Business/Use Case

- Finding the highest growth in 60 days for a specific stock with the intention of expanding functionality to multiple stocks.
- The goal is to streamline the process below on a larger scale and build a stock porfolio of highest forecasted growth.

In Depth Analysis of MongoDB Stock

- Showcasing functions built specifically for EDA and Modeling of stock time series forecasting
- Historical stock data obtained from finance.yahoo.com
- Using ARIMA, Auto Arima and Facebook Prophet models

In [2]:
```
from Functions import *
```

In [3]:
```
df = pd.read_csv('Data/MongoDB.csv')
```

In [4]:
```
df.head()
```

Out[4]:

	Date	Open	High	Low	Close	Adj Close	Volume
0	10/19/2017	33.000000	34.000000	29.100000	32.07	32.07	11508500
1	10/20/2017	33.369999	33.369999	30.100000	30.68	30.68	2358700
2	10/23/2017	30.510000	31.330000	30.190001	30.50	30.50	749400
3	10/24/2017	30.459999	30.920000	30.438999	30.57	30.57	420700
4	10/25/2017	30.500000	31.100000	29.879999	31.00	31.00	1219400

Preprocessing Function

- From the default stock data provided, we want to look at the change in Adj Close price over time (days)
- The Volume will be our exogenous variable

In [10]:
```
X, Xvol = preprocess(init_data=df,exog=True)
```

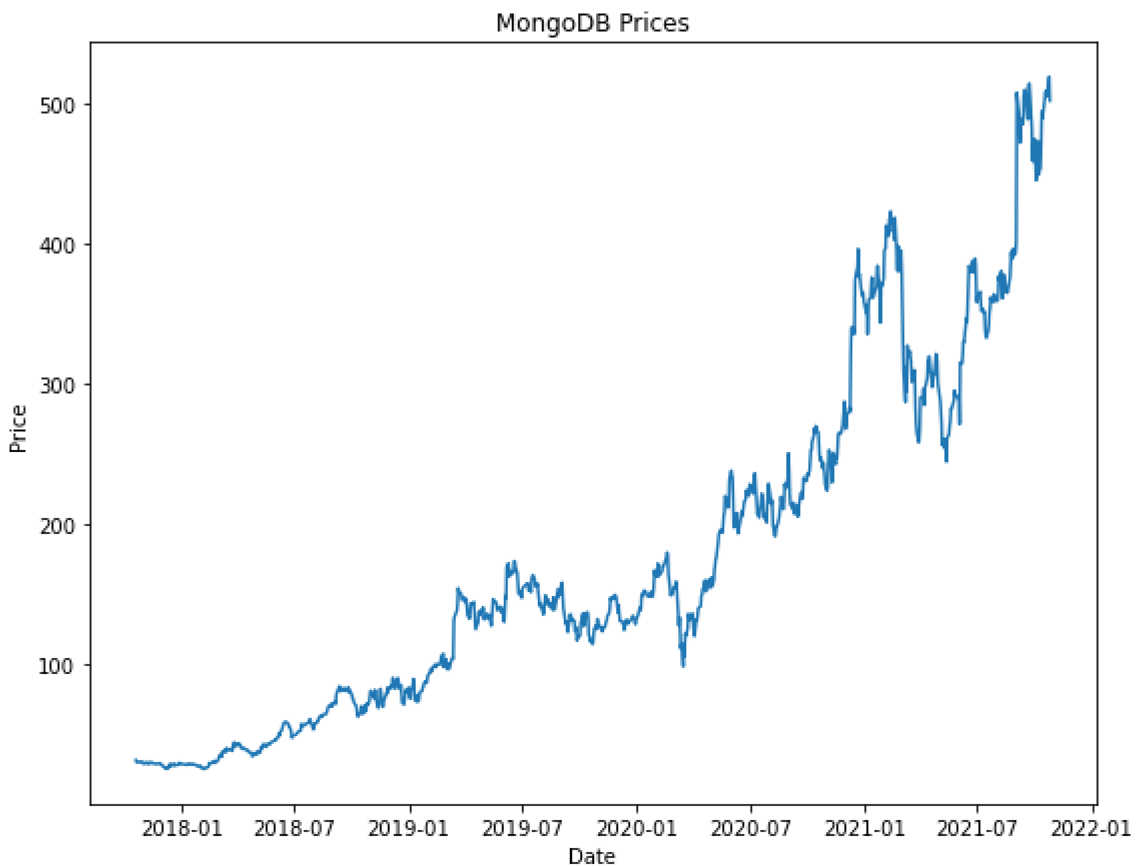
In [11]:
```
X.head()
```

Out[11]:
```
Date
2017-10-19    32.07
2017-10-20    30.68
2017-10-23    30.50
2017-10-24    30.57
2017-10-25    31.00
Name: Adj Close, dtype: float64
```

In [12]:
```
Xvol.head()
```

Out[12]:
```
Date
2017-10-19    11508500
2017-10-20     2358700
2017-10-23      749400
2017-10-24      420700
2017-10-25     1219400
Name: Volume, dtype: int64
```

In [17]:
```
figure = plt.figure(figsize=(9,7))
plt.plot(X)
plt.title('MongoDB Prices')
plt.xlabel('Date')
plt.ylabel('Price')
plt.show();
```



Log Transformations and FB Prophet Prep

- Preprocessing can perform log transformations on the data
- Can also shape the data in the format used by Prophet

In [19]:
```
Xlog, Xvollog = preprocess(init_data=df, exog=True, logged=True)
Xfb = preprocess(init_data=df,facebook=True)
```

