CocaCola Forecasting White Paper

by Moshe Burnstein

Abstract:

This white paper investigates whether it is a financially sound decision to accept a credit card cash offer at a 5% cost, with the goal of investing in CocaCola (KO) stock and making a profit? Is it worth the risk that one may lose money if the stock does not appreciate within a limited time period? Many people are bombarded with bank offers to advance cash with no interest for 6, 12, or 18 months. They are charged at origination with a 5% fee. A cash advance of $10,000 will see $9,500 deposited in one's bank account. With what level of confidence can we forecast Coca Cola close prices for future time periods?

Business Problem

Compare the cost of borrowing $10,000 at a cost of 5% with the value of KO stock bought for that $9,500 and then sold at 6, 12, or 18 months in the future.

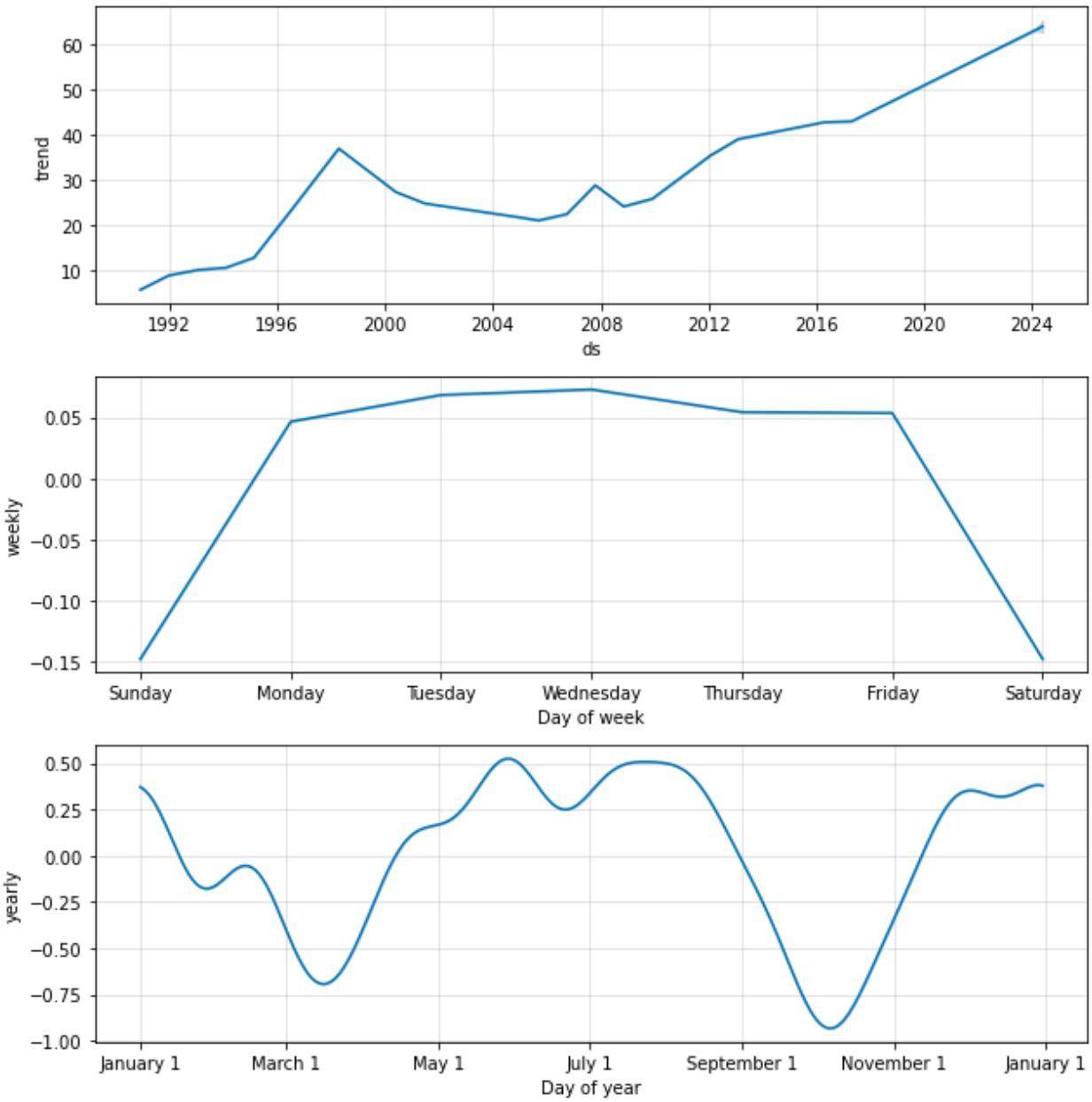
Background/History

KO Price History

KO stock price remained steady until around 1990. It then grew in an upward trend with dips along the way. The past year has seen a drop of almost 8%. 2020 shows a nice recovery from the Covid-19 pandemic. 2012 shows nice growth due to encouraging data coming out about the economic recovery subsequent to the 2008 crisis which had resulted in sustained losses. Late nineties growth represents the dot-com bubble (which burst over the next several years) and low inflation. KO has weathered the ups and downs admirably and has trended upward growth. The upward trend has slowed down a bit since the nineties because the rate of expansion slowed and because consumers are eschewing unhealthful drinks.

