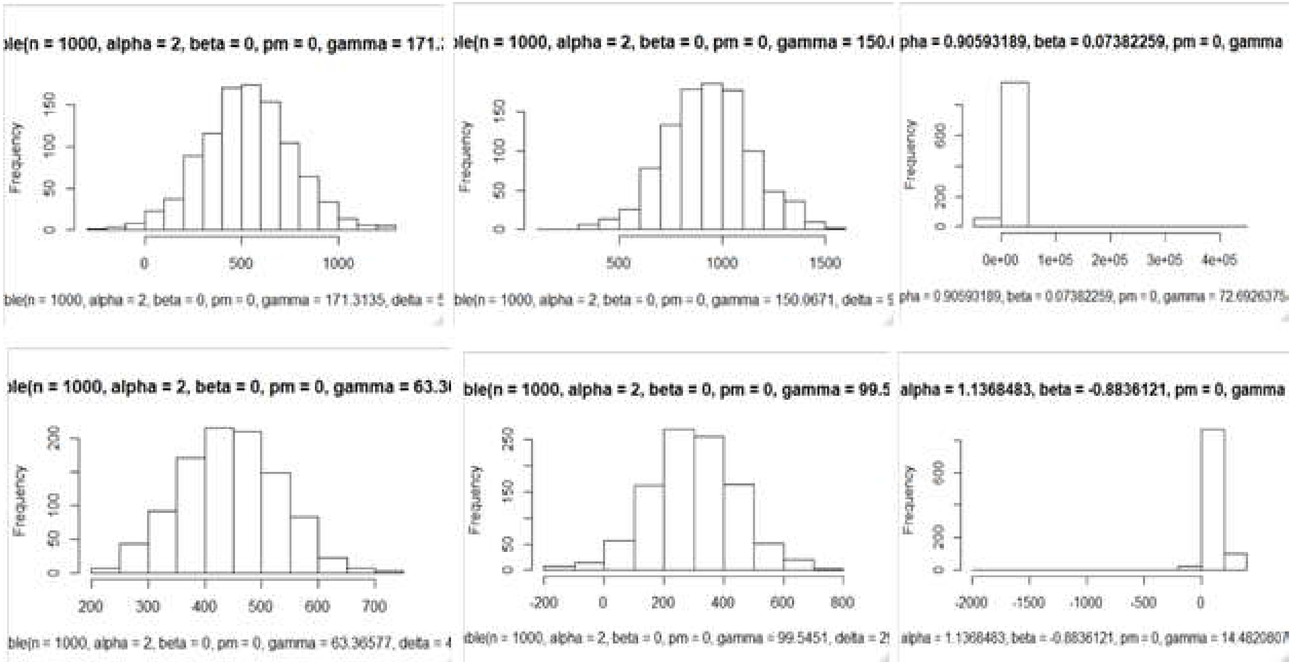
Stock-39: Tata Motors

Table-197 : Tail index and classification of the total price random variable

S.No.	Year	Parameters				Domain for total
		α	β	σ	μ	
1	2007-2009	2	0	171.3135	536.7209	Normal
2	2010	2	0	150.0671	933.3757	Normal
3	2011-2014	0.90593189	0.07382259	72.69263755	442.57129372	Stable
4	2015-2016	2	0	63.36577	446.14730	Normal
5	2017-2019	2	0	99.5451	298.9613	Normal
6	2020	1.1368483	-0.8836121	14.4820807	184.3646952	Stable

Source: From researcher's data analysis

Figure -100 : Distribution of total stock prices



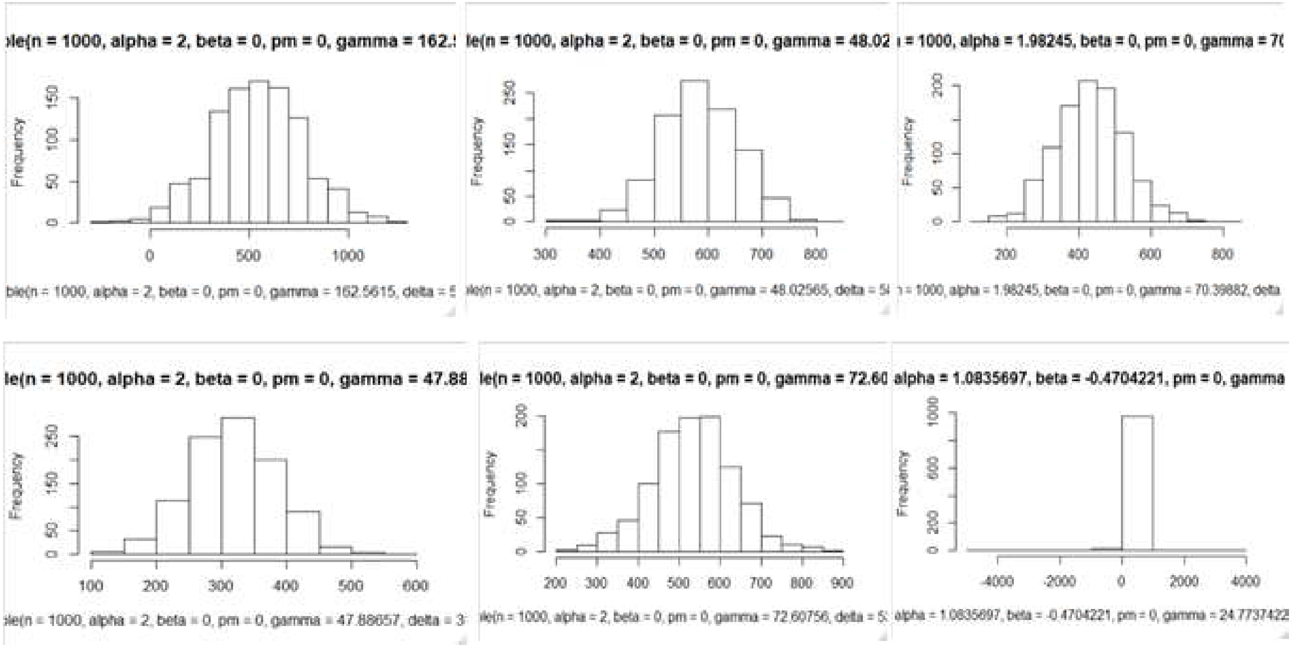
Stock-40: Tata Steel

Table-198 : Tail index and classification of the total price random variable

S.No.	Year	Parameters				Domain for total
		α	β	σ	μ	
1	2007-2009	2	0	162.5615	541.3234	Normal
2	2010	2	0	48.02565	584.54414	Normal
3	2011-2014	1.98245	0	70.39882	434.33092	Normal
4	2015-2016	2	0	47.88657	319.24359	Normal
5	2017-2019	2	0	72.60756	538.37519	Normal
6	2020	1.0835697	-0.4704221	24.7737422	453.0814632	Stable

