MIDDLE EAST TECHNICAL UNIVERSITY Ankara, Turkey

INSTITUTE OF APPLIED MATHEMATICS
http://iam.metu.edu.tr

Technical Indicators and LSTM Prediction for Stock Prices

A.Akar [1], Ö. Uğur[2]

Abstract. In this report, we study, first, Tesla Motors' stock price prediction in a traditional way using technical indicators like Moving Average, Relative Strength Index, Parabolic SAR, Commodity Channel Index, Stochastic Oscillator and Awesome Oscillator in the first part. Having analyzed Tesla Motors' stock price with traditional technical indicators, we use long short term memory model for prediction. In long short term memory model, closing stock prices of Tesla Motors' for two years are used. The model can predict the trend successfully. The technical indicators can provide context to trends, be used to identify divergences, and even help with timing of potential entry and exit signals. But using just one of the technical indicators is generally considered as a risky decision because one must be aware of announcements and headlines that play a crucial role to determine the stock price.

Keywords. Technical Indicators, Long Short Term Memory, Stock price prediction

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TERM PROJECT

Student : Aslıhan Akar
Advisor : Prof. Dr. Ömür Uğur

[1]Middle East Technical University, Institute of Applied Mathematics, 06800 Çankaya, Ankara, Turkey. *E-Mail*: ougur@metu.edu.tr
[2]Middle East Technical University, Institute of Applied

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1 Introduction

The aim of the project is to predict stocks price in near future. To predict a stock price, the traditional stock price analysis tools and Long Short Term Memory Model (LSTM) through machine learning is used in this project. Specifically, the stock price of Tesla Motors is used to compare the techniques in the study. The study is carried out using Pandas, NumPy, Seaborn libraries in Python. First, summary information and summary statistics of the company are shown, including the number of observations, maximum and minimum prices in the analyzing period, standard deviation, and the 50 and 75 percentile of the stock prices. Secondly, historical closing prices, moving averages, moving averages convergence – divergence (MACD) are analyzed. They are used the following indicators to examine stock prices: Relative Strength Index, Parabolic Stop and Reverse, Stochastic Oscillator, Commodity Channel Index and Awesome Oscillator. Finally, we apply LSTM in order to analyze the stock prices and predict the future prices.

2 About the Company

Martin Eberhard and Marc Tarpenning founded Tesla Motors in 2003. The headquarter of the company settles in Palo Alto, California. The main objective of Tesla Motors is designing and improving electric vehicles and their components. The company defends that clean energy is better than fossil fuels. Basically, it produces automobiles which have electrical power. In addition, the company's mission is being an innovator of energy. Tesla has own sales and service network. It can be said that well established automobile companies, BMW and Mercedes, are the main competitors of Tesla Motors. However, Tesla takes the leadership in electric vehicles because it has accomplished to produce faster electric vehicles and the consumers can charge their cars in their home in a very short period of time. Rapid innovation power and strong customer relationship of the company provide to get a big share of the electric vehicles industry, a relatively new one.

The company took 60 million dollars investment in 2007. Tesla's first initial public offering (IPO) was held in 2010. The IPO price of Tesla Motors (TSLA) was 17.In this report, TSLA's closing prices are used for the analysis from July 2017 to June 2021. In the period, revenue of the company has risen constantly. In 201, the revenue was $11.76 billion, $21.46 billion in 2018, $24.58 billion in 2019 and $31.54 billion in 2020. Market cap of the company is $593.3 billion right now [1]. Earnings before interest, taxes, depreciation, and amortization (EBITDA) of the company was $95 million in 2017, $1.67 billion in 2018, $2,273 billion in 2019 and $4,49 billion in 2020.

3 Technical Indicators

In this part of the study, we study the prices using traditional technical analysis tools. Firstly, summary statistics and the closing price history of the stock will be explained then technical indicators and oscillators will be used.

3.1 Summary Statistics

In the following data, some basic summary statistics can be seen for TSLA. For the last two years, there are 505 closing prices are analyzed. The average stock price for these 505 closing prices is $314.04. Deviation from this number $263.4. In this period, the minimum closing price of the stock was $41.85 and maximum price of the stock was $883.09. 25 percentile of the closing prices is at $70.44, 50 percentile of them is at $188.13 and 75 percentile of the closing prices is at $576.83.

3.2 Closing Price History

In a regular trading day, the closing price is the last price that security traded. Dataset is set for two years. As the following chart, it can be seen closing prices of TSLA.