KO stock is one of Berkshire Hathaway's largest holdings. Such approbation is a feather in the cap for any company. According to a June 30, 2023, 13F filing, Buffet's company owned a 9.2% stake in the soft drink powerhouse (Team, T.I.). KO offers a sustained growth strategy that has worked for 125 years. It is also a dividend machine, offering consistent dividend payments since 1963 (Robbins, N.). KO is always an attractive buy. If one were able to invest for a longer period of time, KO would be a definite buy.

Trend Components



Note the upward trend in stock price overall. The weekly trend is not surprising in that Saturday and Sunday KO does not trade. It appears that Wednesday has the highest close. While the decline during March and April is not easily understood, the September, October decline is not unexpected (Mitchell, A. C.). Investors wish to lock in gains and losses as the year ends.

Data Explanation

I used data from Yahoo Financial (Yahoo!).

https://finance.yahoo.com/quote/KO/history?period1=657849600&period2=1701820800&interval=1mo&filter=history&frequency=1mo&includeAdjustedClose=true

This website has accurate data on stock prices, including date, open, high, low, close, adjusted close, and volume. I corroborated the Yahoo data with historical data from The CocaCola Company itself (*Historical data*. The Coca-Cola Company) and from Nasdaq. There were no null values or other abnormalities in the data. I used the date and close variables for all models. The 'close' price represents the last price fetched for a given stock before the market closes for the day. The Prophet model requires two columns, a 'ds' column in datetime, and a 'y' column as the target price. The LSTM model requires the datetime feature to be the index and the dependent variable to be the singular column.