Source: From researcher's data analysis

Figure-101 : Distribution of total stock prices



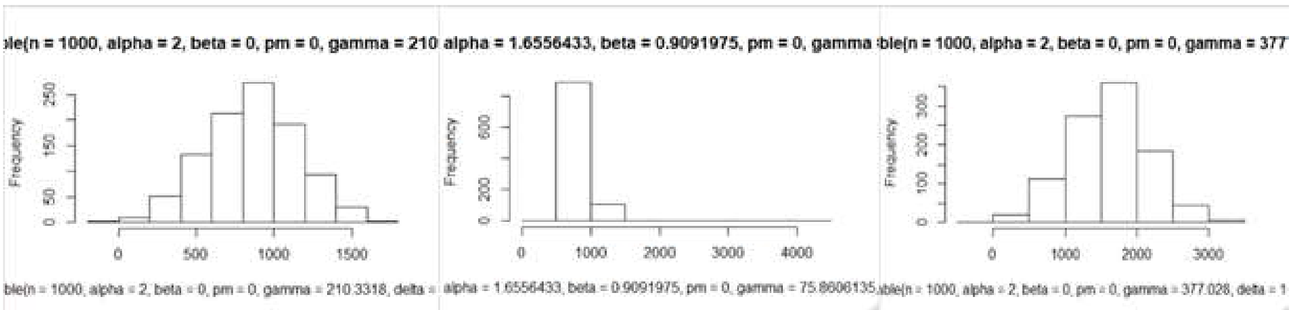
Stock-41: TCS

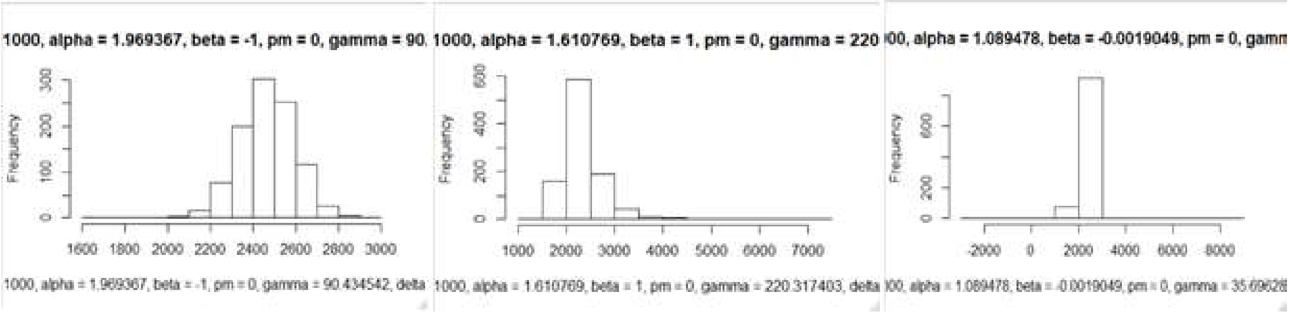
Table-199 : Tail index and classification of the total price random variable

S.No.	Year	Parameters				Domain for total
		α	β	σ	μ	
1	2007-2009	2	0	210.3318	838.8975	Normal
2	2010	1.6556433	0.9091975	75.8606135	828.9894519	Stable
3	2011-2014	2	0	377.028	1614.197	Normal
4	2015-2016	1.969367	-1	90.434542	2480.865117	Stable
5	2017-2019	1.610769	1	220.317403	2249.612183	Stable
6	2020	1.089478	-0.0019049	35.69628	2111.826	Stable

Source: From researcher's data analysis

Figure-102 : Distribution of stock prices





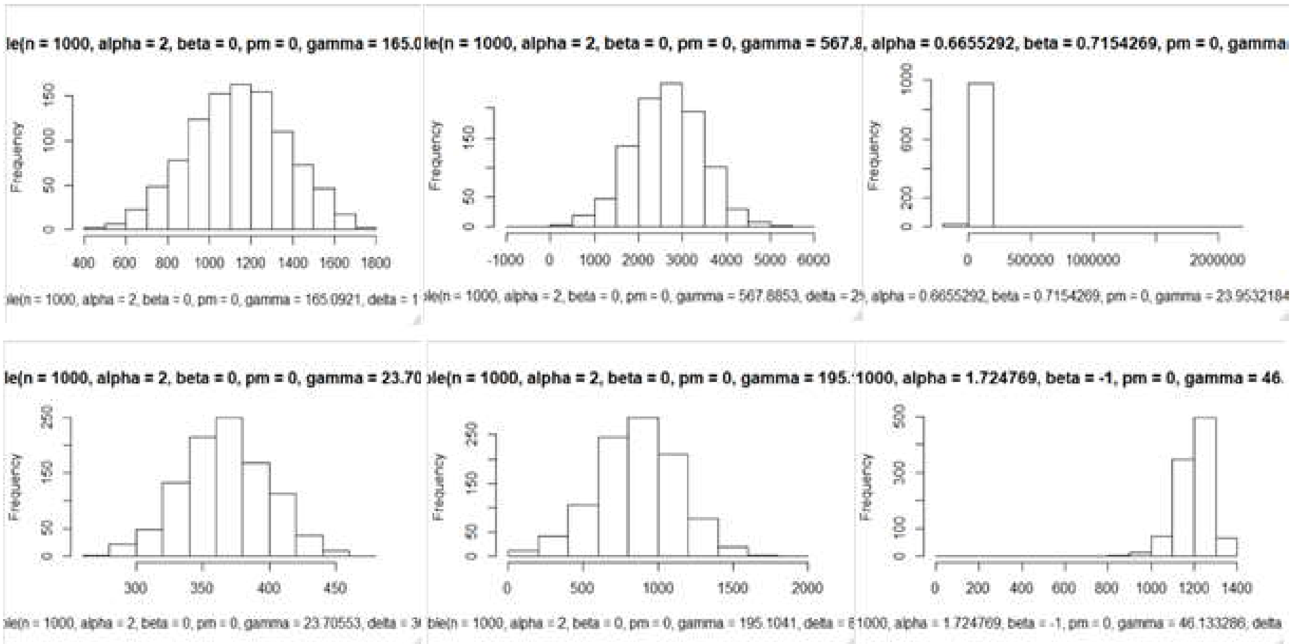
Stock-42: Titan

Table-200 : Tail index and classification of the total price random variable

S.No.	Year	Parameters				Domain for total
		α	β	σ	μ	
1	2007-2009	2	0	165.0921	1133.3726	Normal
2	2010	2	0	567.8853	2589.0636	Normal
3	2011-2014	0.6655292	0.7154269	23.9532184	233.9569570	Stable
4	2015-2016	2	0	23.70553	367.42969	Normal
5	2017-2019	2	0	195.1041	857.0489	Normal
6	2020	1.724769	-1	46.133286	1220.243543	Stable