Figure 1. TSLA's Closing Price History

The closing prices of TSLA were not over volatile between July 2019 and July 2020. However, by the last months of 2020, the prices started to increase with a trend and have become more volatile.

3.3 Moving Average

Moving average is used to analyze stock prices creating different types of averages in the analyzing period. It is also called as rolling average or running average. There are different kinds of moving averages, because of this reason this tool generally called as Simple Moving Average (SMA). The analysts use simple moving averages for determining stock price direction. Through the moving averages, noise terms of a stock price can be eliminated so that the analyst can observe the main trends clearly [2].

Simple Moving Average for a stock price is calculated by summing all closing prices and dividing this sum by the number of days in the analyzing period. It is said as moving because the value is recalculated every day. It is a technical indicator that an analyst applies to find out

buying or selling signals for a stock price. Simple moving averages assist to find entry and exit prices defining resistance and support prices.

The formula of simple moving average for n prices:

$$SMA = (A1 + A2 + \ldots + An)/n \tag{1}$$

In this formula, An are the closing prices in the period and n is the number of periods.

To find simple moving averages of TSLA, 10, 20, 30, and 50 days are used for the value of n. Using more than 50 days, like 200 days, reflects the direction of the trend later than the shorter periods. If the moving average of a stock price has increased, it means that it is in an uptrend. If the moving average of it has decreased, it means that it is in a downtrend. However, this way is not enough to determine an investment strategy. In addition to this, a couple of moving averages should be used. If a stock price enters in an uptrend, the short-term SMAs should be above the long-term SMAs. If a stock price enters in a downtrend, short term SMAs should be below the long term SMAs.

Some of TSLA's moving averages are depicted in Figure 2. To be able to see the trend clearly, smoothing out the noise terms is a useful way. 10 and 20-day moving average lines can predict better than others, because when the trend is upward, the price line stays above the 10 and 20-day lines. However, 30 or 50-day moving average lines do not stay above or below the price line, they are late to make a decision about the strategy.

Figure 2. The Moving Averages of TSLA

3.4 Moving Average Convergence Divergence

Gerald Appel discovered this indicator in 1970's. To be able to calculate MACD, closing prices are used as in the moving average calculation. Appel mentions about basic concepts of MACD as follows. MACD is calculated by the difference of the short-term exponential moving average minus the long-term exponential average. Generally, 26-day exponential moving average is simply deducted from 12-day exponential moving average. In addition to the MACD line, there

is a signal line that can be used for deciding on buying and selling of a stock.

$$MACD = 12day\ Exponential\ Moving\ Average - 26day\ Exponential\ Moving\ Average \tag{2}$$

$$Signal\ Line = 9day\ Exponential\ Moving\ Average\ of\ MACD \tag{3}$$

When the trends have upward direction, short term averages will increase faster than long term averages. In this case, MACD lines will disperse. If the trends are losing power being downward, shorter-term averages will be flattened. If the reduction continues, it will be below longer-term averages. It can be said that changing trends influences the direction of MACD. However, every trend reversal cannot be considered as settled till other signs occur. Usually, short-term moving averages diverge (or converge) with longer-term moving averages. Therefore, this indicator called moving average convergence-divergence.

There are three ways to use MACD indicator. First one is crossovers. If the MACD falls below the signal line, it means that it is time to buy the asset. If the MACD line is above the signal line, it is time to sell the asset. Second way is to use divergence of the asset price. When the price of an asset diverges from MACD, it means the trend is over. The last way is to look for abnormal rises in MACD. If MACD indicator increases abnormally, this means that the short-term moving averages pushes up the long-term moving averages so the asset price takes place in overbought points, in a short period, it will turn its normal condition. Additionally, investors should pay attention to the zero line. If MACD is above the zero-line, short-term moving averages is above the long-term averages and the upside movement can go on. If MACD is below the zero-line, short term averages are below the long term averages and the downside movement can go on.

In Figure 3, closing prices of TSLA, MACD and the signal line can be observed. It can be said that there is a good estimation of the prices. When the stock price falls down, MACD is below the signal line; when it rises up, MACD is above the signal line. Therefore, MACD is a good indicator for estimating TSLA stock price.

