

# Application of Normal Distribution in insight development of stocks

Runtime Terror

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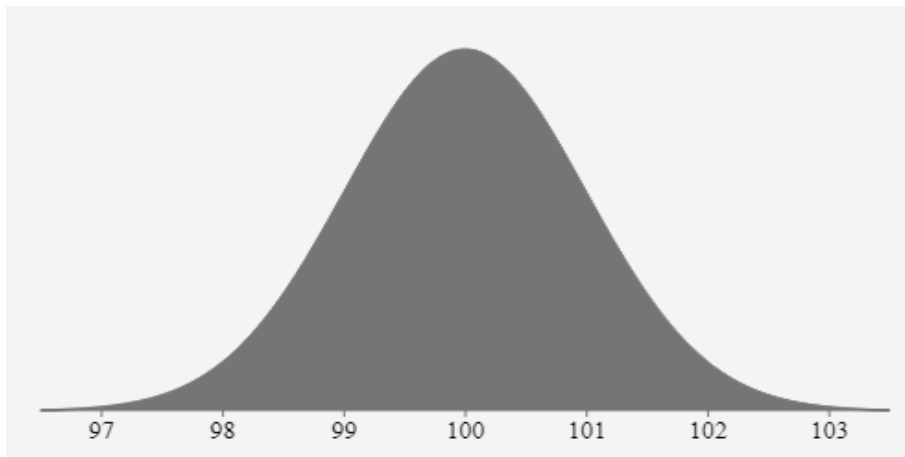
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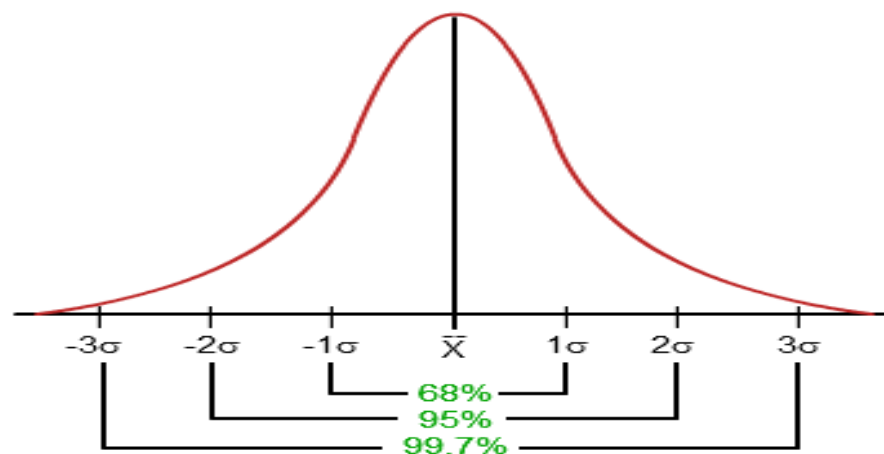
# 1 Normal Probability Distribution

A probability distribution is a statistical function that describes all the possible values and likelihoods that a random variable can take within a given range. Suppose you draw a random sample and measure the heights of the subjects. As you measure heights, you can create a distribution of heights. This type of distribution is useful when you need to know which outcomes are most likely, the spread of potential values, and the likelihood of different results.

If you plot the probability distribution and it forms a bell-shaped curve and the mean, mode, and median of the sample are equal then the variable has a normal distribution. A normal distribution is a distribution that is solely dependent on two parameters of the data set: its mean and the standard deviation of the sample. The normal distribution is also the sum of many random distributions. The idea revolves around the theorem that when you repeat an experiment a large number of times on a large number of random variables then the sum of their distributions will be very close to normality. If we plot the normal distribution density function, its curve has following characteristics:



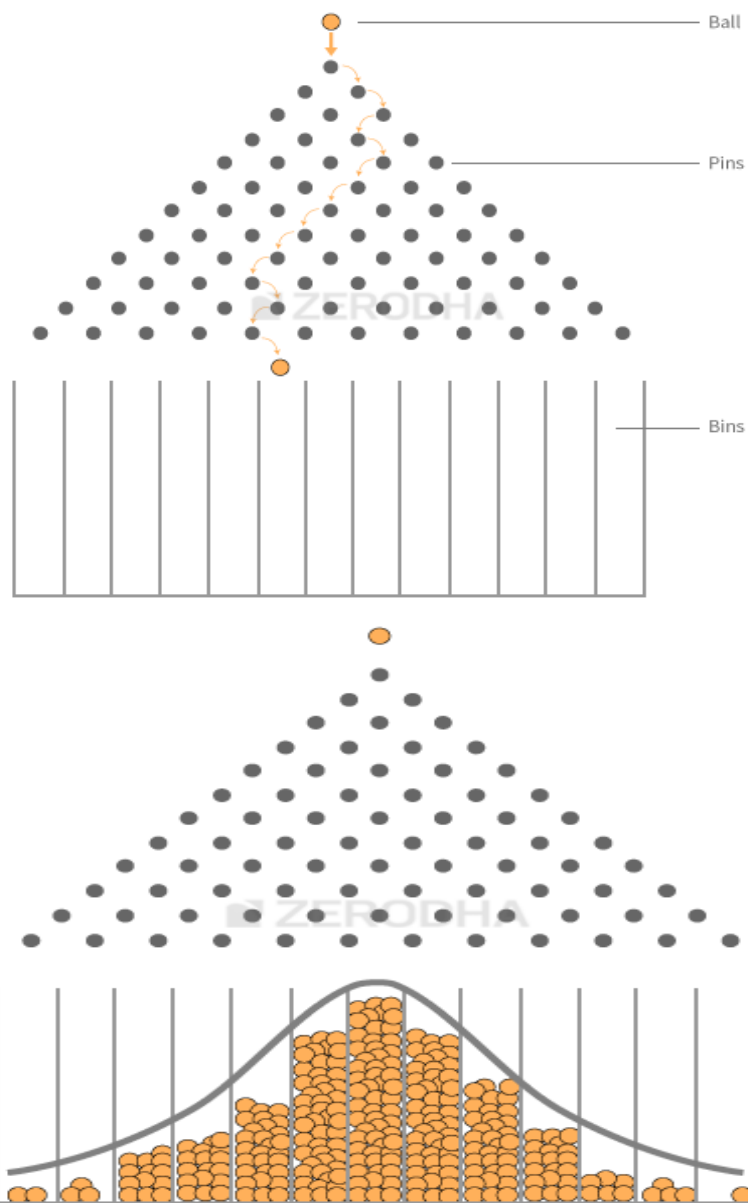
The bell-shaped curve above has 100 mean and 1 standard deviation. Mean is the center of the curve. This is the highest point of the curve as most of the points are at the mean. There are equal number of points on each side of the curve. The center of the curve has the most number of points. The total area under the curve is the total probability of all of the values that the variable can take. The total curve area is therefore 100%.



Approximately 68.2% of all of the points are within the range -1 to 1 standard deviation. About 95% of all of the points are within the range -2 to 2 standard deviations. About 99.7% of all of the points are within the range -3 to 3 standard deviations. This allows us to easily estimate how volatile a variable is and given a confidence level, what its likely value is going to be. As an instance, in the gray bell-shaped curve above, there is a 68.2% chance that the value of the variable will be within 101–99.

## 1.1 Normal distribution with the Galton Board

Galton Board is a very good concept that describes how the normal distribution works. What happens is that you pick up some balls, you drop them one after the other from the top (neutral point). The balls move through the various nails on the board then falls into one of the bins under. When the ball hits each nail in theory, there is a 50/50 chance of it moving left or right and so each path is pretty much unpredictable. This is because, dropping two balls at the same time from the top, does not guarantee that they will fall in the same bin but we can make some few statements and assumptions where we can say a ball is more likely to fall in the middle bin as compared to falling into the bins far on both ends. In the process of dropping more ball from the top, we can't predict where this ball will end up but we can accurately predict the overall pattern that these balls in the bins will take. The shape that comes of this is called the Normal Distribution or the bell-shaped curve. The figure below describes how it looks like:



Now lots of things in nature follow this pattern, for instance, if you measure people's height, weight, shoe sizes and so on will follow this pattern. So in a nutshell what all this is telling us is that because the ball has choices of moving to the left or right on each bin its a binomial distribution and therefore having loads of ball going down, we get closer and closer to exactly matching a normal distribution. So in probability, we can't predict the exact location of where one ball will end up but we are sure to tell what will happen across lots of balls. We

would like to draw your attention to one more interesting variable that follows the normal distribution – the daily returns of a stock!

Before we begin talking about the normal distribution in stock returns, let's dive into the definition of some terminologies and also give an illustration for us to better understand how all these work out.