Source: From researcher's data analysis

Figure-103 : Distribution of total stock prices



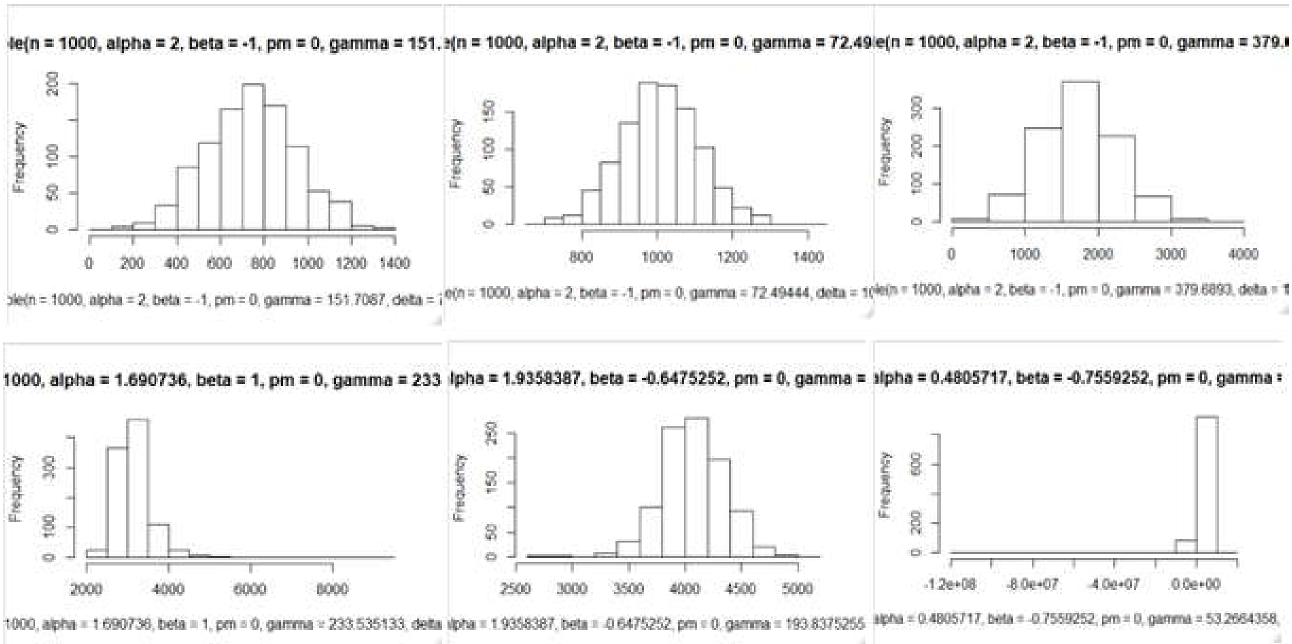
Stock-43: Ultra Cemco

Table-201 : Tail index and classification of the total price random variable

S.No.	Year	Parameters				Domain for total
		α	β	σ	μ	
1	2007-2009	2	0	151.7087	738.2575	Normal
2	2010	2	0	72.49444	1011.80532	Normal
3	2011-2014	2	0	379.6893	1711.7737	Normal
4	2015-2016	1.690736	1	233.535133	3054.147673	Stable
5	2017-2019	1.9358387	-0.6475252	193.8375255	4077.5442735	Stable
6	2020	0.4805717	-0.7559252	53.2664358	4427.7661061	Stable

Source: From researcher's data analysis

Figure-104 : Distribution of total stock prices



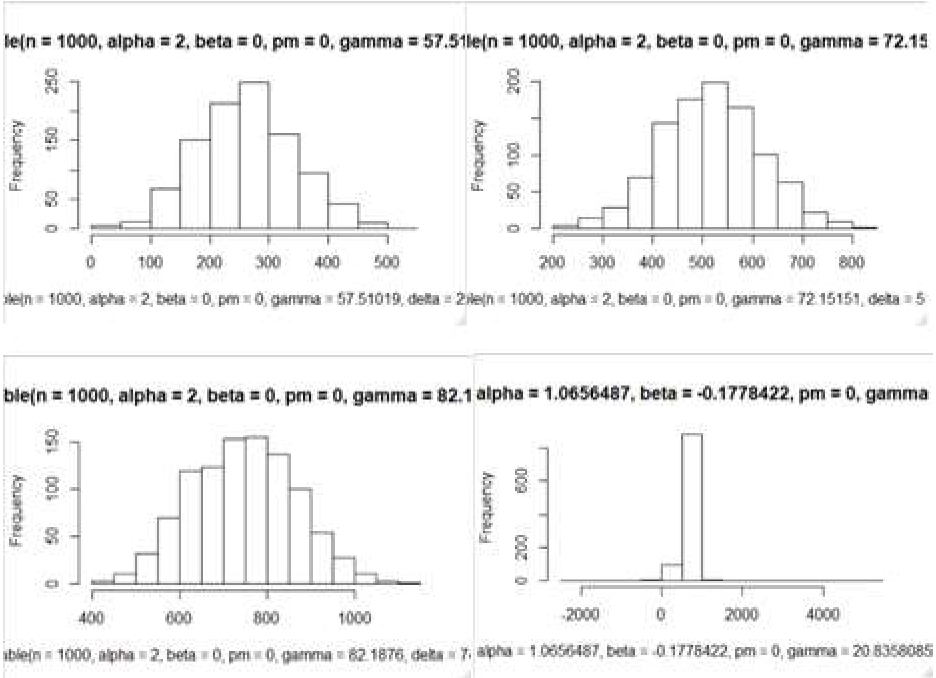
Stock-44: UPL

Table-202 : Tail index and classification of the total price random variable

S.No.	Year	Parameters				Domain for total
		α	β	σ	μ	
1	2011-2014	2	0	57.51019	265.40164	Normal
2	2015-2016	2	0	72.15151	516.57394	Normal
3	2017-2019	2	0	82.1876	741.6079	Normal
4	2020	1.0656487	-0.1778422	20.8358085	567.7807188	Stable

