Investigating TSLA Stock Price Movement by Using Additive Model of Time Series

Beyza Arslan

Koç University

34450 İstanbul, Turkey

barslan16@ku.edu.tr

Anıl Şen

Koç University

34450 İstanbul, Turkey

asen16@ku.edu.tr

Berkay Yılmaz

Koç University

34450 İstanbul, Turkey

berkayyilmaz18@ku.edu.tr

Abstract

With the dawn of the information age, range of investment opportunities expanded greatly. This situation made making right investments incredibly hard. Making correct choices in the face of vast opportunities requires information and knowledge about investment tools. One of these tools is stock exchange and it is known that stock prices tend to fluctuate with the actions of firms. It is crucially important to see the connection between the actions of CEOs and everchanging prices. In this paper, relation between these two will be shown with the example of Elon Musk's Tesla. To achieve this Tesla's trending stocks over the years will be shown and compared with oil prices, google query volumes and S&P 500 data. Then, the model and data site we prepared will be shown. To conclude our findings will be shared and examined.

Author Keywords

Stock Price; Time Series; TSLA; Prophet Modelling; Change Point.

CSS Concepts

• **Human-centered computing~Human computer interaction (HCI)** ~Collaborative and social computing • **Social and professional topics~**Finance

Introduction

Studying the causes of changes in stock prices has long been one of the greatest pursuits of humanity. Different interests have played role in these studies. Financial time series prediction in stock market has received focus from investors, speculators and researchers for a long time due to its potential profits (Xiaowei Lin, 2009).Different methods aimed to analyze and then predict changes. However, these methods vary from company to company and from event to event. As a result, the analyzes cannot be spread across the country and remain on a firm basis. The price effects of this firm-specific forecasting ability do not spill over to other firms followed by the same analyst (Park, 2000). Co-operating stock prices were observed in the past. A time series of stock price synchronicity for the U.S. market also shows that the degree of co-movement in U.S. stock prices has declined, more or less steadily, during the 20th century (Randall Morck, 2000). Whereas, if the reasons of the sharp changes in the stock prices of the sharp changes in the stock prices of the company are well understood in the studies based on the company, which makes it significantly easier to develop the strategies to be followed. For example, a fluctuation in oil prices does not affect a telecommunication company, while it may cause serious changes in the stock prices of an oil company. In addition, it is observed that the use of social media increased 65% between 2005 and 2015 (Perrin, 2015).In addition to this, the social media which is reflecting and influencing behavior of other complex systems can also prove that the data flow and the movements experienced have serious effects on stock prices (Gabriele Ranco, 2015).Social media analytics is showing promise for the prediction of financial markets (Ilya Zheludev, 2014). *Google* query volumes for search terms related to the f changes in finance may create specific patterns that may be interpreted as "early warning signs" of stock market moves (Tobias Preis, 2013). In addition, data from google trend, which provide data on people's search behavior, is also used in risk diversification studies (Kristoufek, 2013). Serious price returns were observed 1-2 weeks before or after the sudden changes in the searches (Laurens Bijl, 2016). Google query volumes as a "bad news" indicator for each corporation listed in the Standard and Poor´s 100 index (Heiberger, 2015). Depending on the tweets sent by Elon Musk, changes in Tesla's stock prices were examined and correlations were observed. (Zhiang Hu, 2013). In this respect, it is important to examine and recognize Tesla and Elon Musk closely to make sense of the changes in stock prices. (Appendix A1.)

In this study, the effects of S&P index, oil prices and Elon Musk's search popularity on TSLA stock prices will be investigated using additive model of time series and market stock price forecasting will be done using prophet modeling and components in forecasts will be examined.

In this article, the selected data set and model will be explained together with the reasons for their selection, then at the end of the study will be evaluated and information will be given about the future studies.

Methodology
a) Data Set

In order to construct the dataset, we collected data separately. To better understand the macroeconomic effects on TSLA, we reached the S&P 500 index and crude oil prices via Yahoo Finance. We extracted the closing data on the 1st day of every month between 2010 and 2019. Fluctuations in crude oil prices are observed to have a positive or negative effect on stocks (Kuang-Liang Chang, 2013). The reason for this is that oil, one of the main energy sources, measures economic activity. We wanted to observe this effect in TSLA shares. The S&P 500 index (Standard & Poor's 500 index) covers the largest 500 publicly traded US companies and is considered as the best indicator of US stocks (S&P 500 ENDEKSİ NEDİR?, 2018).In this regard, the S&P 500 index shows us that similar stocks in the market where TSLA is located are stagnant or rising at certain periods. In order to measure the impact of TSLA's CEO Elon Musk's popularity and some of his effects on the shares of TSLA, we have reached the data regarding the search data for Musk in Google Trends between 2010 and 2019. Finally, in order to make comparisons, we reached TSLA's stock prices via Quandl and filled the missing part in the data by taking quarterly averages.