- **Volatility:** It is a rate at which the price of a security increases or decreases for a given set of returns. Volatility is measured by calculating the standard deviation of the annualized returns over a given period of time. It shows the range to which the price of a security may increase or decrease. Volatility represents how large an asset's prices swing around the mean price - it is a statistical measure of its dispersion of returns. Volatile assets are often considered riskier than less volatile assets because the price is expected to be less predictable.

Volatility is often calculated using variance and standard deviation. The standard deviation is the square root of the variance.

- **Current Market Price:** means the mean or average daily closing price per share of common stocks where the initial end date of trading and the previous date of trading matters. The market price per share of stock usually termed simply "share price" is the dollar amount that investors are willing to pay for one share of a company's stock. It has no specific relation to the value of the company's assets

Because the current market price is readily available, there is no need to calculate it. It's basically the figures that appears when you go online and ask to see a company's current share price. All you have to do is to enter the company's stock symbol in your search engine along with the phrase 'share price' to determine the share price online as of any given date.

## 2 Stock Return

Someone might ask, what is stock? How does it work? How is it beneficial for them? The stock market is an electronic market place buyers and sellers meet and trade their points of view. For example, consider a situation of a company X that is facing a succession issue, and most of its senior-level management personnel are quitting the company for internal reasons. It seems like the leadership vacuum is weighing down the company's reputation heavily. As a result, the stock price dropped to 3000 dollars all the way from 3500 dollars. Whenever there are new reports regarding the company's management change, the stock

prices react to it.

Assume there are two traders – T1 and T2. T1’s point of view on company X – The stock price is likely to go down further because the company will find it challenging to find a new CEO. If T1 trades as per his point of view, he should be a seller of company X’s stock. T2, however, views the same situation in a different light and therefore has a different point of view – According to him, the stock price of company X has overreacted to the succession issue and soon the company will find a great leader, after whose appointment the stock price will move upwards. If T2 trades as per his point of view, he should be a buyer of company X’s stock. So at, 3000 dollars T1 will be a seller, and T2 will be a buyer in company X’s stock. Now both T1 and T2 will place orders to sell and buy the stocks respectively through their respective stock brokers. The stockbroker obviously routes it to the stock exchange. The stock exchange has to ensure that these two orders are matched, and the trade gets executed. This is the primary job of the stock market – to create a market place for the buyer and seller.

A stock market is a place where market participants can access any publicly listed company and trade from their point of view, as long as there are other participants who have an opposing point of view. After all, different opinions are what make a market.

## 2.1 What moves the stock?

Let us continue with company X’s example to understand how stocks really move. Imagine you are a market participant tracking Company X’s stock. It is 10:00 AM on 11<sup>th</sup> June 2018 ,and the price of Company X’s stock is 3000. The management makes a statement to the press that they have managed to find a new CEO who is expected to steer the company to greater heights. They are confident on his capabilities and they are sure that the new CEO will deliver much more than what is expected out of him. Two question:

1. How will the stock price of company X react to this news?
2. If you were to place a trade on company X, what would it be? Would be a buy or a sell?

The answer to the first question is quite simple, the stock price will move up. Company X had a leadership issue, and the company has fixed it. When positive announcements are made market participants tend to buy the stock at any given price and this cascades into a stock price rally.

Let’s illustrate this further :

SI No	Time	Last Traded Price	What price the seller wants	What does the buyer do?	New Last Trade Price
01	10:00	3000	3002	He buys	3002
02	10:01	3002	3006	He buys	3006
03	10:03	3006	3011	He buys	3011
04	10:05	3011	3016	He buys	3016

Notice, whatever prices the seller wants the buyer is willing to pay for it. This buyer-seller reaction tends to push the share price higher. So as you can see, the stock price jumped 16 dollars in a matter of 5 minutes. Though this is a fictional situation, it is a very realistic, and typical behavior of stocks. The stock price tends to go up when the news is good or expected to be good. In this particular case, the stock moves up because of two reasons. One, the leadership issue has been fixed, and two, there is also an expectation that the new CEO will steer the company to greater heights. The answer to the second question is now quite simple; you buy company X's stocks considering the fact that there is good news surrounding the stock. To summarize, the price moves because of expectation of news and events. The news or events can be directly related to the company, industry or the economy as a whole. In some cases there would be no news but still the price could move due to the demand and supply situation.