Source: From researcher's data analysis

Figure-105 : Distribution of total stock prices



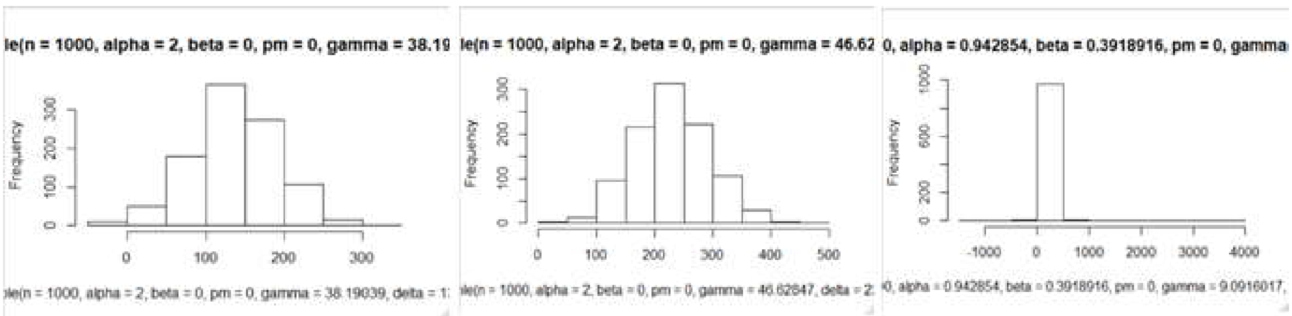
Stock-45: VEDL

Table-203 : Tail index and classification of the total price random variable

S.No.	Year	Parameters				Domain for total
		α	β	σ	μ	
1	2015-2016	2	0	38.19039	135.97283	Normal
2	2017-2019	2	0	46.62847	231.29696	Normal
3	2020	0.9428540	0.3918916	9.0916017	139.8423360	Stable

Source: From researcher's data analysis

Figure-106 : Distribution of total stock prices



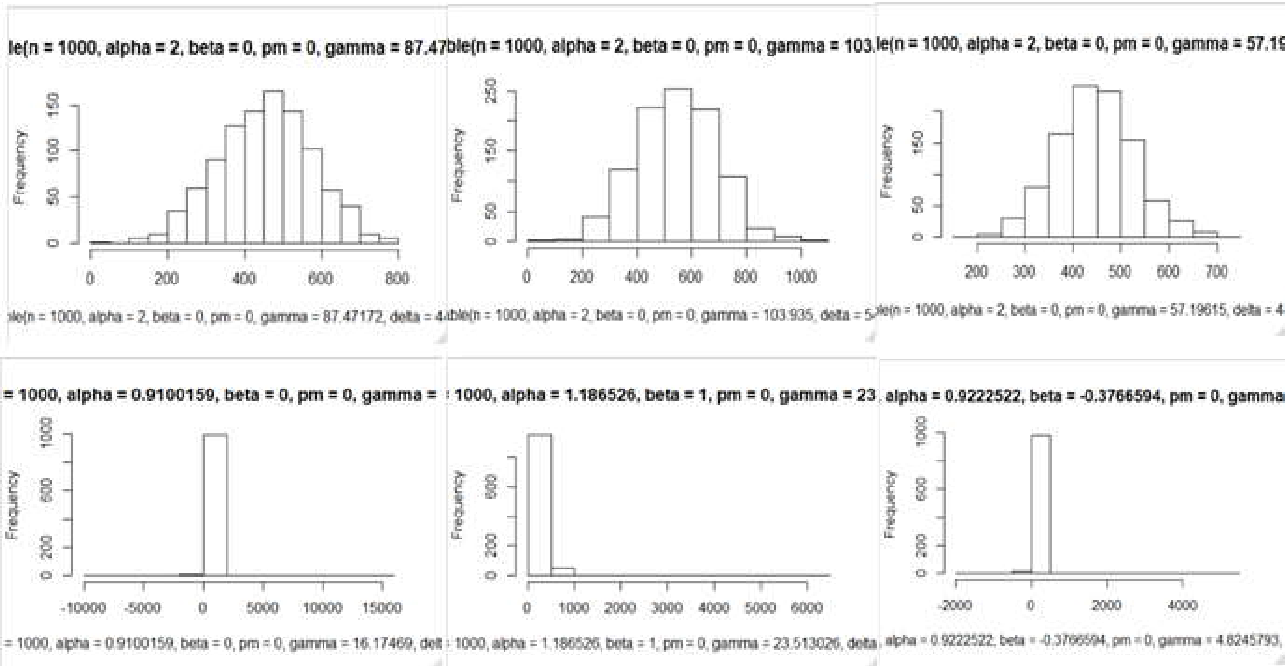
Stock-46: Wipro

Table-204 : Tail index and classification of the total price random variable

S.No.	Year	Parameters				Domain for total
		α	β	σ	μ	
1	2007-2009	2	0	87.47172	449.39049	Normal
2	2010	2	0	103.9350	541.5864	Normal
3	2011-2014	2	0	57.19615	445.71057	Normal
4	2015-2016	0.9100159	0	16.17469	550.0902	Stable
5	2017-2019	1.186526	1	23.513026	316.346386	Stable
6	2020	0.9222522	-0.3766594	4.8245793	241.2596202	Stable