b) Model Specification
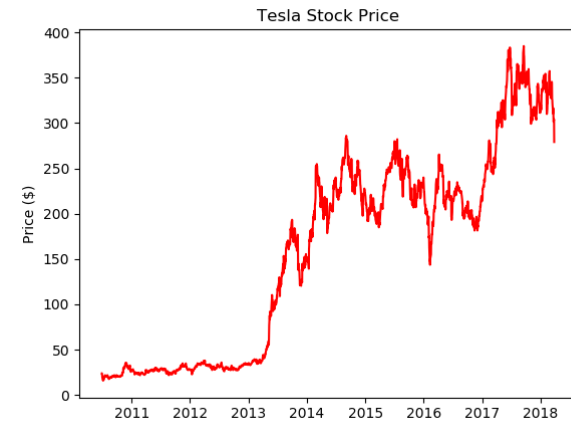

Figure 1:Tesla Stock Price(2010-2019)

We thought that the additive models of time series were appropriate in order to examine different factors for the reasons of change in Tesla's stock prices over time. Time based increase-decrease chart of stock prices were examined (Figure 1) and linearization trend was observed. Therefore, we decided that using additive model can end up giving more logical results.
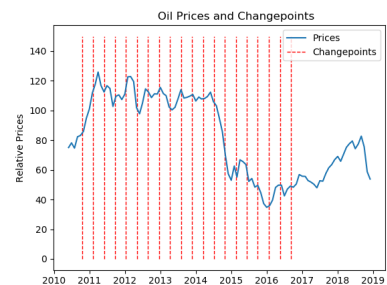
c) The Additive Model

Synthetically it is a model of data in which the effects of the individual factors are differentiated and added to model the data.
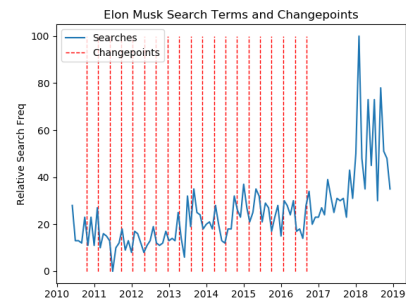
Figure 3: Elon Musk Search Terms and Changepoints, Relative Search Frequency
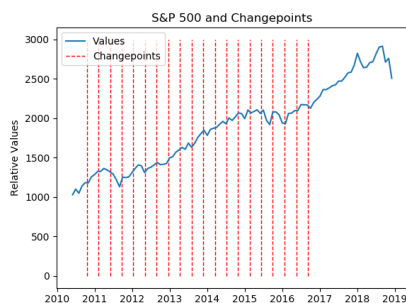
Figure 4:S&P 500 and Changepoints, Relative Values

Figure 5: Crude Oil Prices and Changepoints, Relative Prices

It can be represented by:

$$y(t) = \text{Level} + \text{Trend} + \text{Seasonality} + \text{Noise}$$

Figure 2:The Additive Model Equation

In the additive model, the behavior is linear where changes over time are consistently made by the same amount, like a linear trend. In this situation, the linear seasonality has the same amplitude and frequency (Sigmundo Preissler Jr, 2018). For additive model of time series, we decided that the Prophet Modelling library provided by Facebook is suitable. Because stock prices do not fluctuate on weekends and holidays, we thought we would have the chance to make more accurate forecasts thanks to the Prophet Modelling's holiday feature. We can briefly explain Prophet Modelling as follows.

Prophet is an additive model with the following components:

$$y(t) = g(t) + s(t) + h(t) + \epsilon_t$$

Figure 3:The Prophet Additive Model Equation

- $g(t)$ models trend, which describes long-term increase or decrease in the data. Prophet incorporates two trend models, a saturating growth model and a piecewise linear model, depending on the type of forecasting problem (Liu, 2018).

- $s(t)$ models seasonality with Fourier series, which describes how data is affected by seasonal factors such as the time of the year (e.g. more searches for eggnog during the winter holidays)

- $h(t)$ models the effects of holidays or large events that impact business time series (e.g. new product launch, Black Friday, Superbowl, etc.)

