Statistical analysis of Tesco PLC stock by James Nagel

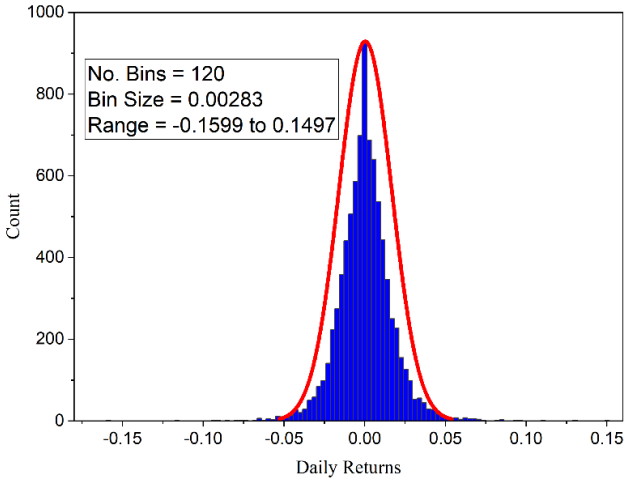
ABSTRACT

Tesco PLC was founded in 1919 and is the largest grocery retailer in the UK with a 27% market share. In this report I analyse key graphs that show how the stock has performed and make stock price predictions. In addition to this I have constructed a two-step binomial tree to display how the option price varies over a 2-month European long call and long put option. In the report I show why a bank account would be a safer investment.

Introduction

Tesco was founded in 1919 by Jack Cohen who traded from the East End of London selling goods such as tea, making £1 profit on his first day of trading [1]. Now, over 100 years later, Tesco currently holds 27% of the market share of grocery stores in the UK [2]. Tesco owns over 4000 grocery stores in the UK, which range from small Tesco Express high street outlets to giant Tesco Extra supermarkets [1,3]. Tesco has overcome many different challenges ranging from internal scandals to trouble with branching out into different countries. Currently COVID-19 has rocked Tesco into spending £533m in the first half of 2020, part of this cost was due to hiring over 16,000 new, permanent staff to support the large growth in its online business [4,5]. Fig. 1 displays the adjusted daily closing price for Tesco.

Fig. 2. Histogram of daily returns over the time frame for the report with a superimposed normal distribution curve that fits the histogram.



Tesco PLC - 15th March 2021

TSCO.L

Price: 223.8 GBX (GBX = pence)

Time frame used throughout report: 01-Jan-89 to 15-Mar-21

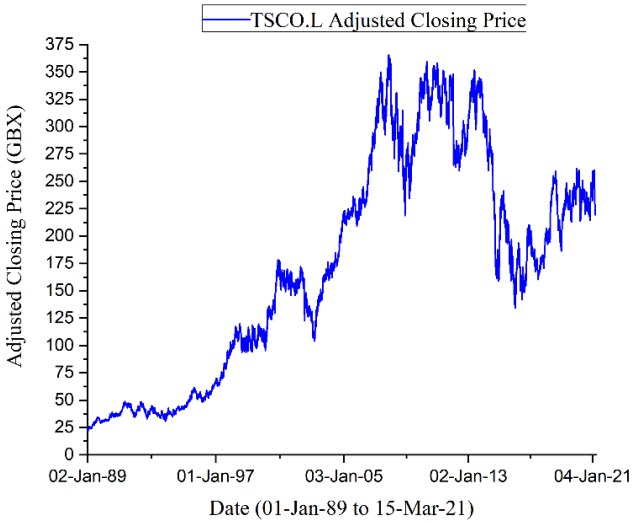


Fig. 1. Adjusted closing price for Tesco's stock from 01-Jan-89 to 15-Mar-21.

Daily Returns for Tesco

Looking at the daily returns of the Tesco stock we can gain a better understanding as to how it has performed over different time periods. Fig. 2 is a histogram of the daily returns over the 32-year period. The daily returns range from -0.1599 to 0.1497. Fig. 2 displays that the distribution of daily returns is heavily peaked in the middle, this high cluster of daily returns offsets the superimposed normal distribution to not fit the histogram flush.