Source: From researcher's data analysis

Figure-107 : Distribution of total stock prices



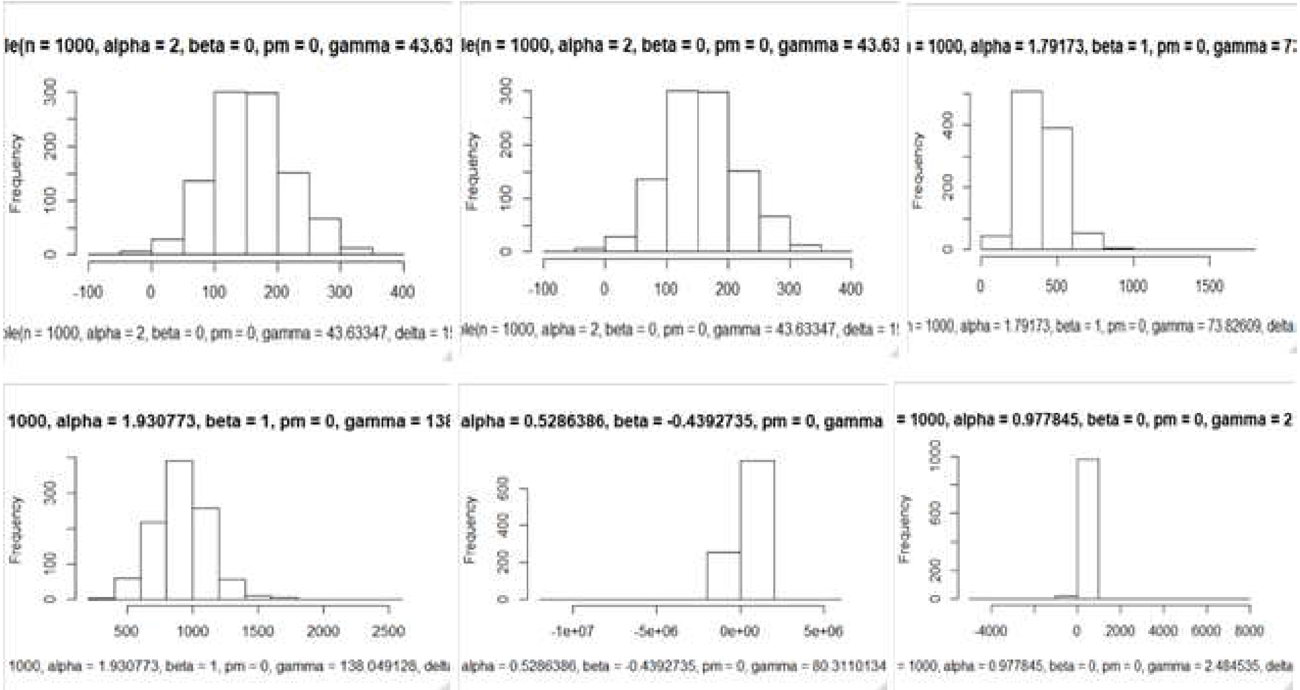
Stock-47: Yes Bank

Table-205 : Tail index and classification of the total price random variable

S.No.	Year	Parameters				Domain for total
		α	β	σ	μ	
1	2007-2009	2	0	43.63347	156.72178	Normal
2	2010	2	0	28.26784	293.67879	Normal
3	2011-2014	1.79173	1	73.82609	379.28049	Stable
4	2015-2016	1.930773	1	138.049128	907.485042	Stable
5	2017-2019	0.5286386	-0.4392735	80.3110134	272.5240707	Stable
6	2020	0.977845	0	2.484535	45.570633	Stable

Source: From researcher's data analysis

Figure-108 : Distribution of total stock prices



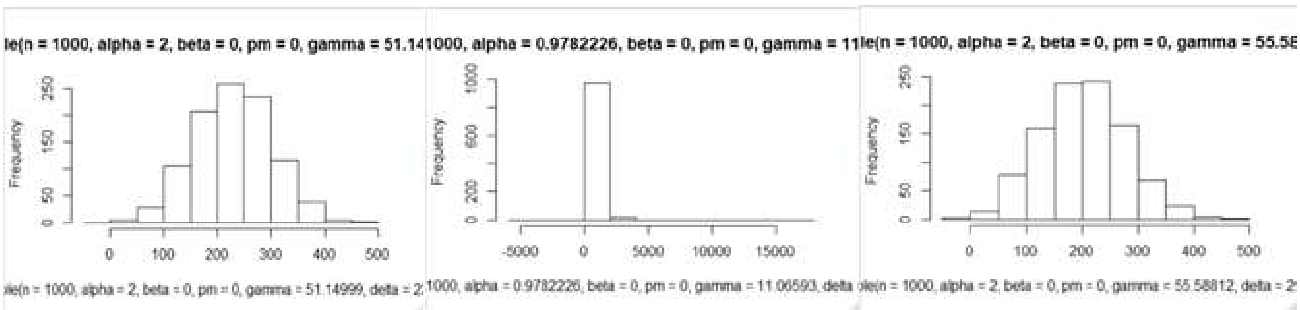
Stock-48: Zeel

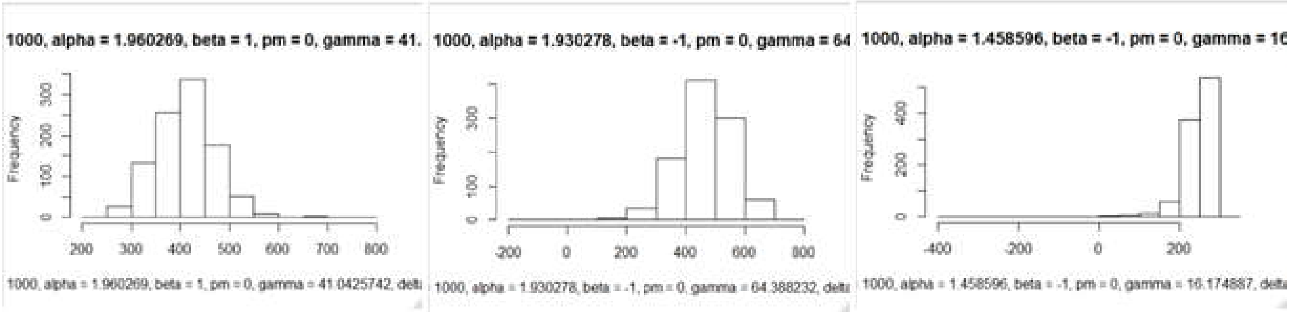
Table-206 : Tail index and classification of the total price random variable

S.No.	Year	Parameters				Domain for total
		α	β	σ	μ	
1	2007-2009	2	0	51.14999	225.29321	Normal
2	2010	0.9782226	0	11.0659300	1852.3074408	Stable
3	2011-2014	2	0	55.58812	204.44342	Normal
4	2015-2016	1.960269	1	41.042574	410.249922	Stable
5	2017-2019	1.930278	-1	64.388232	474.043558	Stable
6	2020	1.458596	-1	16.174887	257.118522	Stable