In [20]:
```
Xlog.head()
```

Out[20]:
```
Date
2017-10-19    3.467921
2017-10-20    3.423611
```

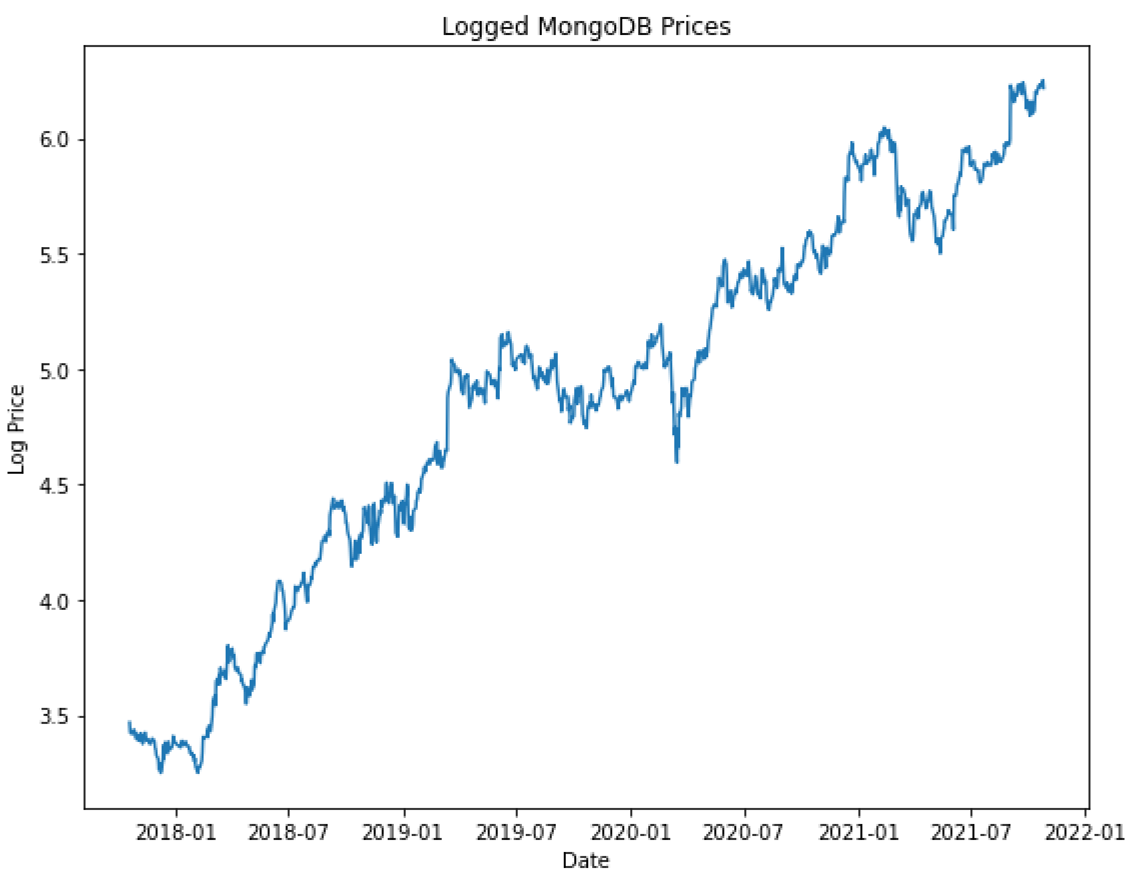
```
2017-10-23    3.417727
2017-10-24    3.420019
2017-10-25    3.433987
Name: Adj Close, dtype: float64
```

In [21]:
```
Xfb.head()
```

Out[21]:

	ds	y
0	2017-10-19	32.07
1	2017-10-20	30.68
2	2017-10-23	30.50
3	2017-10-24	30.57
4	2017-10-25	31.00

In [23]:
```
figure2 = plt.figure(figsize=(9,7))
plt.plot(Xlog)
plt.title('Logged MongoDB Prices')
plt.xlabel('Date')
plt.ylabel('Log Price')
plt.show();
```



Train Test Split for Time Series

- Instead of taking random samples of the data, train test split sets a cutoff date for training and testing data

- The same preprocessing above is built in to the split, along with log transform and prophet set up
- Default split is 75% Train, 25% Test

In [10]:
```
Xtrain,Xtrainvol,Xtest,Xtestvol = train_test(df,exog=True)
```

In [11]:
```
Xtrain.head()
```

Out[11]:
```
Date
2017-10-19    32.07
2017-10-20    30.68
2017-10-23    30.50
2017-10-24    30.57
2017-10-25    31.00
Name: Adj Close, dtype: float64
```

In [12]:
```
Xtest.head()
```

Out[12]:
```
Date
2020-10-26    240.100006
2020-10-27    244.009995
2020-10-28    240.039993
2020-10-29    235.690002
2020-10-30    228.470001
Name: Adj Close, dtype: float64
```

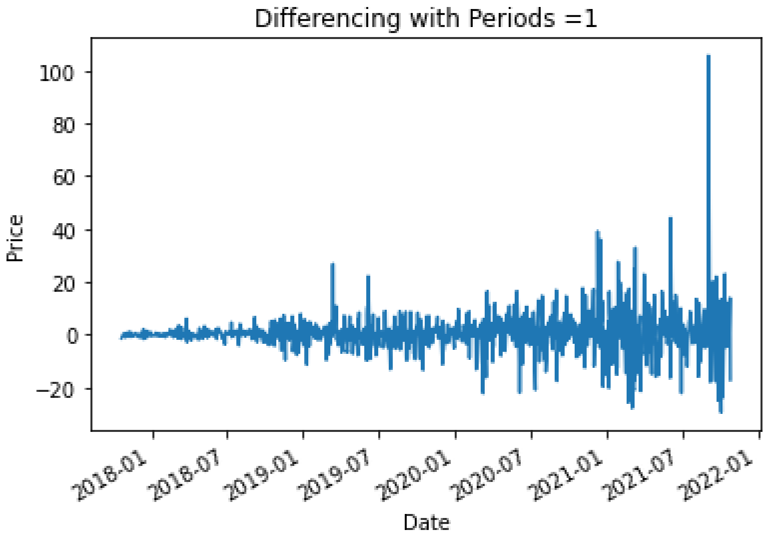
In [13]:
```
length_data = len(df)
length_train = len(Xtrain)
length_test = len(Xtest)
print('Total Data Length:',length_data)
print('Train Length:', length_train, length_train/length_data*100,"%")
print('Test Length:', length_test, length_test/length_data*100,"%")
```

```
Total Data Length: 1012
Train Length: 759 75.0 %
Test Length: 253 25.0 %
```

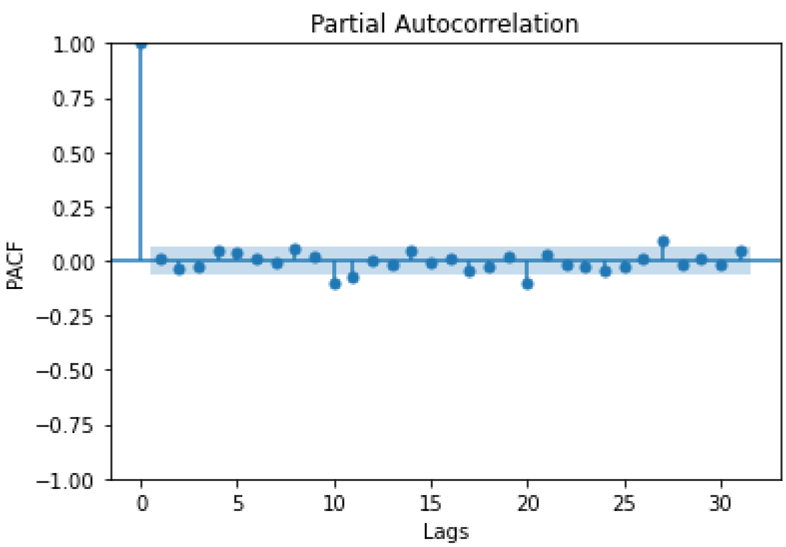
ARIMA Order Parameters

- These functions provide intial p,d,q values from ACF, PACF and Dickey-Fuller tests