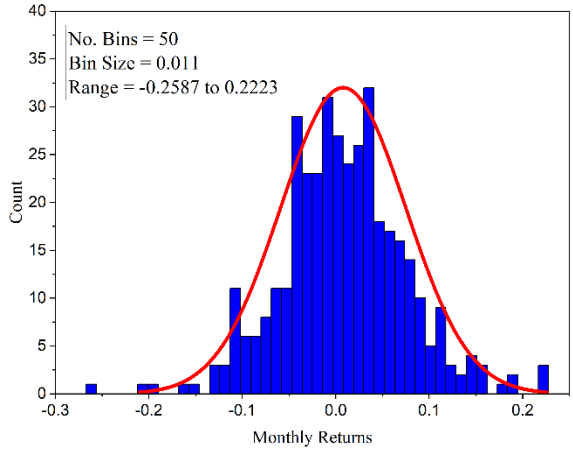


Fig. 3 Histogram of monthly returns over the time frame for the report with a superimposed normal distribution curve that fits the histogram.

Fig. 3 is a histogram for the monthly returns of Tesco's stock. In this figure it is easy to see that the normal distribution fits the monthly returns better than it does the daily. When we consider the monthly returns, we are reducing the influence the volatility has over the returns of the stock. Conversely this also increases the influence the drift has over the returns of the stock as it is over longer time intervals. The range is also larger as over these longer time periods the stock has a month to change price.

How well do the daily returns of Tesco stock follow the normal distribution?

Fluctuations in the daily returns can be where large amounts of money can be made or lost, so they are extremely important. If one were trying to model how the stock price were to move, then using the normal distribution would not account for large fluctuations. A model that lacks the ability to account for such large fluctuations could result in great losses and missed large gains such as the Geometric Brownian Motion model (which assumes normal returns) [11].

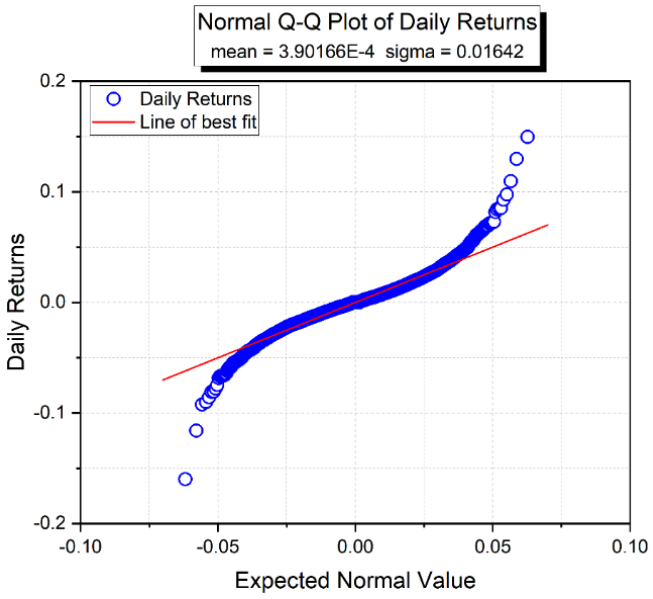


Fig. 4. Is a QQ plot displaying how well the daily returns for Tesco's stock follow a normal distribution.

The tails of the QQ plot tell us that the data is heavily peaked in the middle, as seen in Fig. 4 and 2 [6]. The largest fluctuation is -0.1598 which occurs at 9.714 standard deviations out from the mean. This results in a near 0% chance of this occurring if the daily returns were to be normally distributed. Thus, we can see that the daily returns for Tesco are not normally distributed. This is because the price of a stock is not just based on a mathematical equation but in fact a value that is affected by humans, this is a direct reason as to why the daily returns do not follow a normal distribution.

From Fig. 4 we can see the minimum and maximum fluctuations in daily returns are -0.1599 and 0.1497, respectively. This minimum return occurred on 11th January 2012 where the stock price dropped from 325.91p to 273.80p the very next day. This huge -16% fall was due to the announcement from Tesco that the profits for the year would be at the low end of their predictions. This announcement caused the stock to plunge as shareholders sold shares to dampen the economic damage [7]. This wiped £4bn off the market value of Tesco [8]. The maximum fluctuation occurred on 7th January 2015 where Tesco announced it's 'turnaround plan' where it planned to close 43 unprofitable stores across the UK and close their staff pension scheme which would reduce their overheads by 30% [9,10]. This shot the stock price up from 175.02p to 201.23p the next day as shareholders welcomed the changes being made to Tesco.