Figure 3. Moving Averages Converges Divergence of TSLA

3.5 Relative Strenght Index

Relative Strength Index or RSI is an indicator that predicts the direction of short term and medium term trend using previous period's closing price. It is created by J. Welles Wilder in 1978. RSI shows signals whether overbought and oversold of a stock. Basically, it measures the anomalies of price movements. Usually, fourteen-day period is used and this fourteen-day period falls below 30, the investor should buy and rises above 70, the investor should sell the asset.

The formula of the RSI as follows:

$$RSI = 100 - [100 / (1 + (Average\,of\,Upward\,Price\,Change / Average\,of\,downward\,Price\,Change)] \quad (4)$$

Relative strength index of TSLA can be seen in Figure 4. In march 2020 and 2021 RSI falls below 30. After march 2020, it can be observed that the index increases and never fall below 30 until march 2021. Considering the January 2021 closing prices, it can be seen that TSLA's prices hit the new record then started to fall. Relative strength index of TSLA was above 70. Thus, TSLA showed selling signals.

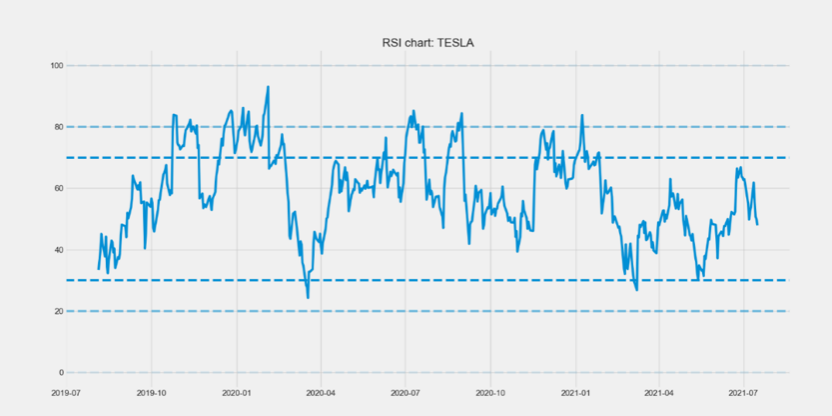

Figure 4. Relative Strength Index of TSLA

3.6 Parabolic Stop and Reverse

The Parabolic Stop and Reverse (SAR) is created by J. Welles Wilder, too. It determines the direction of an asset's price. An analyst uses Parabolic SARs to analyze possible turnabout in the price movement of a stock price. In addition to this, it can be used to decide entry and exit prices. When the Parabolic SAR decreases below the current stock price, it means that this is a buying signal. If it takes place above the current price, it will be a selling signal. To establish stop losses and target profits, these signals can be used by the analysts. Generally, near the price bars, there are a set of dots representing the asset. If the points stay below the price, it indicates that the stock price direction is upward and it shows a buying signal. If there is a change in the direction of the dots, there might be a profit opportunity. Because of this, Parabolic SAR is not a good indicator in a flat or ranging market [3]. To identify the place of the indicator, the highest

and lowest price and the acceleration factor is used to calculate Parabolic SAR. The formula is as follows:

$$Uptrend\,Parabolic\,SAR\;=\;Prior\,SAR\;+\;Prior\,AF\,(Prior\,EP-Prior\,SAR) \quad (5)$$

$$Downtrend\,Parabolic\,SAR\;=\;Prior\,SAR-Prior\,AF\,(Prior\,SAR-Prior\,EP) \quad (6)$$

EP is the extreme point that stands for the highest or the lowest in a trend. AF means the acceleration factor and it starts at 0.02 (when each time EP is recorded, acceleration factor is increased by 0.02 each time, with a maximum of 0.20). In Figure 5, the yellow line indicates the uptrend Parabolic SAR and the red line indicates the downtrend Parabolic SAR. The decision maker should sell when the Parabolic SAR is red. The decision maker should buy the asset when the Parabolic SAR is yellow. In Figure 5, the indicator can predict the trend most of the time. At some points, the indicator shows false signals. However, this condition is expected when the analyst uses Parabolic SAR. Wilder recommends that the analysts should use other indicators in conjunction with the Parabolic SAR to be sure about the trend.

Figure 5. Parabolic Stop and Reverse of TSLA

3.7 Stochastic Oscillator

Stochastic oscillator is a technical analysis tool which is developed by Dr. George Lane in the late 1950s. Within a specific period of time, Stochastic Oscillator compares the most recent closing price of a security to the highest and lowest prices. This tool might give an idea about the momentum of a stock price. It generally shows as a percentage and uses a 14-day period as the analyzing period. Zero means it is the lowest point of the analyzing period. 100 shows the highest point of the period. 80 and 20 are the two default lines. Any value above 80 line shows that the stock is overbought. Any value below the 20 line shows that the stock is oversold [4].