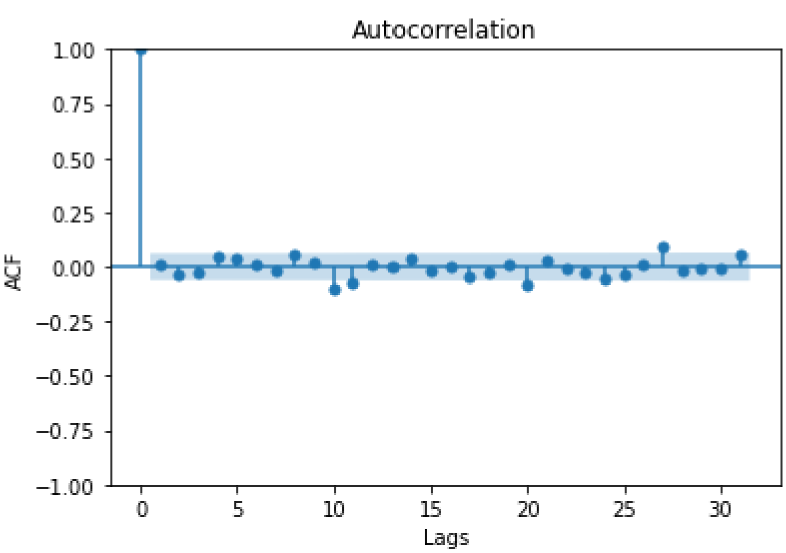
In [14]:
```
d = return_d(data=X,plotting=True)
```



In [15]:
```
p = return_p(data=X,plotting=True) # Uses differenced data to calculate PACF
```



In [16]:
```
q = return_q(data=X,plotting=True) # Uses differenced data to calculate ACF
```



In [17]:
```
print("p = ",p)
```

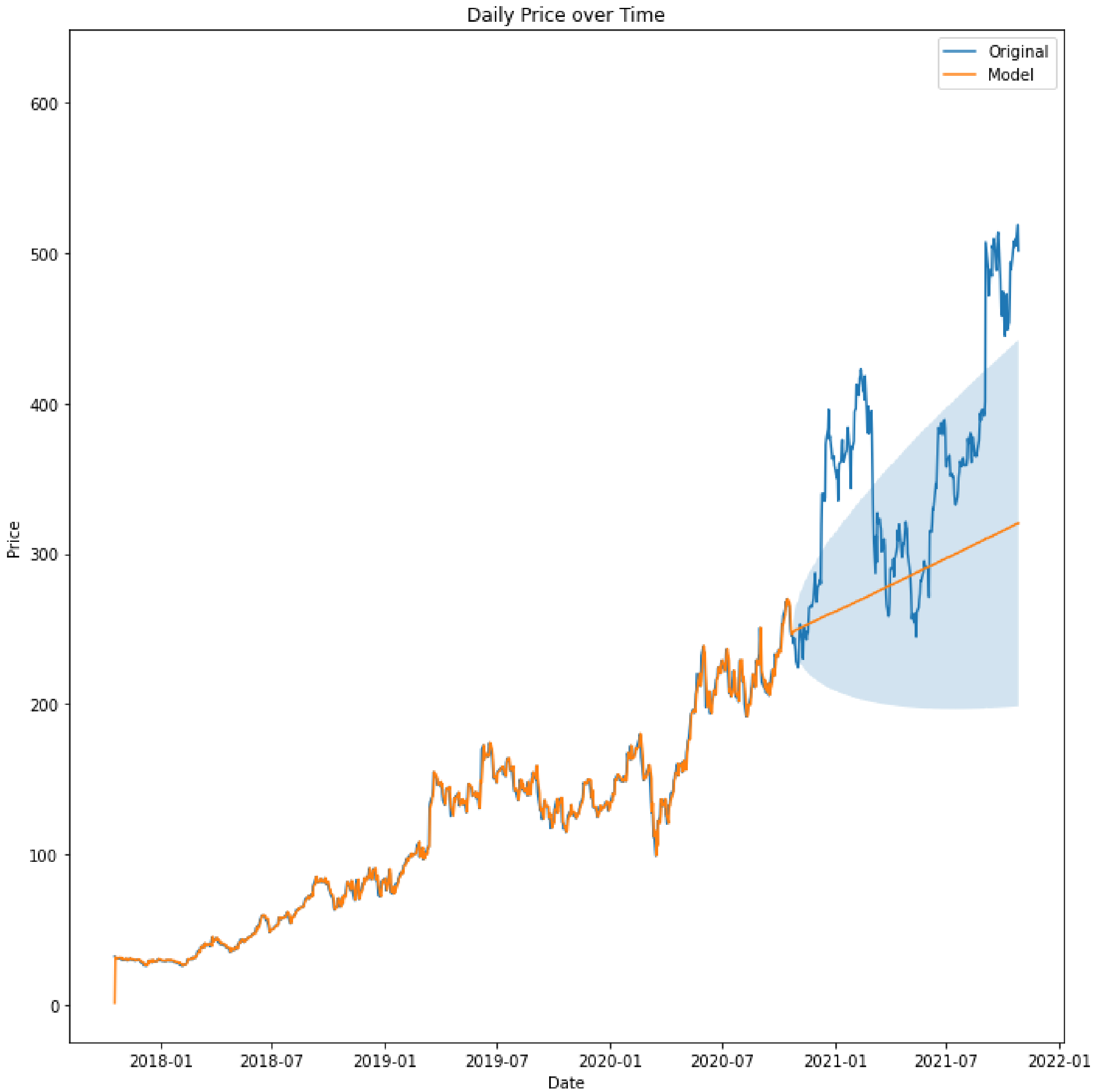
```
print("d = ",d)
print("q = ",q)
```

```
p =  0
d =  1
q =  0
```