Methods

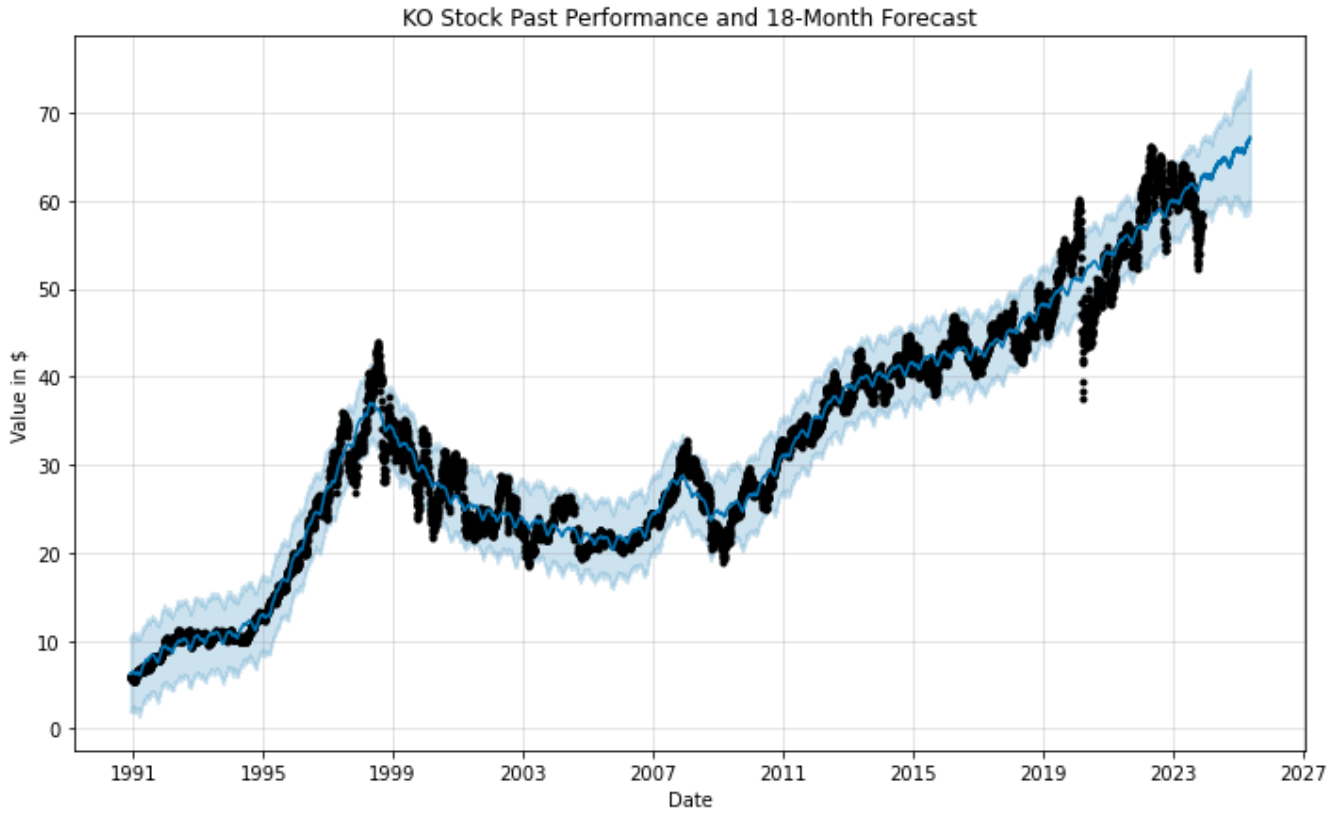
I built a baseline model using Prophet and a tuned Prophet model using grid search. Facebook produced the Prophet model to better model time-series data and to automate it seamlessly (*Forecasting at scale.* Prophet). Prophet does a particularly good job at modeling trends, seasonality and holidays. To assess whether tuning helped the Prophet model, I compared a slew of metrics, including mse, rmse, mae, mape, mdape, and smape. Across the board, the tuned model produced lower values for the loss functions.

I then built three LSTM models with varying lookback time periods. Long Short-Term Memory Networks are a type of recurrent neural networks which model long-term dependencies well (Understanding LSTM Networks -- colah's blog). The main metric which I chose for the loss function to compile the LSTM is mean squared error (MSE). The one caveat when using MSE is that it disproportionately penalizes large errors. It is a good indicator of predictive accuracy.

Analysis

Prophet Models

The baseline Prophet model predicted a price of $64.19 dollars at six months, $65.60 at twelve months, and $67.25 at eighteen months. KO was bought for $58.58 per share. The Prophet model with grid search produced prices of $64.73 at six months, $65.79 at twelve months, and $67.47 at eighteen months, a higher price increase across the board.