## 2.2 How does the stock get traded?

You have decided to buy 200 shares of company X's at 3016, and hold on to it for 1 year. How does it actually work? What is the exact process to buy it? What happens after you buy it? Luckily there are systems in place which are fairly well integrated. With your decision to buy the stock, you place an order then an order ticket gets generated containing the following details:

- Details of your trading account through which you intend to buy Infosys shares – therefore your identity is revealed.
- The price at which you intend to buy Infosys
- The number of shares you intend to buy

Before your broker transmits this order to the exchange he needs to ensure you have sufficient money to buy these shares. If yes, then this order ticket hits the stock exchange. Once the order hits the market the stock exchange (through their order matching algorithm) tries to find a seller who is willing to sell you 200 shares of Infosys at 3016. Now the seller could be 1 person willing to sell the entire 200 shares at 3030 or it could be 10 people selling 20 shares each or it could be 2 people selling 1 and 199 shares respectively. The permutation and combination does not really matter. From your perspective, all you need is 200 shares of company X at 3016 and you have placed an order for the same. The stock exchange ensures the shares are available to you as long as there are sellers in the market.

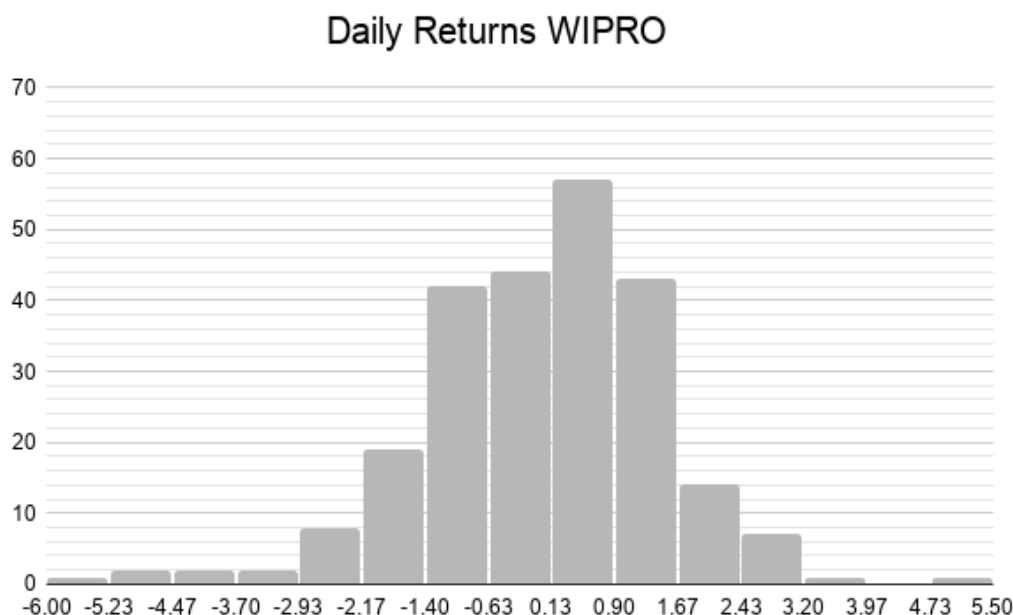
## 2.3 What happens after you own a stock?

After you buy the shares, You are now a part owner of the company, to the extent of your share holding. By virtue of owning the shares you are entitled to few corporate benefits like dividends, stock split, bonus, rights issue, voting rights etc. We will explore all these shareholder privileges at a later stage.



### 3 Application of Normal Distribution in insight development of stocks

The reason why normal distribution is important in understanding of stock is that the daily returns of the stock/indices also form a bell curve or a normal distribution. This implies that if we know the mean and standard deviation of the stock return, then we can develop a greater insight into the behavior of the stock's returns or its dispersion. Let's take a closer look at WIPRO stock. All the stock data for the last 244 days are found [Here](#). To begin with, here is the distribution of WIPRO's daily returns is:



As we can see the daily returns are clearly distributed normally. we've calculated the average and standard deviation for this distribution. Remember to calculate these values we need to calculate the log daily returns:

$$Mean = 0.01\%$$

$$StandardDeviation = 1.47\%$$

$$CurrentMarketPrice = 567.55$$

Do note, an average of 0.01 indicates that the daily returns of WIPRO are centered at 0.01. Now keeping this information in perspective let us calculate the following things:

- The range within which WIPRO is likely to trade in the next 1 year
- The range within which WIPRO is likely to trade over the next 30 days.

For both the above calculations, we will use 1 and 2 standard deviation meaning with 68% and 95% confidence.