Modeling

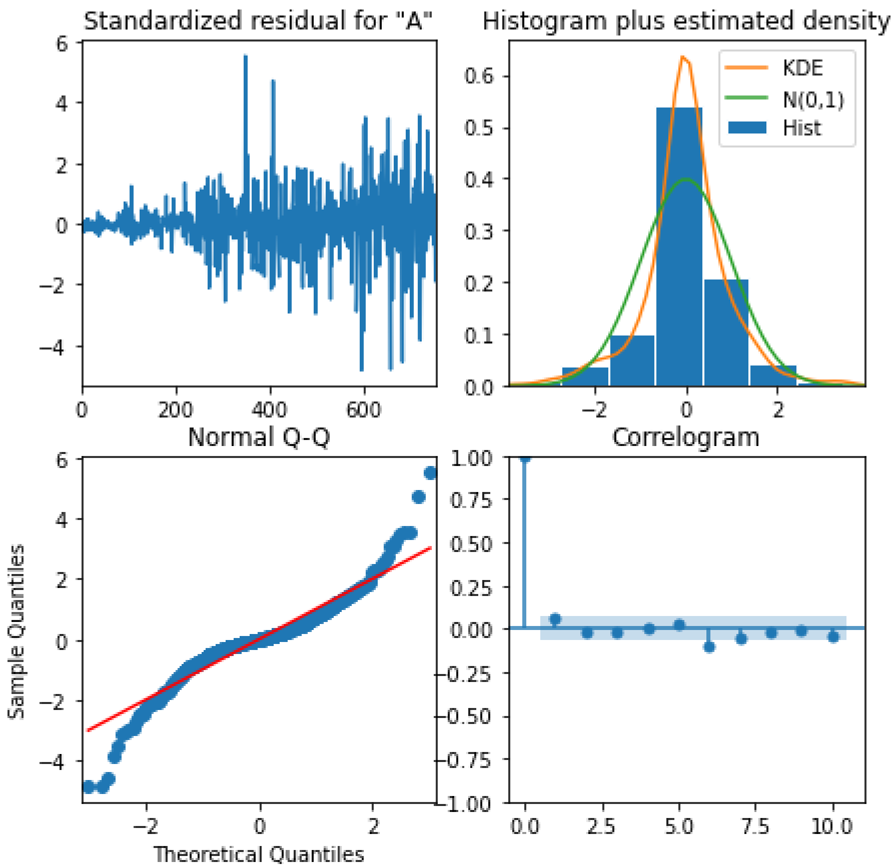
Base ARIMA Model

In [18]:
```
arima = base_model(df,exog=True,logged=False,plotting=True,summary=True,mse=True)
```

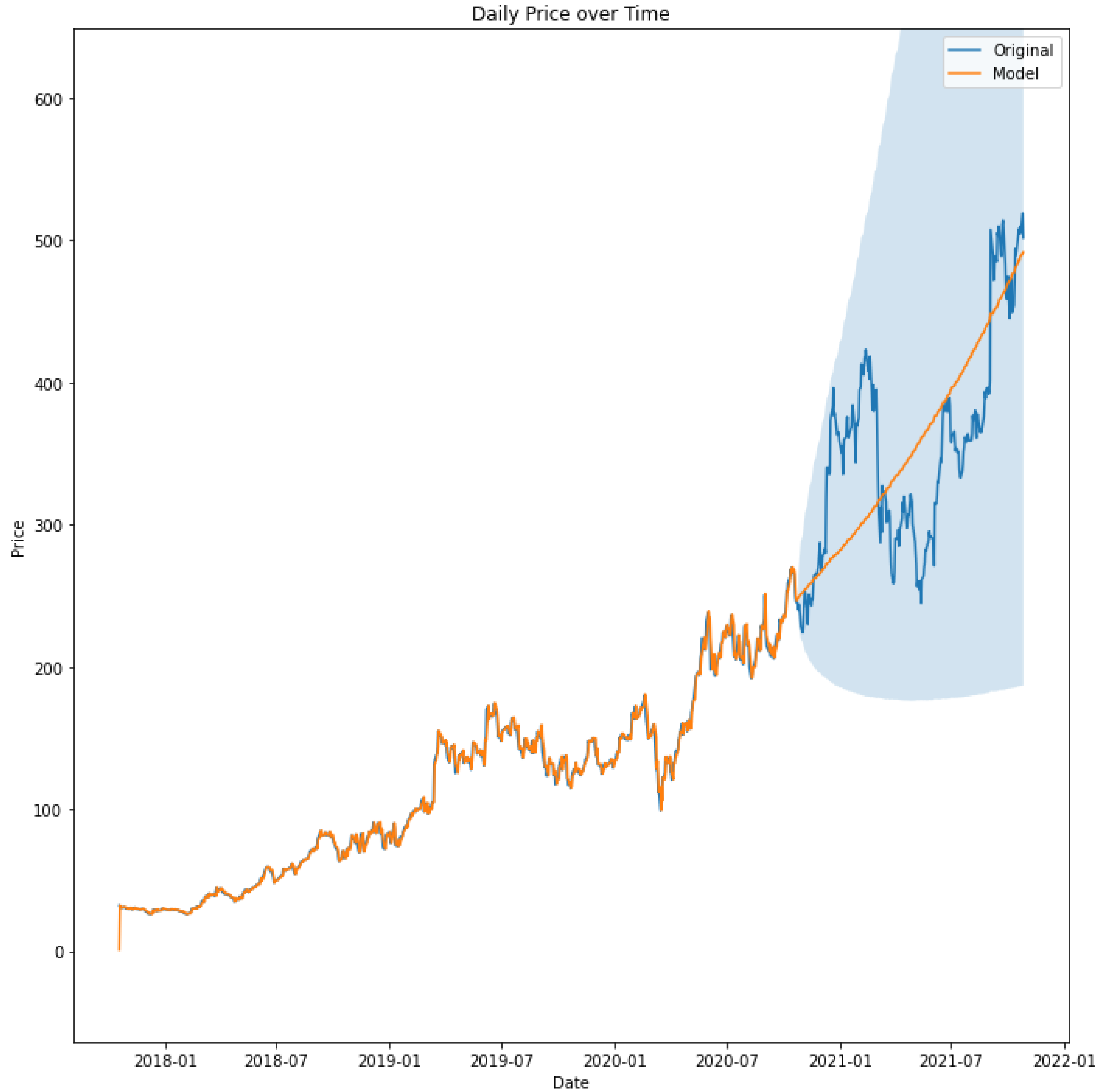



```
                               SARIMAX Results
==============================================================================
Dep. Variable:              Adj Close   No. Observations:                  759
Model:               SARIMAX(0, 1, 0)   Log Likelihood               -2241.718
Date:                Mon, 15 Nov 2021   AIC                           4489.435
Time:                        20:36:09   BIC                           4503.327
```

```
Sample:                             0   HQIC                          4494.785
                                - 759
Covariance Type:                  opg
==============================================================================
                 coef    std err          z      P>|z|      [0.025      0.975]
------------------------------------------------------------------------------
intercept      0.2859      0.183      1.566      0.117      -0.072       0.644
Volume      7.089e-08   9.42e-08      0.752      0.452   -1.14e-07    2.56e-07
sigma2        21.6920      0.620     35.009      0.000      20.478      22.906
===================================================================================
Ljung-Box (L1) (Q):                   2.51   Jarque-Bera (JB):               749.00
Prob(Q):                              0.11   Prob(JB):                         0.00
Heteroskedasticity (H):              18.00   Skew:                            -0.14
Prob(H) (two-sided):                  0.00   Kurtosis:                         7.86
===================================================================================

Warnings:
[1] Covariance matrix calculated using the outer product of gradients (complex-step).
ARIMA Test RMSE:  92.10970700146592
```