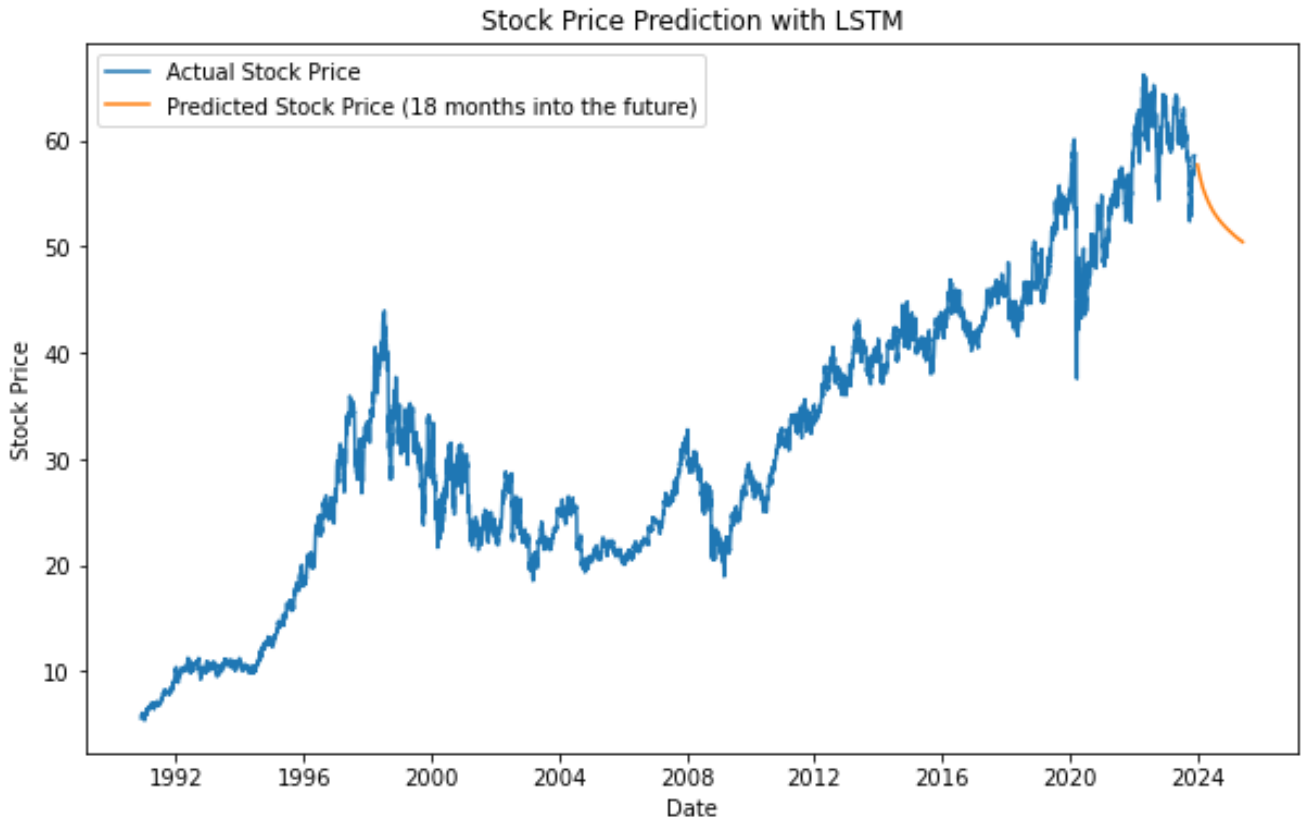


This illustrates the Prophet model prediction. The black dots represent the actual values of the stock. The light-blue line is the trend line. This snapshot displays a nice upward trend and highlights the volatity. KO has weathered the ups and downs admirably and has trended towards upward growth. The upward trend has slowed down a bit since the nineties because the rate of expansion slowed and because consumers were eschewing unhealthful drinks.

LSTM Models

The LSTM model with a lookback of 60 days, predicted prices of $55.59 for six months, $51.13 for twelve months, and $49.61 for eighteen months. The model with a 180-day lookback predicted prices of $55.06 for six months, $54.32 for twelve months, and $53.53 for eighteen months. The model with a lookback of 365 days predicted prices of $53.76 for six months, $51.73 for twelve months, and $50.45 for eighteen months. I increased the lookback to 365 days for the last LSTM model. The six-month prediction is $53.76, the twelve-month prediction is $51.73, and the eighteen-month prediction is $50.45. I increased the lookback to explore whether greater lookback time capture trends.

The following graph shows LSTM predictions for 18 months.