Source: From researcher's data analysis

Figure-109 : Distribution of total stock prices





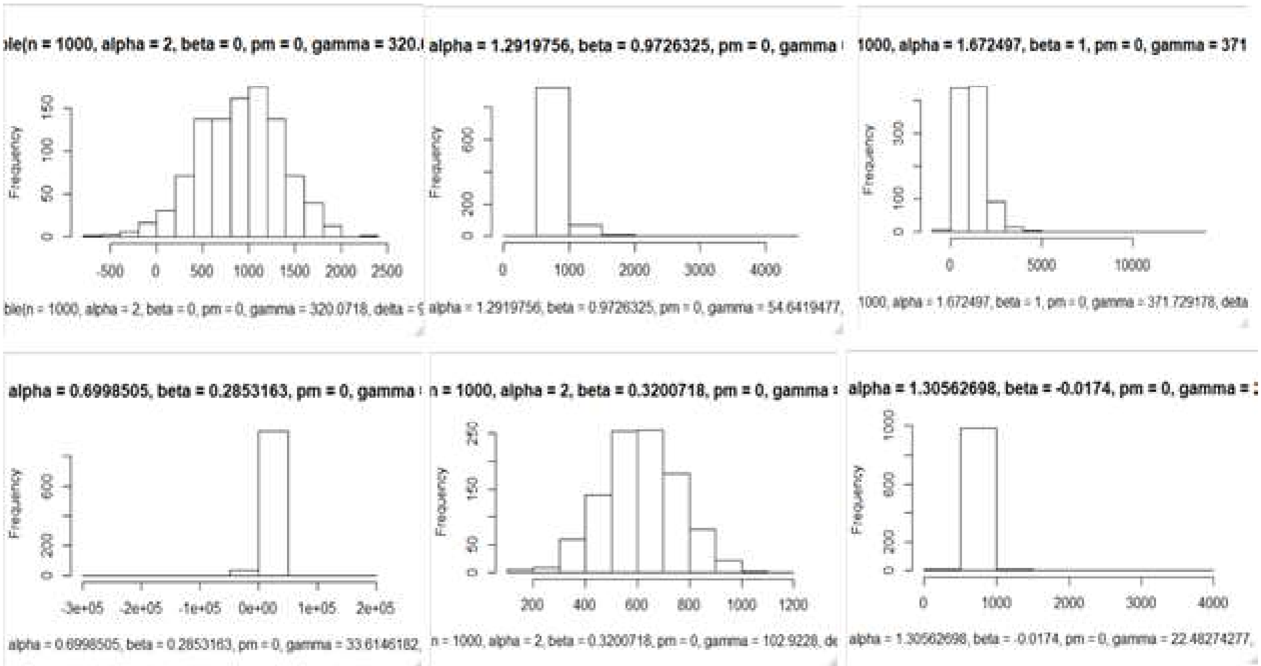
Stock-49: TECHM

Table-207 : Tail index and classification of the total price random variable

S.No.	Year	Parameters				Domain for total
		α	β	σ	μ	
1	2007-2009	2	0	320.0718	906.6542	Normal
2	2010	1.2919756	0.9726325	54.6419477	724.0171071	Stable
3	2011-2014	1.672497	1	371.729178	1017.522244	Stable
4	2015-2016	0.6998505	0.2853163	33.6146182	497.6370973	Stable
5	2017-2019	2	0.3200718	102.9228	617.2900	Normal
6	2020	1.30562698	-0.0174000	22.48274277	774.42323076	Stable

Source: From researcher's data analysis

Figure-110 : Distribution of total stock prices



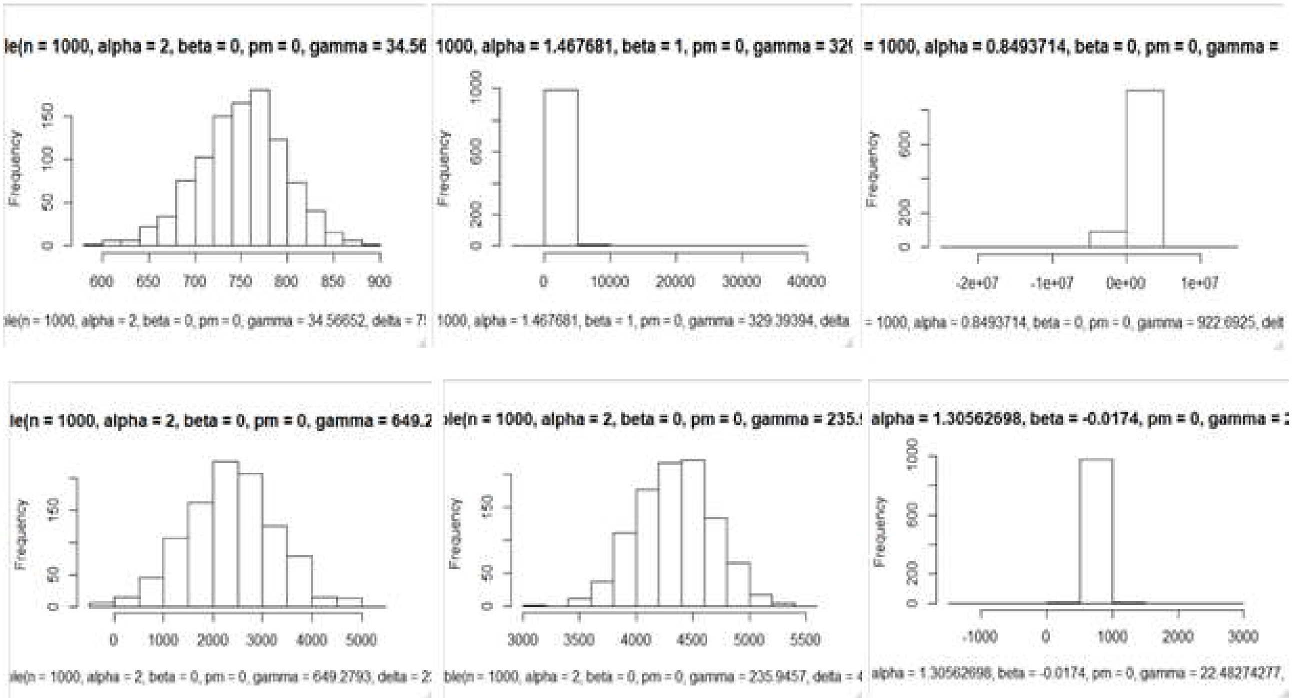
Stock-50: Bajaj Finance

Table-208 : Tail index and classification of the total price random variable

S.No.	Year	Parameters				Domain for total
		α	β	σ	μ	
1	2007-2009	2	0	34.56652	750.34784	Normal
2	2010	1.467681	1	329.393940	1129.097492	Stable
3	2011-2014	0.8493714	0	922.6925	5155.836	Stable
4	2015-2016	2	0	649.2793	2345.0756	Normal
5	2017-2019	2	0	235.9457	4343.6160	Normal
6	2020	1.30562698	-0.0174000	22.48274277	774.42323076	Stable

Source: From researcher's data analysis

Figure-111 : Distribution of total stock prices



Overall Conclusion on the total stock price random variable for the individual stocks

We now present the discussion on total price random variable. Note that, the total price random variable converges to one of the two types of distributions. The first one is the normal distribution and the second is the stable law. Based on the stable index or exponent, we classify the distribution into one of the two types. Again, the idea is to describe the nature of the behaviour the total stock price random variable has and note the changes in the distributions, with change in the time points. We again present the analysis for few stocks and others can be interpreted in the same way.

Table-159 gives the analysis for the first stock Adaniports. One can observe that the stock has almost stable behaviour during many time points. Only during the time period 2015-16 the behaviour is normal. This indicates that Adaniports have faced turbulence during the market crashes and the same can be seen in the index value. During the period 2007-09, the total price random variable has an index value less than 2 and the is positively skewed. There is an improvement during the period 2010. One can note that the behaviour has moved towards normality and less skewness. During the period 2011-14, again, the behaviour has become stable but symmetric. Overall the behaviour is stable throughout. From this we conclude that the total stock price random variable has a stable distribution, where the variance is infinite. Hence, one has to carefully take decisions on the cumulative stock prices with respect to Adaniports.