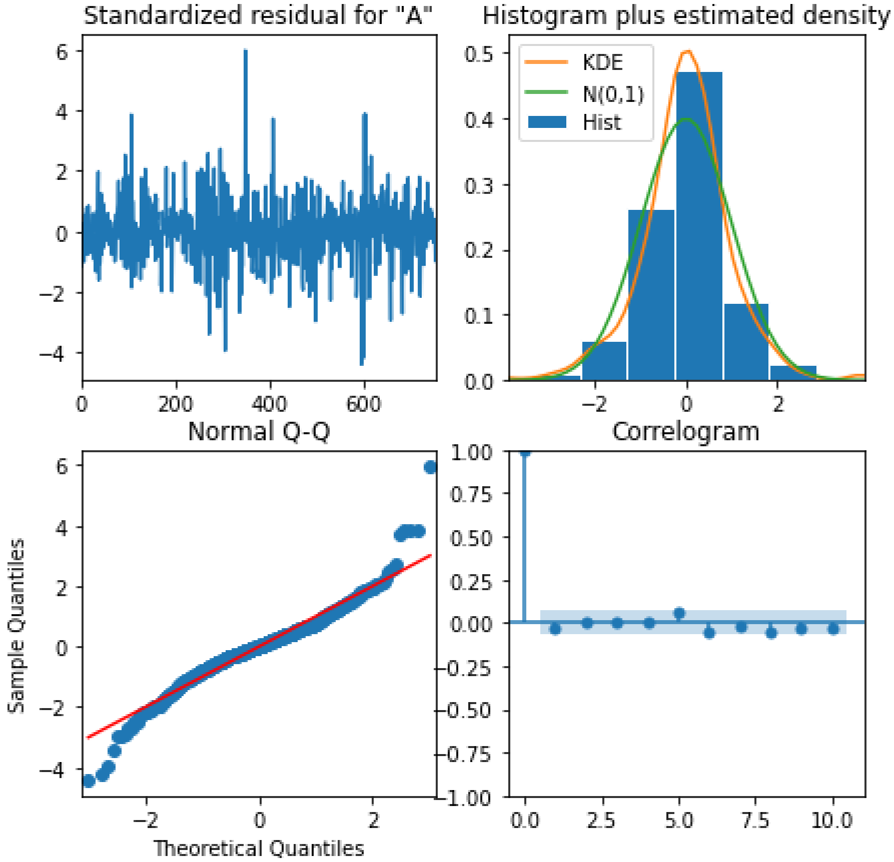


In [19]:
```
arima_logged = base_model(df,exog=True,logged=True,plotting=True,summary=True,mse=True)
```




```
                               SARIMAX Results
==============================================================================
Dep. Variable:              Adj Close   No. Observations:                  759
Model:               SARIMAX(0, 1, 0)   Log Likelihood                1423.479
Date:                Mon, 15 Nov 2021   AIC                          -2840.958
Time:                        20:36:10   BIC                          -2827.065
Sample:                             0   HQIC                         -2835.607
                                - 759
Covariance Type:                  opg
==============================================================================
                 coef    std err          z      P>|z|      [0.025      0.975]
------------------------------------------------------------------------------
intercept      0.0027      0.002      1.764      0.078      -0.000       0.006
Volume         0.0023      0.002      1.003      0.316      -0.002       0.007
sigma2         0.0014   4.21e-05     32.481      0.000       0.001       0.001
===================================================================================
Ljung-Box (L1) (Q):                   0.73   Jarque-Bera (JB):               414.68
Prob(Q):                              0.39   Prob(JB):                         0.00
Heteroskedasticity (H):               1.53   Skew:                             0.05
Prob(H) (two-sided):                  0.00   Kurtosis:                         6.62
===================================================================================
```

```
Warnings:
[1] Covariance matrix calculated using the outer product of gradients (complex-step).
ARIMA Test RMSE:  58.08241838017868
```



Base Model Findings

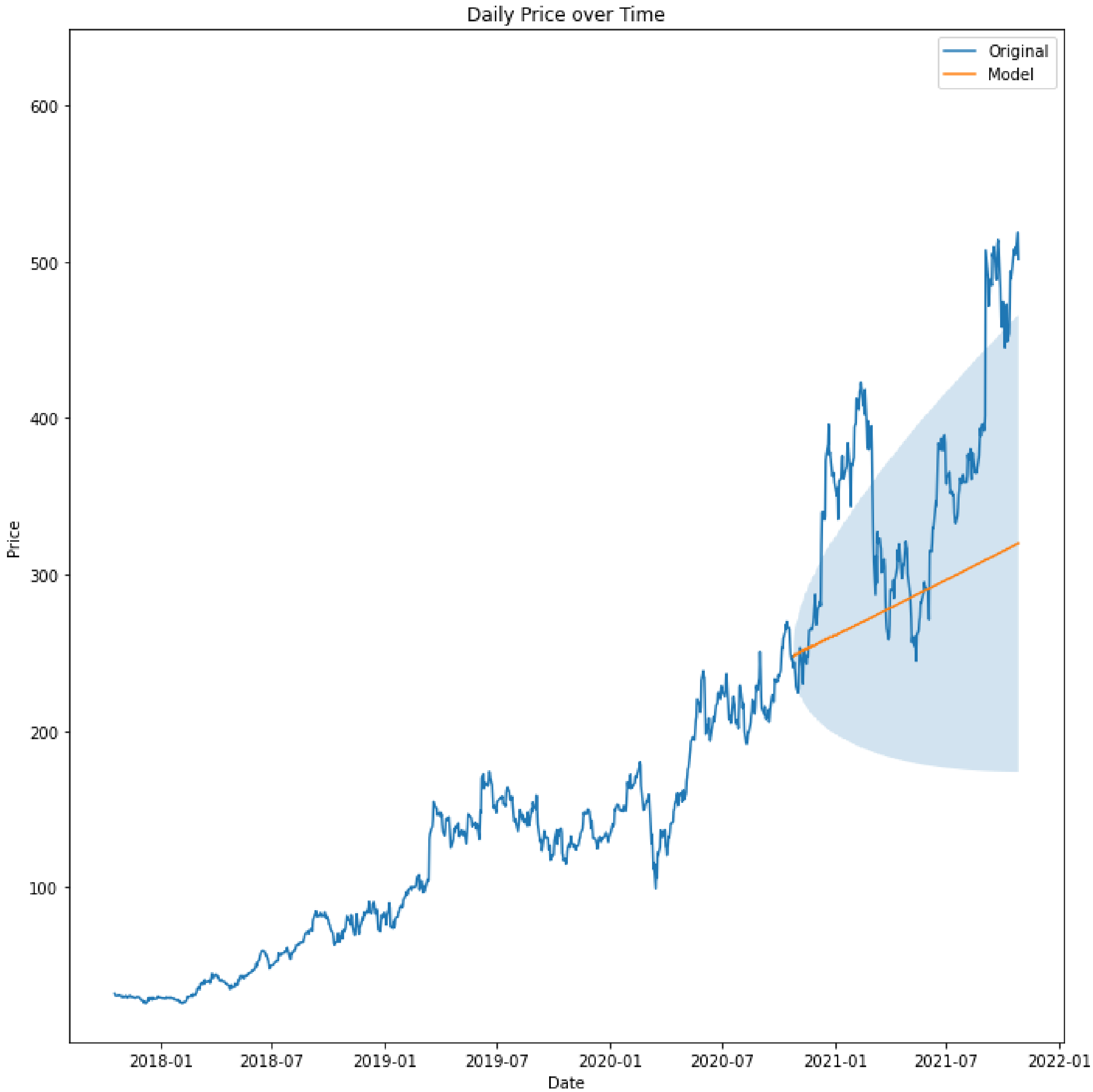
- Base ARIMA model has an AIC of 4489 and RMSE of 92
- Base ARIMA model with log transformed data has an AIC of -2840 and RMSE of 58
- In both metrics and visualization, the model with log transformed data performed better
- In both cases, it appears the Volume variable is insignificant