Conclusions

Actual and Forecast Close Values

Models	Actual Prices	6 Months	12 Months	18 Months
Baseline Prophet	$9,500	$10,539.97	$10,760.09	$11,454.43
Prophet (Grid)	$9,500	$10,577.92	$10,711.70	$11,485.68
LSTM (60 days)	$9,500	$9,611.33	$8,863.16	$8,557.58
LSTM (180 days)	$9,500	$9,533.07	$9,443.16	$9,154.38

LSTM (365 days)	$9,500	$9,183.31	$8,815.15	$8,566.05

Note that both Prophet models predict KO values of more than the $10,000 owed, while none of the LSTM model predictions predict a close value of $10,000.

The most crucial question to be answered is which model most accurately predicts future prices. If one were to rely on any of the LSTM models, he would most certainly not invest in KO for the short term. The Prophet models present a rosier picture. I chose Prophet because it does a better job capturing the trends and seasonality of the data. Although LSTMs model longterm dependencies, I fear that it became biased based on the recent downturn in stock price. LSTMs are also prone to making “too good” of a model-overfitting. Prophet was able to train on a thirty-year time period which includes many ups and downs due to a myriad of factors...so nothing in the next year and a half should “surprise” it.

Assumptions

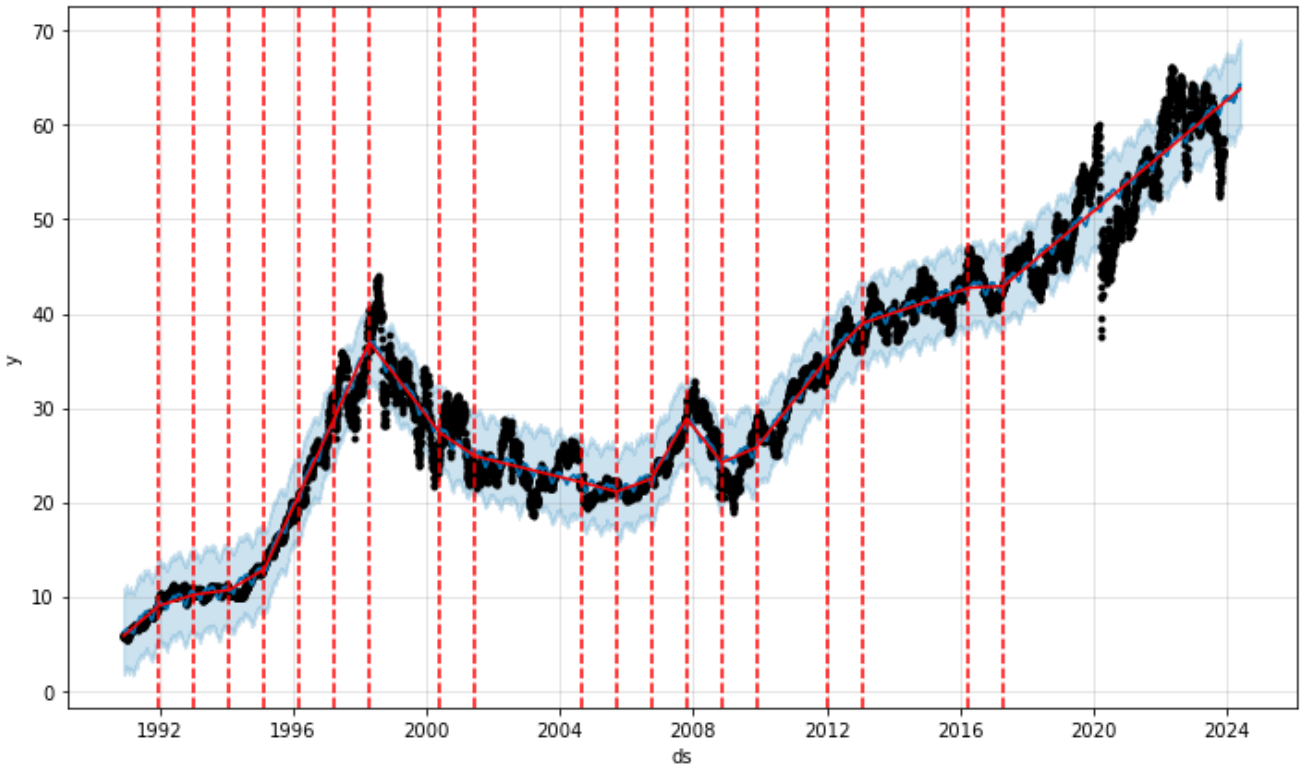
There is an assumption that there will not be any events more out of the ordinary than any event over the past thirty years. Those of us who have weathered Covid-19, well appreciate that unforeseen events can and will happen. There is a riskier assumption that past stock price data can predict the future. We have consistently been proven wrong by dartboards and monkeys (Ferri, R.).