Stochastic oscillator gives indications of overbought and oversold. It looks at the current price and compares it to the previous period. It is factoring in highest high and lowest low across the period of its lookback in making its comparison.

The Stochastic Oscillator formula is calculated by the following:

$$\%K = (C–L14)/(H14–L14)x100 \tag{7}$$

$$\%D = 3 - day\ Moving\ Average\ of\ \%K \tag{8}$$

In the formula, K is the current value of the stochastic oscillator. C shows the last closing price, L14 stands for the lowest stock price traded of the 14 previous trading sessions. H14 stands for the highest price traded during the same 14-day period.

There are three ways to use stochastic oscillator. The first is defining overbought and oversold regions as indications of potential reversals in the stock price. Another way is that looking crossovers of %K and %D and using those as trading signals. If the %K crosses below %D, the trader would sell the stock, if %K crosses above %D, vice versa. The last way of using it is that looking divergences between the price and oscillator. If there is a divergence between the price and the oscillator that could be signal of potential reversal.

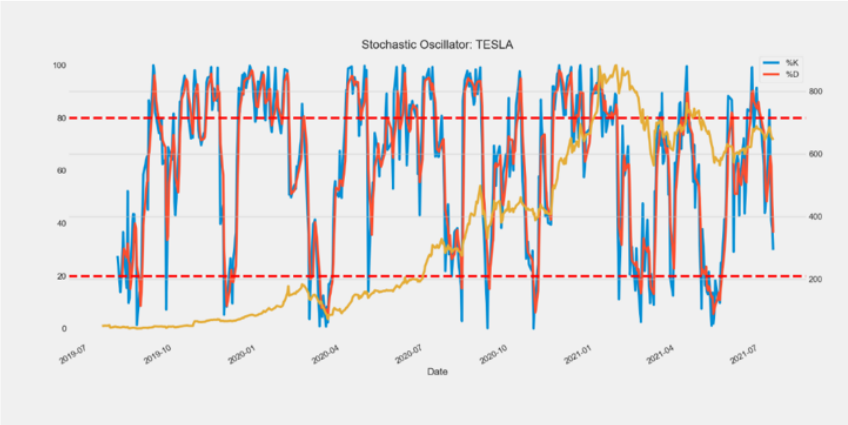

Figure 6. Stochastic Oscillator of TSLA

In Figure 6, it can be observed the stochastic oscillator 14-day periods for TSLA. The yellow line shows the historical closing prices of TSLA. It can be said that the oscillator can predict the trend most of the time.

3.8 Commodity Channel Index

The commodity Channel Index (CCI) had been used for commodity prices; however, it has also been used for security prices. The CCI measures the relationship between the price of a security and its moving average. It is common to use 20-day moving average. The indicator contains three lines. One line is said as zero, the second one is -100 and the third one is +100. The CCI takes values between -100 and +100. If the price movements are above the moving average, the CCI line is above zero. If it crosses below the moving average, the CCI falls below zero. However, if the price deviates significantly from the moving average, the CCI line crosses

outside the other channel lines, and the underlying security could be considered overbought or oversold. These crosses can be used to help identify potential entry and exit signals. If the CCI rises above the +100 line and then crosses back below it, an investor might see this as a potential exit signal. The CCI is used for defining the time of entry and exit signals. But the security price can continue to move higher because there is no upside or downside limit in CCI.

To be able to calculate CCI, one should calculate the average price and the simple moving average of this average in the analyzing period, subtract the SMA from the average price. The subtraction is divided by the mean deviation multiply by .015. This number is a constant that allows 70 to 80 percent of CCI values reside in the +100 to -100 range. The sum of the highest price, the lowest price, and the last closing price divided by three gives the average price. The formula for CCI is:

$$CCI = (AveP - SMA\,of\,AveP) \,/\, (0.015\,x\,Mean\,Deviation) \tag{9}$$

$$AveP = Average\,Price = (High + Low + Close) \,/\, 3 \tag{10}$$

CCI of TSLA can bee seen in the Figure 7. When the red line rises above the +100 line, this is an exit signal and stays below -100, this is an entry signal. Sometimes, it may give the false signals. In addition, the indicator is late to show the trend. However, it can be said that the index can be used to predict the overbought and the oversold points most of the time.