Auto Arima Model

In [20]:
```
autoarima = create_auto_arima(df,exog=True,logged=False,
                              plotting=True,summary=True,
                              mse=True, trace=True)
```

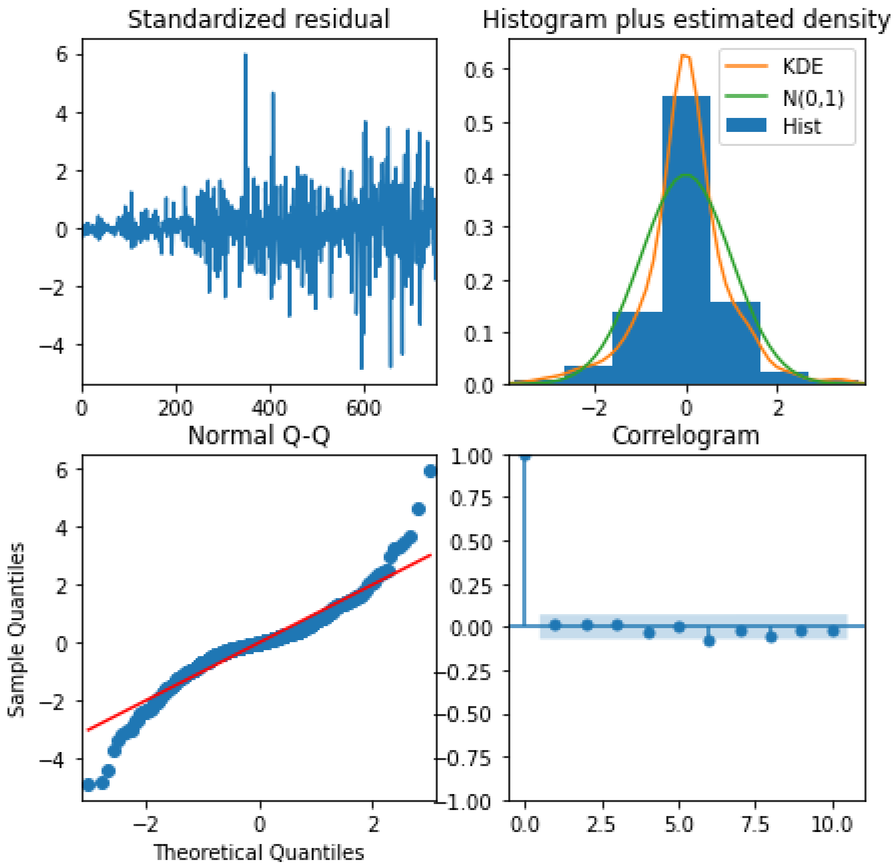
```
Performing stepwise search to minimize aic
 ARIMA(2,1,2)(0,0,0)[0] intercept   : AIC=4478.800, Time=0.62 sec
 ARIMA(0,1,0)(0,0,0)[0] intercept   : AIC=4487.592, Time=0.06 sec
 ARIMA(1,1,0)(0,0,0)[0] intercept   : AIC=4487.080, Time=0.05 sec
 ARIMA(0,1,1)(0,0,0)[0] intercept   : AIC=4486.999, Time=0.05 sec
 ARIMA(0,1,0)(0,0,0)[0]             : AIC=4488.422, Time=0.02 sec
 ARIMA(1,1,2)(0,0,0)[0] intercept   : AIC=inf, Time=0.59 sec
 ARIMA(2,1,1)(0,0,0)[0] intercept   : AIC=inf, Time=0.58 sec
 ARIMA(3,1,2)(0,0,0)[0] intercept   : AIC=4480.460, Time=0.76 sec
 ARIMA(2,1,3)(0,0,0)[0] intercept   : AIC=4480.513, Time=0.84 sec
 ARIMA(1,1,1)(0,0,0)[0] intercept   : AIC=4488.916, Time=0.13 sec
 ARIMA(1,1,3)(0,0,0)[0] intercept   : AIC=4492.609, Time=0.26 sec
 ARIMA(3,1,1)(0,0,0)[0] intercept   : AIC=4492.633, Time=0.26 sec
 ARIMA(3,1,3)(0,0,0)[0] intercept   : AIC=4480.974, Time=0.96 sec
```

```
 ARIMA(2,1,2)(0,0,0)[0]             : AIC=4479.588, Time=0.31 sec

Best model:  ARIMA(2,1,2)(0,0,0)[0] intercept
Total fit time: 5.480 seconds
```