- ϵ_t represents an irreducible error term

d) Application

In order to test our hypothesis, firstly 20 Tesla stock price changepoints were determined by using the Prophet Model. Then Elon Musk search frequencies, S&P 500 indexes; and crude oil prices and Tesla stock prices were transferred to the charts over time. Then, 6 different regression Prophet Models were performed with different combinations to see if the graphics reflect the reality. To understand which model is more fitted, the regression r-squared, mean-squared-error, mean-absolute errors were recorded and compared. Regression was performed without using additional regressor to examine the general status of stock price over time. Then the forecast was made and the components of the forecast were analyzed depending on the time.

e) Findings

As seen in Figure 3, it is seen that Elon Musk's popularity has increased in search trends and there is a relationship between changepoints. However, it can be said that the graph cannot be explained only with this in some periods of time. It is appropriate to say that in overall graphic is Countercyclical.

Contrary to our expectations in Figure 4, there no apparent effect of S&P 500 indexes on the Tesla's stock prices. Although several changepoints and index values appear to move simultaneously, we can see that Tesla's stock prices behave lagging in comparison to S&P 500 across the chart. This is in line with our hypothesis.

In Figure 5, it has been examined whether crude oil prices have any effect on Tesla stock prices. Although the graph is seen to be related at several points the
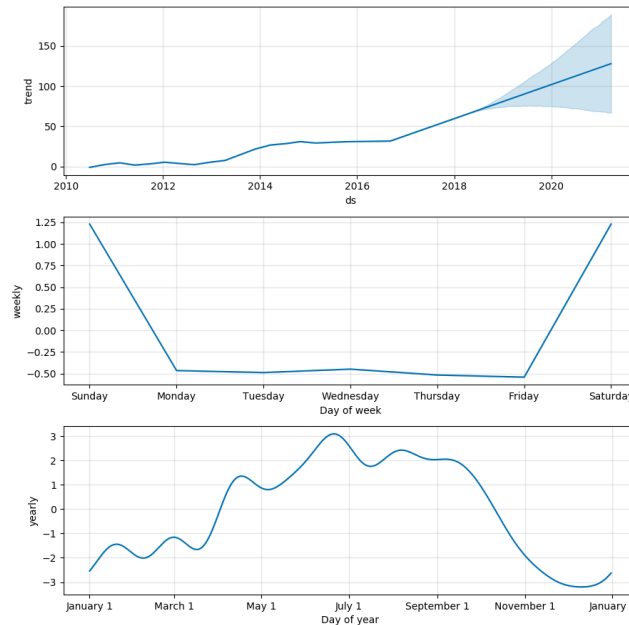
Figure 6: Investigation of forecast's component

overall graph is negative for our hypothesis.

Since the graphics are thought to be misleading, 6 different regressions were performed with 6 different combinations. Below you can see the values of r-squared, mean-squared-error, mean-absolute error for each regression.

When the values of r-squared, mean-squared-error, mean-absolute error in 6 different models are examined, we see that the results are almost the same. In addition, error rates are very high in all of them. This means that even though the graphics seem positive for our hypotheses, it has been misleading for us. By looking at the r-squared values, we can say that we could not reach the fitted line we wanted to achieve. In short, although there are graphically related relationships, no positive evidence was found in regressions in terms of our 3 hypotheses.

In addition to these, we have obtained some information as a result of forecasts about Tesla stock prices. Stock prices tend to increase after 2018. In addition, it is determined that it is increasing mostly in the summer months. When we look at the weekly, there is a small difference that is increasing in the middle of the week, mainly on Wednesdays.[Figure 6]

Conclusion

In this study, the effects of S&P index, oil prices and Elon Musk's search popularity on TSLA stock prices have been investigated using additive model of time series and market stock price forecasting has been done using prophet modeling and components in forecasts have been examined.

In the light of the findings, it was concluded that there is a coincidence between the changepoints of Tesla's stock prices and the search popularity of Elon Musk. On the other hand, the effect of S&P 500 indexes and oil prices on Tesla's stock prices is minor. In line with these results, it is seen that our hypotheses should be rejected. However, although it seems to be a coincidence, the relationship between Elon Musk's search popularity and stock prices should not be ignored. In other words, in line with this research it has been observed that most of the changes in stock prices cannot be explained through S&P index, oil prices and Elon Musk's search popularity. Failure to explain this change in stock prices with a specific pattern is to be expected as the random walk theory in economics states there is no predictable pattern in stock prices on a daily basis. As evidenced by our analysis, in the long run, stocks tend to increase, but there is no evidence about what this change is dependent on.