Limitations

All stock forecasts are limited by the fact that past performance is not a true indicator of future performance. The greatest model cannot predict with certitude what the market will do. We do not understand all stock movements in the present. This study used close instead of adjusted close, which may prove a better predictor because it “adjusts” for all splits and dividends.

Challenges

Even the powerhouse KO stock has experienced extraordinary volatility.



The "changepoints" are indicated by the broken, vertical lines. They represent points in time where the data exhibits a notable change in its trajectory. Note the plethora of changepoints.

It is clearly a risk to invest in stocks, as is abundantly illustrated in the numerous changepoints, even in a stalwart like KO. In addition, one must have the "stomach" to invest in any stock, even in a "sure" bet. If there is a "sure" bet in stocks, however, it is KO. KO produces 3% of all worldwide daily consumed beverages (*History of Coca-Cola*. IG.). Their iconic brands include Coke, Diet Coke, Sprite, Fanta, and Minute Maid. It is appropriate to invest $9,500 in KO because the Prophet models most completely models all trends and it forecasts good gains. One must constantly assess whether the data sample is appropriate. Does one need go back further in time to capture more fully KO's trends?

Future Uses/Additional Applications

This project can be extrapolated to other stalwart stocks with long price histories. However, it must be optimized for the specific security. One must explore any potential stock buy to model its unique attributes. The greatest application of this project is as a risk management tool in a comprehensive financial advisory plan. The model can help to assess risk of stocks in a portfolio on a constant basis.

Recommendations

Use the Prophet model as a baseline KO predictor. Despite the hype surrounding LSTM models, exercise caution in relying on it for the volatile market. Evaluate the risk tolerance of the investor on an individual basis. The model must be maintained and updated constantly to assure its accuracy.

Implementation Plan

Borrow the money and buy the stock. Decide how much volatility and loss you are willing to accept. If an as yet unseen disaster occur in the economy, when shall one sell out? If a disastrous recession occurs and the stock is tanking, what is the floor price beyond which one must sell? If there is an unforeseen spike, at what price shall one sell and take profits?

Ethical Assessment

The most important ethical consideration in stock predictions is the famous disclaimer that past performance is not an indicator of future performance. One must caution the stakeholder not to rely solely on the model. One must protect himself from the unpredictable. One option is to hedge. One can also diversify his portfolio. He can maximize his chances of success by building a robust forecasting model. One must decide whether the data team members must disclose their stock holdings to protect against insider training and conflicts of interest. One must consistently warn of the unpredictability of the stock market as well as the ever-present risks. There are looming signs of an impending recession (Sor, J.). The model must be maintained and updated constantly to assure its accuracy. One must constantly ensure that the stakeholder understand the recommendations as well as the rationale behind the same in order that he may make informed decisions.

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Appendix 1

Predicted Performance Table

Model	Actual Price	6 Months	12 Months	18 Months
Baseline Prophet	$58.58	$64.19	$65.60	$67.25
Prophet with Grid Search	$58.58	$64.73	$65.79	$67.47
LSTM (60 days lookback)	$58.58	$55.59	$51.13	$49.61
LSTM (180 days lookback)	$58.58	$55.06	$54.32	$53.53
LSTM (365 days lookback)	$58.58	$53.76	$51.73	$50.45