Annual Drift and Volatility

The volatility of Tesco's stock gives us an insight as to how predictable the stock price is and thus how likely an investor is to buy shares in Tesco at any given time. If the volatility is high, the stock is unpredictable which may lead to either large gains or losses. Often this trait is not favourable.

The volatility of the stock from 1989 to 2021 was 26.13%. Conclusions are difficult to be made when the historic volatility is isolated, but we can learn more when we delve into seasonal trends [12].

Season	Drift (%)	Volatility (%)	Average Return (10^{-5})	Max Return (10^{-2})	Min Return (10^{-2})
Spring	20.99	24.86	8.331	8.520	-9.004
Summer	2.510	24.11	9.979	10.96	-8.083
Autumn	4.580	27.97	18.19	9.750	-11.59
Winter	11.72	27.10	4.653	14.97	-15.98

Each season includes different holidays and celebrations and this can affect the volatility and drift.

Winter and Autumn have a similar volatility and are at least 2.24% higher than both Spring and Summer. The reason for this is because Winter and Autumn include more celebratory events i.e. Halloween, Bonfire night, Christmas, New Year and Valentine's day, all of which increase sales for Tesco. However, Spring and Summer only include Mother's Day, Father's Day and Easter, combined with the fact that many Britons go abroad for holidays.

In October 2014 Tesco's stock had fallen into a trough after consistent under performance of the stock. At the time Tesco had an on-going accounting scandal where it overstated its profits by £263m and added to this a 4.6% annual decline in UK sales [13,14]. On 29th May 2014 the share price was 291.34p, and it stayed at this price until 24th October 2014 where it dipped to 161.19p. The drift over this 105-day period was -134.77% and a volatility of 31.44%. The high volatility in the stock price resulted in shareholders selling off their shares due to fears of the stock falling any further which in turn lead to the stock price to fall even further. Although the drift during this 105-day period is bleak, the annual drift of the stock over the next 252 days was 15.23%, showing that Tesco had begun recovering from this downfall as the stock price had reached 183.29p on 23rd October 2015.

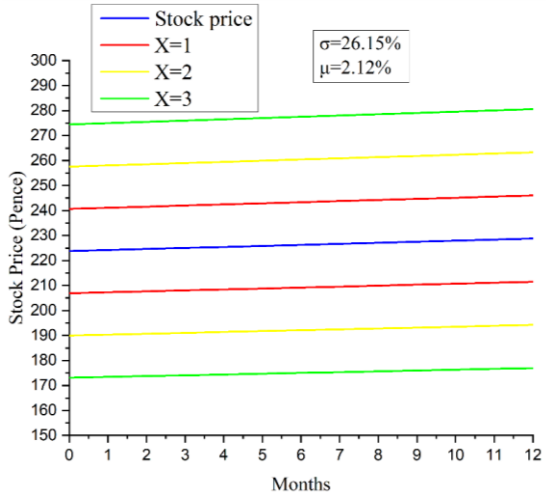


Fig. 5. Is a prediction of the stock price including upper and lower bounds based on a confidence level, X.

Stock price prediction

To predict the stock price, I used the below equation to obtain values for both the stock price and the upper and lower bounds based on a given confidence level, X. Fig 5. uses the volatility and drift for the past year (during COVID-19). The three pairs of red, yellow and green lines differ by only the X value which is the confidence level we want to show in the predicted stock price.

$$\delta S = \mu S \delta t \pm \sigma S \delta t^{\frac{1}{2}} X$$

In Fig. 5 when X=1 we expect 68% of the stock price to fall within the red lines, for X=2, 95% and with X=3, 99.7%. As discussed above with the scandal that lead to the drop in the stock price, this could not have been predicted or written into a model. Thus, this model fails to account for human acts because no model can.