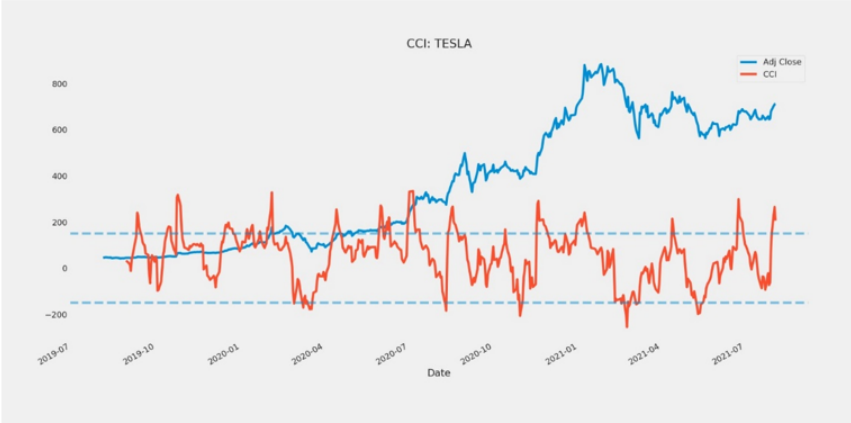

Figure 7. Commodity Channel Index of TSLA

3.9 Awesome Oscillator

To be able to compare the recent market price changes, the awesome oscillator can be used. It is a market momentum indicator. In the indicator, there are two different moving averages and a zero line in the middle of these moving averages. Stock price movements are plotted according to these different moving averages.

The Awesome Oscillator is a measure to find momentum dynamics. It compares the momentum of the last 5 candlesticks with the momentum of the last 34 candlesticks on a larger

time frame. The value of the Awesome Oscillator indicator is calculated as the difference between the moving averages on timeframes larger than these timeframes. The Simple Moving Average is calculated using the midpoint of each candlestick, not the closing price of the candlestick.

There are three ways to use this oscillator. The first one is twin peaks. On the zero line, two peaks are considered. One can observe a bearish signal if the following conditions occur. The awesome oscillator is below zero. The second peak is lower than the first peak and the histogram is green. She can observe the bullish signal if the conditions as follows. There are two peaks below zero. The second low is higher than the first low. The color of the histogram that comes after the second low is green. The second way to use awesome oscillator is looking at crossing zero line. The buying strategy occurs when the awesome oscillator crosses above the Zero line. In this condition, the short term momentum increases faster than the long term momentum. If the oscillator crosses below the Zero line, the strategy will be bullish. The last way to use awesome oscillator is the saucer strategy. The investor should buy the asset when the following conditions occur. There are two red histograms side by side. If the second one is shorter than the first red candle stick below above the Zero line and the color of the third stick is green. The investor should sell the asset when there are two green histograms side by side, the second one is shorter than the first one, the third one is red.

The awesome oscillator formula is as follows:

$$Median\,price = (High\,price\,of\,a\,session\ +\ low\,price\,of\,a\,session)\,/\,2 \tag{11}$$

$$Awesome\,Oscillator = 5\,period\,SMA(median\,price) - 34\,period\,SMA\,(median\,price) \tag{12}$$

In Figure 8, it can be observed the awesome oscillator of TSLA. As the other indicators, awesome oscillators can give the idea about the trend most of the time.

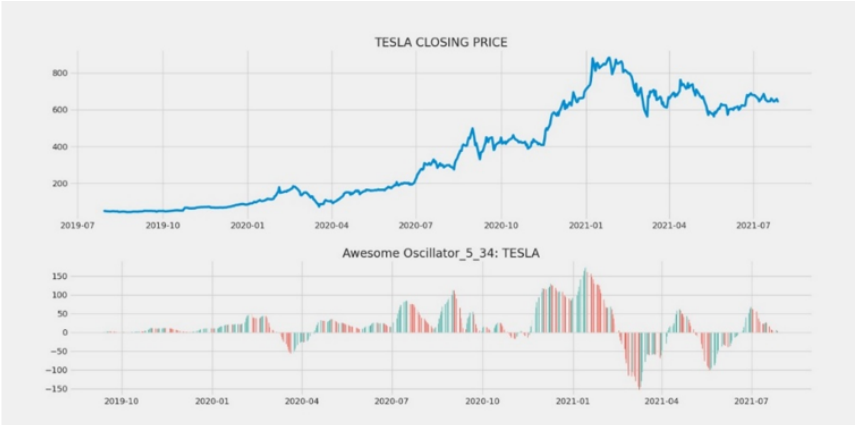

Figure 8. Awesome Oscillator of TSLA

4 Long Short Term Memory Model

Long Short Term Memory (LSTM) is an architecture that is used in deep learning. It has an artificial recurrent neural network that can be capable of learning [5].