Table-161 gives analysis related to Axis bank. Interestingly, it has almost normal pattern during the market crashes. One reason for this behaviour could be, the affect due to market crash on the total stock price of Axis bank is limited. Also, the data may not have many extremes during the periods. That is, not a drastic jump in the stock prices is noted. One can note here that the sum or total gets affected by the extremes. Absence of extremes may indicate that the stock prices didn't get much affected by the market crashes. This also can be seen from the index values presented in table-11.

On similar lines, one can interpret and draw conclusions on other stocks. Overall, one can observe that the total stock prices fluctuate between normal and stable distributions. In many cases, the behaviour has equally shifted from each other. While drawing conclusions on any stock, one can observe the index value and the beta value. Based on these two values appropriate conclusions can be drawn. If the value of index is close 2, then one can conclude that the behaviour is almost normal. If not, then the behaviour is stable.

We now present a table that gives the stocks with the corresponding frequency of domain change, with change in the events. Based on the number of times the domain has changed, we classify the stocks into three categories. Category-1: Highly affected by the market crashes (4 to 6 times stable), Category-2: Moderately affected by the market crashes (2 to 3 times stable), Category-3: Low affected by the market crashes (0 to 1 time stable)

Table-B : Stocks Classification based on the change of domain

Symbol	Stable	Normal	Remarks
ADANIPORTS	5	1	High Affect
HCLTECH	4	2	High Affect
KOTAKBANK	4	2	High Affect
MARUTI	4	2	High Affect
POWERGRID	4	2	High Affect
TCS	4	2	High Affect
TECHM	4	2	High Affect
YESBANK	4	2	High Affect
ZEEL	4	2	High Affect
ASIANPAINT	3	3	Moderate Affect
BAJAJFINSV	3	3	Moderate Affect
BAJFINANCE	3	3	Moderate Affect
BPCL	3	3	Moderate Affect
BRITANNIA	3	3	Moderate Affect
DRREDDY	3	3	Moderate Affect
EICHERMOT	3	3	Moderate Affect
HDFC	3	3	Moderate Affect
HEROMOTOCO	3	3	Moderate Affect
ICICIBANK	3	3	Moderate Affect
INFRATEL	3	1	Moderate Affect
IOC	3	3	Moderate Affect
ITC	3	3	Moderate Affect
LT	3	3	Moderate Affect
M&M	3	3	Moderate Affect
NESTLEIND	3	3	Moderate Affect
SBIN	3	3	Moderate Affect
SUNPHARMA	3	3	Moderate Affect
ULTRACEMCO	3	3	Moderate Affect
WIPRO	3	3	Moderate Affect
AXISBANK	2	4	Moderate Affect
BHARTIARTL	2	4	Moderate Affect
CIPLA	2	4	Moderate Affect
COALINDIA	2	3	Moderate Affect
GAIL	2	4	Moderate Affect
GRASIM	2	4	Moderate Affect
HDFCBANK	2	4	Moderate Affect
HINDALCO	2	4	Moderate Affect
INDUSINDBK	2	4	Moderate Affect
INFY	2	4	Moderate Affect
JSWSTEEL	2	4	Moderate Affect
NTPC	2	4	Moderate Affect
ONGC	2	4	Moderate Affect
TATAMOTORS	2	4	Moderate Affect
TITAN	2	4	Moderate Affect
BAJAJ-AUTO	1	5	Low Affect
RELIANCE	1	5	Low Affect
TATASTEEL	1	5	Low Affect
UPL	1	3	Low Affect
VEDL	1	2	Low Affect
HINDUNILVR	0	6	Low Affect

Source: From researcher's data analysis

From the above table one can get the stocks that got affected by the market crashes. Those stocks that have stable domain a greater number of times have to be studied further, before considering for investment or taking any decision.

Conclusion

The main objectives of the study are three-fold. The first one is, identifying the alternative probability distributions that best fits the stock price random variable and estimate the tail index. Based on the tail index value to estimate the thickness of the tail. The second is, to identify the domain the extreme stock price random variables belong to. The third one is, to identify the domain of the total stock price random variable. This is descriptive in nature and we present the results based on the data analysis.

We fit all possible probability models to find the best fit and estimate the tail index value to find the thickness of the tail. Based on the thickness of the tail we draw conclusions on the behaviour of the stock prices during the selected time period. The value of the tail index decides the thickness of the tail and the behaviour of the stock price random variable during that time period. From the analysis we found that, most of the stocks got affected due to the financial crisis 2007-2009 but have been out of the situation to regain back their positions. During other periods few stocks have lost drastically while others didn't lose much. Table-A gives the details of the stocks that have lost drastically during the market crashes and stocks which haven't lost much. We conclude that stocks with index value less than 3 have turbulences during the market crash period and have heavy tails. This indicates that those stocks have got affected by the crashes. Stocks with index value more than 3 have performed better during the market crash periods. Note that, a stock can have index values that fluctuate with values less than 3 and more than 3 as the time period changes. Based on the frequency of change, one can conclude on the weakness of the stock to the market crashes. Also, such stocks will have high volatility and collapse during the crisis period. Whereas few stocks whose index values do not change frequently do not collapse during the market crashes. But one has to consider other factors related to the market or the company or any other external factors while drawing complete conclusions. The inferences drawn based on the index values give, one an idea on the behaviour of the stock and taking this as the starting point one can investigate on other aspects. From our analysis, we have found those stocks that have got highly affected by the market crashes and those that have not got affected much. Table-A gives the details of the same. We finally conclude that studying the tail behaviour of the stock prices is very important to know the effect of the events that happen around. This will help one in identifying the probability model that best fits the behaviour of the stock prices. When none of the probability models best fit the stock prices, then studying the tail thickness will help one in understanding the behaviour. From the study we propose to study the tail behaviour of the stock prices, before taking any decision or using any other methods for further analysis. Taking decisions without this, may sometimes lead to wrong conclusions or other methods may not perform well. Another important point that we would like to highlight is, studying the change in the index value with change in the events or the time periods will help one to take decision on investments. For example, one may avoid a stock if the stock's index fluctuates or change frequently at different time points.

The second objective of the study is, to identify the domain the maximum and minimum stock prices belong to. One can compute the risk using the probability model identified. From the analysis we conclude that most of the stocks have Weibull and Gumbel laws as the probability models and the same can be used to compute the associated probabilities. In few cases the extremes belong to Fréchet law and the same can be used for computation of probabilities. Here, the objective is only to describe the behaviour of the extreme stock price random variable.