From Fig. 5 you can see that the drift over the past year is 2.12% and the model is based on this value. As the drift is so small during the COVID-19 era, the investment is almost like a bank account but with much higher risk. If an investor were to need their money back in a short time after their investment, then this is sub-optimal due to the high volatility. As seen in Fig. 5 the stock price could fall within the bounds of 175p to 230p. But if an investor were to leave their money for a year or longer then over these longer time periods, we would expect the stock to rise by 2.12% each year. Over long time periods for the future of Tesco we do not expect much rise in the stock price.

Principal £1m investment into Tesco

If a £1m investment was made in the new year of 1989 the stock would now be worth £10.48m, which is a return on investment (ROI) of 948%. Although an ROI of 948% is substantial, the investor's money would have been tied up for over 32 years, and even then, it is not the maximum value over the 32-year period. £17.12m was the maximum value for the investment which occurred on 14th November 2007, an ROI of 1612%. The minimum value of the investment was £989k occurring on the 3rd January 1989, just 2 days after the principal investment which accounts to an ROI of -1.1%.

If the principal £1m had been invested into a savings account that accumulated interest (interest rate = 0.43%) at the end of each month then today the investment would be worth £3.16m or an ROI of 216%. This is substantially less than if the principal had been invested into TSCO.L stock, but far less of a risk.

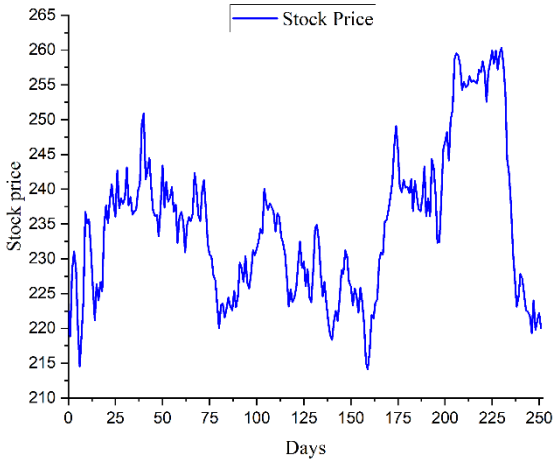


Fig. 6 displays the adjusted closing price for Tesco's stock over the COVID-19 period. Start date 25th March 2020.

Tesco joined the stock market in 1947 with a share price of 25p, but the company was founded in 1919 so that gap meant by the time Tesco was on the stock market it was already a built-up company [15]. By 1989 the stock price was 21.36p, Tesco had over 800 stores across the UK and had branched into the world of petrol. As far as risks go Tesco was a fairly low risk investment, as seen not only by a low volatility of 22.93% at the time but its firm grip on the market with 15.7% of the market share of UK supermarkets in 1989 [16,17].

Recently COVID-19 has forced countless small businesses to close and a few big businesses as well. Luckily for Tesco it operates around 4000 stores across the UK and Ireland [3] which predominantly sell food which means it was able to stay open throughout lockdowns. In the UK (where most Tesco stores are located) COVID-19 caused the entire UK to plunge into lockdown on 25th of March 2020. On that day the stock was worth 223.92p a share. As seen in Fig. 6 the stock price remained steady (apart from towards the end of the time frame) for a year with a stock price on 12th March 2021 being 223.80p. The volatility of the stock of this year was 25.47%. This volatility over a pandemic shows how unpredictable COVID-19 is but the drift of 2.12% (seen in Fig. 5) displays how strong Tesco is in the current market.

Tesco thrived through three national lockdowns in the UK without a significant fall in their stock price, however worth noting there was not much gain either. The UK is a rich, developed country so has been able to buy millions of vaccines which are being rolled out across Britain. These vaccines are paving the way to a normalised life once again in the UK and this will result in high streets becoming busy walks of life again, meaning more customers will be likely to make more frequent purchases driving Tesco's profits up.

I would not advise an investment in TSCO.L. The strong brand has had domination of the UK supermarket scene for over 30 years currently holding 27% market share with its closest competitor being Sainsburys with a market share of 15.3% [2]. Going forward Tesco will see a decrease in expenditure on PPE as the UK heads towards being COVID free. Tesco will also see an increase in profits from customers visiting in store, which will drive up the stock price as the business has more favorable profit margins. Although the UK is heading in the right direction another lockdown is not off the table. If another lockdown were to be put in place in the UK, then Tesco has already proven that it can thrive through lockdowns with the stock retaining its value. With all of these considered TSCO.L is a low-risk investment with the possibility of high growth over long periods of time.