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Appendix A1:

Tesla Inc. is a company that specializes in electric vehicle manufacturing, clean energy production and storage. Company was founded under the name of Tesla Motors in 2003 July. Founders of the company Martin Eberhard and Marc Tarpenning chose the name to associate it with the well-known inventor Nikola

Tesla. Elon Musk joined the Tesla's board of directors as its chairman in February 2004. This development would play an unprecedented role in both Musk's and Tesla Motors' lifespans.

Elon Musk assumed the leadership of the company as CEO and product architect in 2008. With this change of leadership company's long-term strategic goal was shaped into creating affordable mass market electric vehicles step by step. First step was to start with manufacturing high-end sports cars and after creating a trustworthy name, moving into mainstream electric vehicles. Tesla Motors first electric sports car, the Tesla Roadster was built in 2008. About 2500 Roadsters were sold to over 30 countries.

Tesla Motors acquired SolarCity in 2016, a company that specializes in solar energy services, founded by Musk's cousins Rive Brothers in 2006. Musk anticipated that the global lithium-ion battery supply was insufficient for his ambitions. He initiated to solve this problem by opening the first phase of Gigafactory 1, a lithium-ion battery and electric vehicle subassembly factory. Tesla then commenced developing their own autopilot hardware and software in the same year. Company shortened its name to Tesla in 2017 and produced various vehicles up until now. On March 9, 2020, Tesla's 1 millionth electric car was produced.

Today Elon Musk is known for being a billionaire who actively tries to prolong the existence of humans on Earth through ecologically friendly solutions to modern problems. If these efforts prove to be fruitless, then SpaceX, an aerospace manufacturer and space transportation services company founded by Musk, comes to play. Its main purpose is to reduce the cost of space transformation to enable the colonization of Mars. However, Musk's rise to fame and success did not happen overnight. He was born on June 28, 1971, in South Africa as the first child of Maye and Errol Musk. He spent most of his childhood reading and computer programming. He moved to Canada just before he was 18. He studied at Queen's University for 3 years then he crossed to United States to study economics and physics at the University of Pennsylvania in 1992. In 1995 he began a PhD at Stanford University, but he dropped out just after 2 days to launch his first company.

Zip2 was founded in 1995 by Elon and Kimbal Musk. It was a web software company funded by angel investors. It was sold to Compaq for 307 million dollars in 1999. Musk received 22 million dollars from this transaction and used half of his earnings to co-find X.com in March of 1999. X.com was an online financial services company that merged with Confinity, which was a software company based in Silicon Valley that offered a money-transfer service called PayPal. Musk focused on the PayPal service and X.com was renamed to PayPal in 2001. eBay bought PayPal for 1.5 billion dollars in stock in 2002. Musk received 165 million of that amount. He then spent 100 million of his newly acquired fortune to find a company called Space Exploration Technologies Corporation in 2002. This company is now widely known as SpaceX and in May 2019, its estimated worth was 33.3 billion dollars. In 2009 Musk has written on Tesla Motor' blog that he invested 6.35 million dollars in Tesla Motors' 2004 Series A funding. Shares he bought with that investment were worth 2.8 billion dollars in 2015. In 2006 he co-founded SolarCity with his cousins which by 2013, became the second largest solar power systems

provider in the United States. This company acquired by Tesla in November 2016.Musk founded OpenAI in 2015 and Neuralink in 2016. Former aims to develop artificial general intelligence in ways to safely benefit humanity and latter is a neurotechnology startup company that aims to integrate the human brain with artificial intelligence. It is no coincidence that these initiatives are complimentary. He also founded The Boring Company. This company started as a subsidiary of SpaceX in 2016 but become separate and independent in 2018. Its main goal is to dig optimized tunnels for electric vehicles. One of company's greatest projects is to construct a link between Washington, D.C. and Baltimore via a high-speed transit system. All of his shares in these companies combined makes Elon Musk's reported net worth 39.5 billion dollars as of March 2020.

When someone as big as Elon Musk does something out of the ordinary it is almost guaranteed to become public and have unprecedented affects on institutions he is affiliated with. He has been the subject of media outlet not for his business decisions and companies but mostly for his personal life, actions and views. These are including but not limited to, the time when he appeared on a podcast with Joe Rogan, Tham Luang Cave Rescue Incident and the backlash to it, his tweets about Tesla's stock prices being high which led the prices to drop, him sending his car into space, his newly born son's name and his entertaining presentations. This puts him and his companies into spotlight which in return allows Tesla to not spend any money on ads.