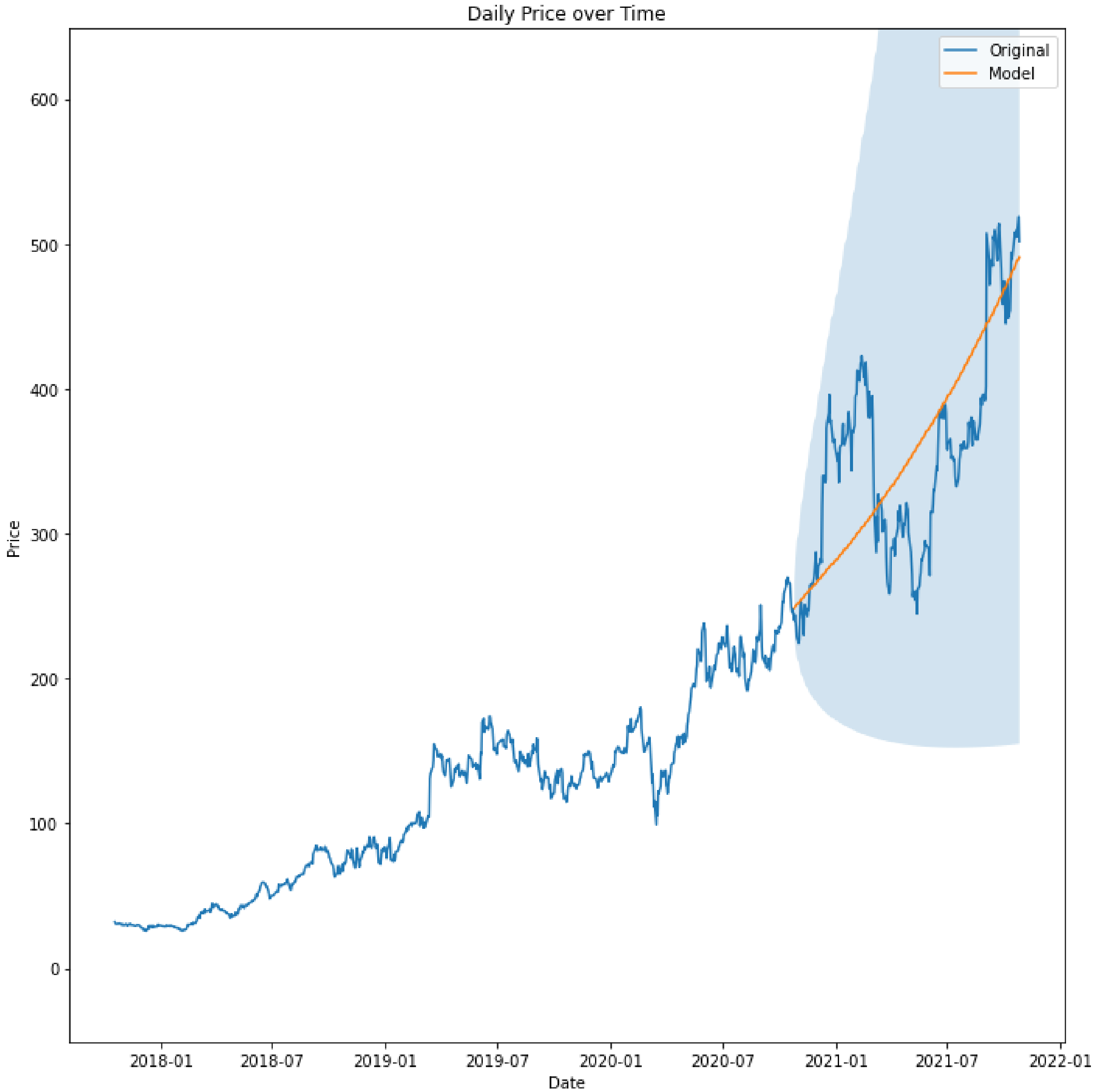

```
                               SARIMAX Results
==============================================================================
Dep. Variable:                      y   No. Observations:                  759
Model:               SARIMAX(2, 1, 2)   Log Likelihood               -2233.400
Date:                Mon, 15 Nov 2021   AIC                           4478.800
Time:                        20:36:17   BIC                           4506.584
Sample:                             0   HQIC                          4489.500
                                - 759
Covariance Type:                  opg
==============================================================================
                 coef    std err          z      P>|z|      [0.025      0.975]
------------------------------------------------------------------------------
intercept      0.5848      0.352      1.663      0.096      -0.105       1.274
ar.L1         -0.0882      0.023     -3.814      0.000      -0.134      -0.043
ar.L2         -0.9625      0.024    -40.573      0.000      -1.009      -0.916
ma.L1          0.1284      0.026      4.958      0.000       0.078       0.179
ma.L2          0.9579      0.024     40.280      0.000       0.911       1.004
sigma2        21.2140      0.586     36.223      0.000      20.066      22.362
```

```
===================================================================================
Ljung-Box (L1) (Q):                   0.30   Jarque-Bera (JB):               796.26
Prob(Q):                              0.59   Prob(JB):                         0.00
Heteroskedasticity (H):              16.58   Skew:                            -0.07
Prob(H) (two-sided):                  0.00   Kurtosis:                         8.02
===================================================================================

Warnings:
[1] Covariance matrix calculated using the outer product of gradients (complex-step).
Auto Arima Test RMSE:  92.40403475573405
```