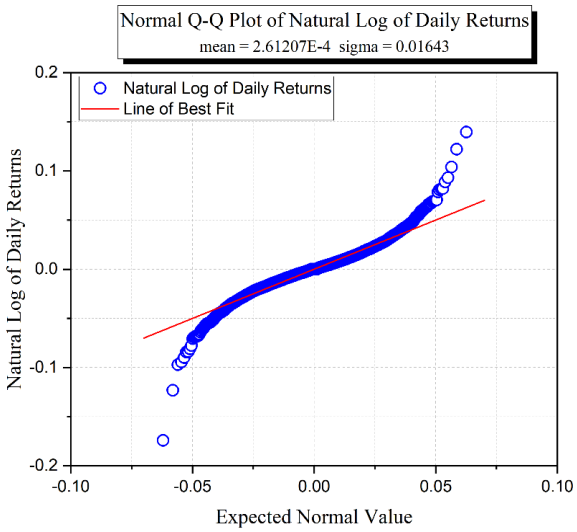


Fig. 7. Is a QQ plot displaying how well the logged daily returns for Tesco's stock follow a normal distribution.

How well do the daily returns of the stock follow the lognormal distribution?

Previously we tested the daily returns against the normal distribution with a QQ plot, although the data was not completely normally distributed it was close with only the extremes of the data falling outside what we would predict from a normal distribution. Another distribution the daily returns can be tested against lognormal distribution which will test to see if the $\ln\left(\frac{s_0}{s}\right)$ fits a normal distribution [18].

As before if the data on a QQ plot fits the red straight line then the data is said to be drawn from the same distribution. Fig. 7 and Fig. 4 look very similar in shape but in Fig. 7 the extreme negative daily returns fall further from what we would expect from the normal distribution and for the positive extremes they fall closer to what we would expect.

The difference in standard deviation for both Fig. 7 and 4 is 1.51E-4, and the mean values differ by 1.29E-4. This difference in mean values results in different values for the drift. The drift of the daily returns for Fig. 7 is 9.99%, whereas for Fig. 4 the drift is 10.31%. As well as drift the values for the largest fluctuation changed, for Fig. 7 this value is -0.1742. This fluctuation is 10.58 standard deviations out from the mean. For the largest positive fluctuation in Fig. 7 is 8.473 standard deviations out from the mean, whereas in Fig. 4 it is 9.097. This tells us that the logged returns account for large positive fluctuation better but worse for large negative fluctuations.

Two-step binomial tree for 2-month long call and long put options.

Stock price at T=0	223.80p
Strike price – Call	234.99p
Strike price - Put	212.61p
Time interval	0.08
Volatility	22.279%
Riskless	0.43%
u	106.64%
d	93.771%
p	48.671%
1-p	51.328%

A two-step binomial tree allows investors to obtain a vague prediction as to where the stock and option price might be in the future. For a 2-month European long call option we know that investors can only exercise their option at the expiration date i.e. in 2 months' time. For the long call option, we are buying a stock at an agreed upon price in 2 months, so are hoping that the stock increases in value. This table displays the values used in producing the two-step binomial tree for both a long call and long put option.

The strike price is the minimum stock price you can exercise an option for, this value is decided by the writer of the option. For the strike price I did as follows; call option is 105% the stock price at T=0 and the put option 95%. I chose these strike prices to allow for the possibility of a larger return yet not too extreme as to never allow for a profit to be made [19].

The time interval is $\frac{1}{12} = 0.08$ as the time-step in the two-step binomial tree is 1 month.

Call						Put					
					254.52						254.52
					19.5304						0
			238.666						238.666		
			9.50225						0		
stock	223.8				223.8	stock	223.8				223.8
option	4.6232				0	option	2.79352				0
			209.86						209.86		
			0						5.44435		
					196.788						196.788
					0						11.19
months	0		1		2	months	0		1		2

Fig. 8. Consists of two two-step binomial tree for 2-month European long call and long put options.