LSTM networks are able to analyze linear problems. Long-term Memory Units are enforced to learn very long sequences. This is a more general version of the gated recurrent system. LSTM has feedback connections. LSTM models are capable of storing information in a period of time. Because of this reason, it can be said that LSTM models have a memory capacity. In this way, LSTM can be used on time series data and it can classify, process and predict them. The ultimate advantage of the LSTM is the ability to learn context-specific temporal dependence. LSTM networks are able to define long term dependencies. Long term dependencies are used for future prediction [6].

A typical LSTM unit consists of a forget gate, an input gate and, an output gate. One can think that the gates are some kinds of filters and have their own neural network. A LSTM output has three dependents. The first one is the current long term memory of the network that is defined as the cell state. The second one is the previous hidden state. This is the output that has occurred previously. The third one is that consists the input data at the current time.

The starting point of the process is the forget gate. At this point, the model can decide the useful data considering hidden state and the new input. The new input and the previous hidden input create a neural network. In the network, each cell state changes in the range of 0 and 1 through the sigmoid activation. If a data is relevant to the model, its output is close to 1. If a data is irrelevant, it will be closer the 0. For the next step of the process, these values are pointwise multiplied with the previous hidden data. So that, irrelevant data cannot make big influence on the next steps. In other words, the forget gate in the LSTM is responsible for forgetting the data that should have less weight in the process.

After the forget gate, considering the previous hidden state and the new data, the model decides the new information that should add the long term memory of the network. In this step, combining the previous hidden state and the new input to create a new memory update vector, there is a tanh activated neural network. The new memory update network consists of the new input data. The vector shows the amount of updating of the network. A new memory vector consists all of the information, relevant or irrelevant. Input gate plays a crucial role to eliminate irrelevant date. To do this, it uses a sigmoid activated network that has values in the range of 0 and 1. If the output is near to one, it is appropriate data for updating the cell state. After the pointwise multiplication of new memory update vector and the sigmoid activated vector, the effect of the new information is determined. The cell state and the new vector is added. This may change or don't change the long term memory of the network.

The final step of the process is determining the new hidden state. The output gate decides the new hidden state using the previous hidden state, the updated cell state and the new input data. In this step, sigmoid activation is implemented to previous hidden state and the new input data. This is a new vector that is the new hidden state.

In Figure 9, closing prices of TSLA have been used for the last two years. The training data is the 80% of it, the testing data is the last 20%. As seen in Figure 10, that the model can estimate the stock price trend successfully. To understand the power of the estimation, we can

look at root mean square error (RMSE). Square all of the errors, taking mean of it, then taking square root of this mean. RMSE is a commonly used metric, since it is a successful general-purpose error metric for numerical predictions [7]. It is normalized in this study, so it occurs between 0 and 1. For the data at hand, the RMSE is approximately 0.2171. So, it can be said that model can predict the data sufficiently. As it can be seen in the Figure 9, it can predict the trend of the stock price most of the time.

Figure 9. Long Short Term Memory Model of TSLA

5 Conclusion

Making investment decision using traditional technical indicators is a risky choice. Because, a stock may remain oversold or overbought for a long time. The technical analysis tools use short periods to predict the price. This leads to give false signals about a stock price. Second risk is that there might be big events or announcements about the company. The tools can be used to define divergences and help with timing about potential entry and exit signals. But the using one of the tools is not enough to decide an investment strategy, the decision making process should be done by trending indicators besides oscillating indicators. So, the decision maker should combine these indicators.

To predict stock price trend, data processing technique and different kinds of algorithms can give good results. For a shorter period of time like 1-3 months, technical studies are frequently used to predict the trend [8]. Using one technique such as LSTM might be helpful to understand the trend. The model can be efficient for defining long term dependencies and uses them for future prediction. Because of this reason, it might be successful to predict the unexpected jumps in the stock price. The traditional way may accomplish to predict these movements. However, the analysts should use multiple indicators to decide the trend.

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