- **WIPRO's range for next 1 year:**

Let us convert the mean and the standard deviation to annualized numbers:

$$Average = 0.01\% * 244 = 2.44\%$$

$$SD = 1.47\% * 244 = 22.96\%$$

So with 68% confidence we can say that the value of WIPRO is likely to be in the range of:

$$= Average + 1SD(Upper) \text{ and } Average - 1SD(Lower)$$

$$= 2.44\% + 22.96\% = 25.4\%$$

$$= 2.44\% - 22.96\% = -20.52\%$$

Note these % are log percentages (as we have calculated this on log daily returns), so we need to convert these back to regular %, we can do that directly and get the range value:

$$Upper = 567.55 * e^{25.4\%} = 731.67$$

$$Lower = 567.55 * e^{-20.52\%} = 462.26$$

The above calculation suggests that WIPRO is likely to trade somewhere between 462.26 and 731.67. How confident are we about this? – Well as you know we are 68% confident about this.

Let us increase the confidence level to 95% or the second standard deviation and check what values we get:

$$Average + 2SD(Upper) \text{ and } Average - 2SD(Lower)$$

$$= 2.44\% + 2 * 22.96\% = 48.36\%$$

$$= 2.44\% - 2 * 22.96\% = -43.48\%$$

Hence the range works out to:

$$Upper = 567.55 * e^{48.36\%} = 920.51$$

$$Lower = 567.55 * e^{-43.48\%} = 367.42$$

The above calculation suggests that with 95% confidence WIPRO is likely to trade anywhere in the range of 367.42 and 920.51 over the next one year. Also as you can notice when we want higher accuracy, the range becomes much larger.

- **WIPRO's range for next 30 days:** Since we are interested in calculating the range for next 30 days, we need to convert the same for the desired time period:

$$Average = 0.01\% * 30 = 0.3\%$$

$$SD = 1.47\% * \sqrt{30} = 8.05\%$$

So with 68% confidence I can say that, the value of Nifty over the next 30 days is likely to be in the range of:

$$\begin{aligned} &= Average + 1SD(Upper) \text{ and } Average - 1SD(Lower) \\ &= 0.3\% + 8.05\% = 8.35\% \\ &= 0.3\% - 8.05\% = -7.75\% \end{aligned}$$

Note these % are log percentages, so we need to convert them back to regular %, we can do that directly and get the range value:

$$Upper = 567.55 * e^{8.35\%} = 616.97$$

$$Lower = 567.55 * e^{-7.75\%} = 525.22$$

The above calculation suggests that with 68% confidence level we can estimate WIPRO to trade somewhere between 525.22 and 616.97 over the next 30 days. In similar ways, we can increase the confidence level to 95% or the 2<sup>nd</sup> standard deviation.

Now you may be wondering what is the applications of standard deviation (volatility) and its relevance to trading. We will discuss one important topic: Selecting strikes that can be sold/written using normal distribution. The above calculation (WIPRO's range for next 30 days) suggests that WIPRO is likely to trade anywhere in the region of 525.22 to 616.97. How sure are we about this, well we know that there is a 68% probability for this calculation to work in our favor. In other words there is 32% chance for WIPRO to trade outside 525.22 to 616.97 range. This also means all strikes outside the calculated range 'may' go worthless.

Hence:

- You can sell all call options (A call is an option contract giving the owner the right, but not the obligation, to buy a specified amount of an underlying security like stock and bond at a specified price within a specified time) above 616.97 and collect the premiums because they are likely to expire worthless after 30 days.
- You can sell all put (A call option may be contrasted with a put, which gives the holder the right to sell the underlying asset at a specified price on or before expiration) options below 525.22 and collect the premiums because they are likely to expire worthless.
- Alternatively if you were thinking of buying Call options above 616.97 or Put options below 525.22 you may want to think twice, as you now know that there is a very little chance for these options to expire in the money, hence it makes sense to avoid buying these strikes.

## 4 Limitations of Normal Distribution in insight development of stocks

As normal distribution is used to give us probability of a certain event happening between given range, it means that our predictions are not guaranteed to happen to increase our level of accuracy in prediction we have to widen the range of the stock price which is not really a desirable thing to do as we want to increase the precision of our stock price range. Additionally, considering the fact that if our daily returns's data doesn't follow a normal distribution. At that moment, we cannot use the same process we did to predict our model.

## 5 Group Member Roles

- Natnael: Research on normal distribution's application on stock. Contributed to the LaTeX file.
- Mahalinoro: Contributed to the tech part and the LaTeX file.
- Chris: Research on stocks. Contributed to the LaTeX file.
- Zubery: Contributed to the tech part with google sheet.

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