On the left of Fig. 7 displays the two-step binomial tree for a call option and on the right a put option. The stock price is the same in both trees, but the option price is what differs. The final call option price is calculated by $final\ stock\ price - strike\ price = final\ option\ price$ and $strike\ price - final\ stock\ price = final\ option\ price$ for the put option. From there you work backward to obtain values for both the 1-month option price and initial option price. The option is only profitable if the stock trades above the profit margin, $strike\ price + premium = profit\ margin$ for a call option and below for a put option.

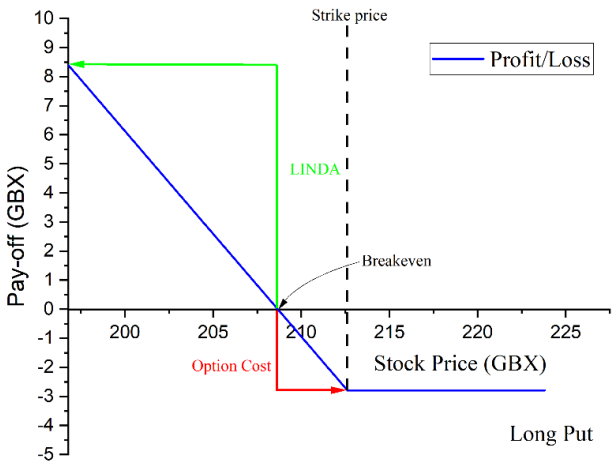


Fig. 9. Is a pay-off diagram for a long put option with a strike price of 212.61p.

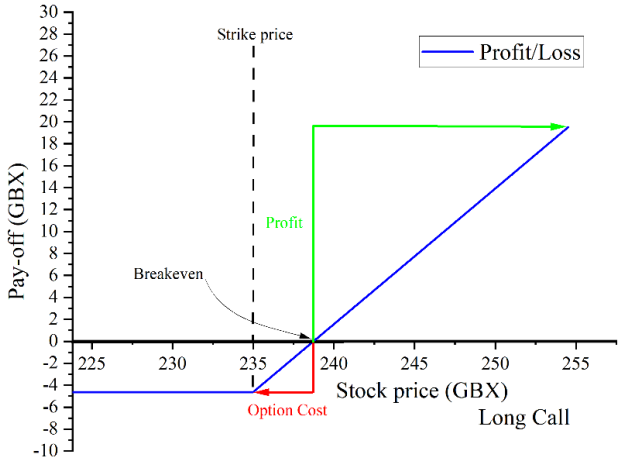


Fig. 10. Is a pay-off diagram for a long call option with a strike price of 212.61p.

Fig. 9 and 10 are pay-off diagrams that illustrate how the profit from the long options vary with the stock price. If the value of the stock never reaches the strike price, then the cost for the option would just be the price of the option at T=0. As seen earlier in this report we predict the stock price to rise. As this is a 2-month European option the chance that the stock reaches the strike price or above for a call or below for a put option is 30.85%. This means that the chance the stock remains within the strike price either way is 69.15%. Clearly it is unlikely that money will be made with either option. But this fails to consider real world events and seasons. If the option were to be purchased in March 2021 it would expire in May, both contained within the season of Spring. Spring has a historic volatility of 24.86%, but more importantly a

historic drift of 20.99% as seen in the first table. From this drift we could guess that the price of Tesco stock over the following 2-months would increase. But this historic drift is over 32 years of data. Recently COVID-19 has shot the annual drift down to 2.12% and because the Spring of 2020 was not a normal Spring the drift was 7.81% and the volatility was 34.3%. The drift of Spring 2020 was down 13.18% from the average and the volatility was up 9.44%. It would be unwise to base a prediction for 2021 Spring on 2020 Spring as the state of the UK is completely different, from customer mindset to lockdown. Mixing unpredictable times with a 30.85% chance of profit, the purchase of either options would be unwise to say the least.

Summary

Although Tesco is a well-established brand with over 4000 stores in the UK COVID-19 has brought the stock price to a standstill. As far as investments go, a bank would be a safer investment as the state of the world is volatile and unpredictable, and although the UK is on the path to financial recovery nothing is certain.

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