Predicted Values

Model	Actual Price	6 Months	12 Months	18 Months
Baseline Prophet	**$58.58**	**$9500/$58.58 * $64.19 = $10420.57**	**$9500/$58.58 * $65.60 = $10634.94**	**$9500/$58.58 * $67.25 = $10881.24**
Prophet with Grid Search	**$58.58**	**$9500/$58.58 * $64.73 = $10479.36**	**$9500/$58.58 * $65.79 = $10652.61**	**$9500/$58.58 * $67.47 = $10913.14**
LSTM (60 days lookback)	**$58.58**	**$9500/$58.58 * $55.59 = $9004.89**	**$9500/$58.58 * $51.13 = $8282.96**	**$9500/$58.58 * $49.61 = $8035.70**
LSTM (180 days lookback)	**$58.58**	**$9500/$58.58 * $55.06 = $8918.16**	**$9500/$58.58 * $54.32 = $8799.45**	**$9500/$58.58 * $53.53 = $8663.68**
LSTM (365 days lookback)	**$58.58**	**$9500/$58.58 * $53.76 = $8701.96**	**$9500/$58.58 * $51.73 = $8376.43**	**$9500/$58.58 * $50.45 = $8166.95**

Appendix 2

Compare Prophet Model Metrics

Prophet Model Without Tuning

	horizon	mse	rmse	mae	mape	mdape	smape	coverage
0	37 days	8.933444	2.988887	2.375877	0.075451	0.063797	0.074968	0.692932
1	38 days	9.030246	3.005037	2.388666	0.075841	0.064274	0.075428	0.688345
2	39 days	9.171865	3.028509	2.406822	0.076272	0.064316	0.075917	0.682891
3	40 days	9.232783	3.038549	2.415404	0.076339	0.064710	0.076071	0.679913
4	41 days	9.247164	3.040915	2.416920	0.076286	0.065219	0.076057	0.679449
...	...	...	...	...	...	...	...	...
324	361 days	26.209452	5.119517	3.943430	0.129060	0.089391	0.126766	0.707204
325	362 days	26.291583	5.127532	3.948980	0.129411	0.089391	0.127075	0.707213
326	363 days	26.363526	5.134542	3.952967	0.129760	0.090121	0.127410	0.708795
327	364 days	26.592953	5.156836	3.964330	0.130282	0.090406	0.127872	0.710005
328	365 days	26.625670	5.160007	3.955674	0.129944	0.090121	0.127467	0.712643

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Prophet Model With Tuning

	horizon	mse	rmse	mae	mape	mdape	smape	coverage
0	37 days	8.344762	2.888730	2.252633	0.071284	0.060383	0.070818	0.453935
1	38 days	8.449034	2.906722	2.265322	0.071663	0.059807	0.071264	0.452626
2	39 days	8.590983	2.931038	2.283457	0.072080	0.060383	0.071744	0.451838
3	40 days	8.664594	2.943568	2.292896	0.072174	0.060632	0.071913	0.451202
4	41 days	8.706273	2.950639	2.298149	0.072286	0.061072	0.072059	0.450011
...	...	...	...	...	...	...	...	...
324	361 days	25.801404	5.079508	3.921880	0.128735	0.091685	0.126068	0.753685
325	362 days	25.916471	5.090822	3.931203	0.129245	0.091778	0.126490	0.753994
326	363 days	26.037184	5.102664	3.938288	0.129676	0.092898	0.126868	0.756724
327	364 days	26.230775	5.121599	3.949229	0.130141	0.092898	0.127286	0.759516
328	365 days	26.236029	5.122112	3.941894	0.129928	0.093150	0.127049	0.762518

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10 Questions From The Audience

1. What was your reasoning to choose these models to forecast?
2. What do you mean by using a grid-search to tune?
3. What are large errors for MSE?
4. What about CocaCola's dividend history makes KO an attractive choice?
5. Is it really safe to accept cash from a credit card, even when predicting gains?
6. Why should one care what Warren Buffett invests in?
7. Does the YTD drop affect your recommendations?
8. Why did you use a 30 year training period? If more training gives better accuracy, why don't you use 40 or 50 years of data?
9. How much confidence can we have in these predictions?
10. How do you account for inflation?