The third objective is to identify the behaviour of the total price random variable. From the analysis we conclude that, the total stock prices belong to the domain of normal in many cases and in other cases to the domain of a stable distribution. This is interesting. In cases where the domain is normal, we conclude that the extremes generated during the market crash hasn't affected the cumulative stock prices during those time periods. It is a well-known fact that extremes affect the total or cumulative returns. If one wishes to check if there exist extremes or the effect of extremes, then one can study the behaviour of the cumulative returns. In the current study, we use the same to study the effect of market crashes on the stock price behaviour. From the analysis, found those time periods where the market crashes have affected the stock prices and cases where they haven't affected. All the cases or time periods where the domain is normal, we conclude that the market crashes haven't affected the stock prices. All the cases or time periods where the domain is stable, we conclude that the market crashes have affected the stock prices. When the domain is normal, majority of the stock prices will be close to the average stock price and 99.73% of the stock prices lie within the 3-sigma limits. If the domain is stable, then based on the index value, one can conclude on the tail and on the existence of the moments. When the index value is less than one, then the tails will be heavy and even mean do not exist. If the index value is between 1 and 2, then mean exists but variance will be infinite. This indicates that the market crashes have affected the stock prices. Table-B gives the details of the stocks that have got affected by the market crashes.

Managerial Implications

From the analysis and findings, we have the following managerial implications

1. An investor looks for a stock that gives better returns as well as the one which is stable. The word "stable" here means, a stock that gets less affected by the market crashes. Through the current study, we propose a mechanism to find the stocks that are stable. One can calculate the tail index value at different time points, which are considered to be critical, and based on the level of the tail index, a stock can be classified as stable or unstable. The tail index value can be observed at these time points and, if the values fall below the value 3 for several times, then one can classify the stock as unstable.

2. Over the years researchers and practitioners have been using traditional probability models like normal, log-normal, student-t, Cauchy, Pareto etc. Through the current study, we propose other probability models that can be used to study the behaviour of the stock prices. Also, during crisis, there may not be any model that can best fit the behaviour. In such cases, we propose to estimate the tail index and based on the level one can understand the behaviour of the stock prices. For example, if the value of tail index is less than 2 for a stock, then one can use a heavy tailed distribution to model the stock prices. In such cases no traditional model can best fit the behaviour of the stock prices.

3. In few cases, one may be interested in studying the behaviour of the extreme stock prices-maximum and minimum. This may help to calculate the value at risk (VAR) or other risk measures. Through this study, we have identified the domain of extreme value distributions, to which the extremes of the stocks belong to. Among the three types, Weibull and Gumbel laws form the important domains for the extremes. Fréchet law forms as domain sometimes. Note that, the domains are identified at all the time points considered. This will help one to note the changes in the domain with changes in the time points. Accordingly, one can calculate the required risk measures using the densify function or other properties of the extreme probability models. Through this study, we propose the domains for each of the stocks, that can be considered for calculations.

4. When a market crash occurs, most of the stocks' price fall and sometimes there may be an increase in stock's price if the market booms. In such cases, it is expected that these extremes affect the performance of the stock. But few stocks may sustain the changes and perform as earlier or may not get affected drastically. To check this, one can consider the total stock price random variable and study its behaviour during the time periods. It is well known that the total or cumulative stock price random variable converges either to a normal domain or to a stable domain. If the domain is normal, then one can conclude that the market crash didn't impact the behaviour drastically. Note that, the prices might have fallen but still the behaviour of the cumulative prices can be normal. That is, majority of the stock prices tend towards the average stock price. This average stock price can be low or high. But still the behaviour of the stock can be normal. Through this study we have identified the domain of the total stock price random variable for all the 50 stocks considered. Based on the index value the domains are identified. We suggest the researchers or practitioners to study the behaviour of the total stock price random variable, before drawing conclusions on the stock. This has to be considered if one doubts that the stock may collapse due to the recent changes.

The above are the major managerial implications of the study. One can adopt these before drawing conclusions on the stock behaviour.

Limitation and Scope for Future Work

Any study will have limitations, and these can be considered as future work. We now present the limitations of the current study and the future work.

1. The current study considers major time periods during which either the financial crisis or market crashes have occurred. We haven't considered events related to individual stocks. One can consider the events specific to each of the stocks and perform in depth analysis.
2. We have considered a descriptive research design as we wish to describe the behaviour of the stock prices and through this, we have described the behaviour at three levels. One can consider other research designs to find out the reasons for these changes, where the answers could be provided for "why".
3. We haven't considered fitting a predictive model using the probability model identified. One can fit a predictive model using the probability model for each of the stocks and predict the stock price movements.
4. One can use the extreme value distributions to calculate the risk measures and other measures to comment on the stock price movements.
5. One can fit multivariate distributions and study the price movements.

These are the major limitations and we propose them as the problems for future work.

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R-Code for computations

```
setwd("E:/Research 2019/Applied projects/Project-2/03.Data/Stock prices")

getwd()
```

```
install.packages("readxl")
install.packages("ptsuite")
install.packages("extRemes")
install.packages("evir")
install.packages("stable")
install.packages("StableEstim")
install.packages("evd")
library(readxl)
library(ptsuite)
library(extRemes)
library(evir)
library(stable)
library(StableEstim)
library(evd)

#Data input
events=read_excel(file.choose(), sheet="events")
View(events)
fix(events)
names(events)
dim(events)

# Removing the missing values from the data and dividing the data into blocks
X07_09=na.omit(events[,1])
X_10=na.omit(events[,2])
X11_14=na.omit(events[,3])
X15_16=na.omit(events[,4])
X17_19=na.omit(events[,5])
X_20=na.omit(events[,6])

#estimation of alpha-tail index
alpha_wls(X07_09)
alpha_wls(X_10)
alpha_wls(X11_14)
alpha_wls(X15_16)
alpha_wls(X17_19)
alpha_wls(X_20)
# Model for Maximum
gev(X07_09)
gev(X_10)
gev(X11_14)
gev(X15_16)
gev(X17_19)
gev(X_20,method="BFGS")

#Model for Minimum
gev(-X07_09)
gev(-X_10)
gev(-X11_14)
gev(-X15_16)
gev(-X17_19)
gev(-X_20)

# Stable parameter estimation and Plotting
install.packages("libstableR")
library(libstableR)
install.packages("stabledist")
library(stabledist)
help("stable_fit_koutrouvelis")
stable_fit_koutrouvelis(X07_09, pars_init = as.numeric(c()), parametrization = 0L)
stable_fit_koutrouvelis(X_10, pars_init = as.numeric(c()), parametrization = 0L)
stable_fit_koutrouvelis(X11_14, pars_init = as.numeric(c()), parametrization = 0L)
stable_fit_koutrouvelis(X15_16, pars_init = as.numeric(c()), parametrization = 0L)
stable_fit_koutrouvelis(X17_19, pars_init = as.numeric(c()), parametrization = 0L)
stable_fit_koutrouvelis(X_20, pars_init = as.numeric(c()), parametrization = 0L)

# plotting the stable density example
hist(rstable(n=1000,alpha=0.9809049,beta=0, pm=0, gamma=23.7937633, delta=758.5277453))
```