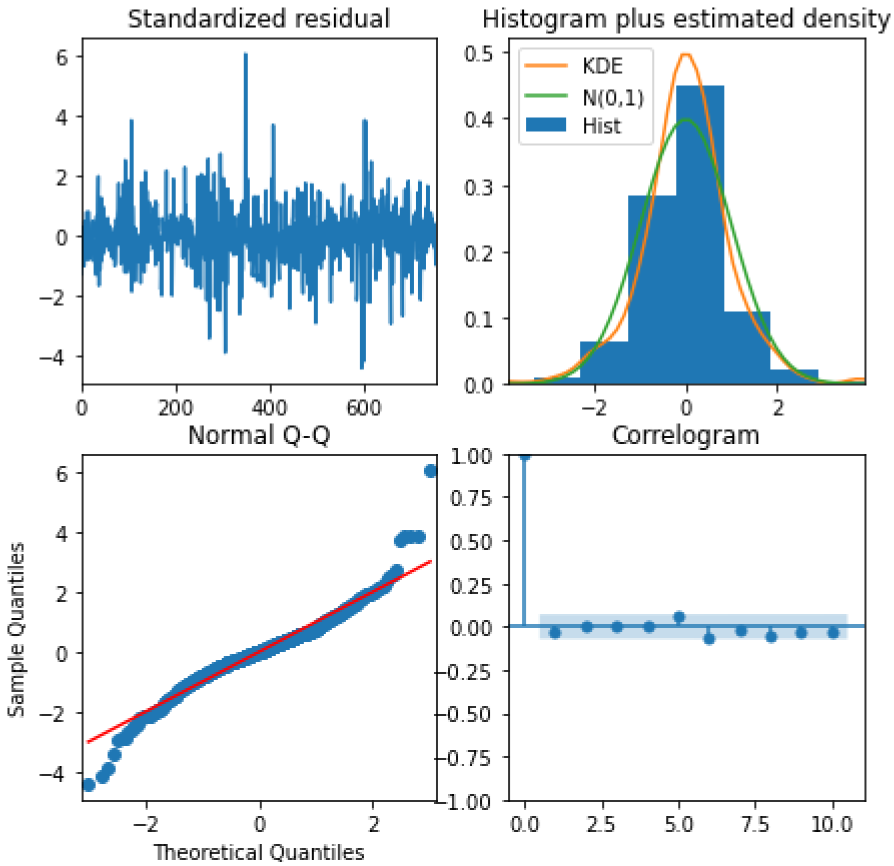
In [21]:
```python
autoarima_logged = create_auto_arima(df,exog=True,logged=True,
                                     plotting=True,summary=True,
                                     mse=True, trace=True)
```

```
Performing stepwise search to minimize aic
 ARIMA(2,1,2)(0,0,0)[0] intercept   : AIC=-2834.919, Time=0.34 sec
 ARIMA(0,1,0)(0,0,0)[0] intercept   : AIC=-2842.212, Time=0.05 sec
 ARIMA(1,1,0)(0,0,0)[0] intercept   : AIC=-2840.910, Time=0.09 sec
 ARIMA(0,1,1)(0,0,0)[0] intercept   : AIC=-2840.905, Time=0.06 sec
 ARIMA(0,1,0)(0,0,0)[0]             : AIC=-2840.194, Time=0.05 sec
 ARIMA(1,1,1)(0,0,0)[0] intercept   : AIC=-2838.918, Time=0.26 sec

Best model:  ARIMA(0,1,0)(0,0,0)[0] intercept
Total fit time: 0.858 seconds
```




```
                               SARIMAX Results
==============================================================================
Dep. Variable:                      y   No. Observations:                  759
Model:               SARIMAX(0, 1, 0)   Log Likelihood                1423.106
Date:                Mon, 15 Nov 2021   AIC                          -2842.212
Time:                        20:36:19   BIC                          -2832.951
Sample:                             0   HQIC                         -2838.645
                                - 759
Covariance Type:                  opg
==============================================================================
                 coef    std err          z      P>|z|      [0.025      0.975]
------------------------------------------------------------------------------
intercept      0.0027      0.001      2.005      0.045    6.07e-05      0.005
sigma2         0.0014   4.19e-05     32.714      0.000       0.001      0.001
===================================================================================
Ljung-Box (L1) (Q):                   0.70   Jarque-Bera (JB):               424.23
Prob(Q):                              0.40   Prob(JB):                         0.00
Heteroskedasticity (H):               1.52   Skew:                             0.11
Prob(H) (two-sided):                  0.00   Kurtosis:                         6.66
===================================================================================

Warnings:
```

```
[1] Covariance matrix calculated using the outer product of gradients (complex-step).
Auto Arima Test RMSE:  58.022142322809934
```

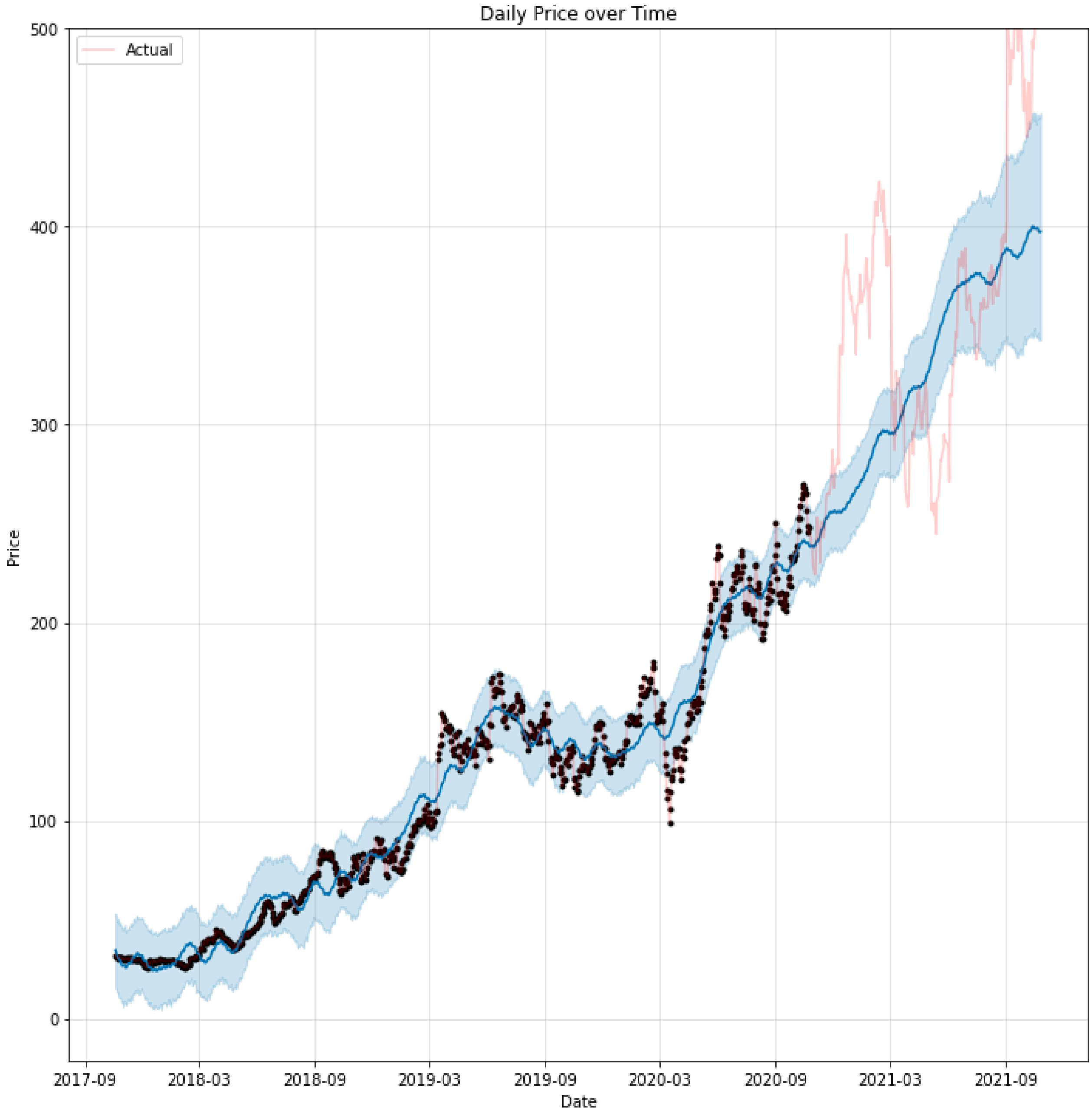


Auto ARIMA Findings

- The auto ARIMA model with untransformed data performed almost the same as the base ARIMA model. AIC = 4478 and RMSE = 92.4
- The auto ARIMA model with log transformed data also performed better with similar results to base ARIMA with transformed data. AIC = -2842 and RMSE = 58
- Visually, the log transformed data appears to be better fit as well

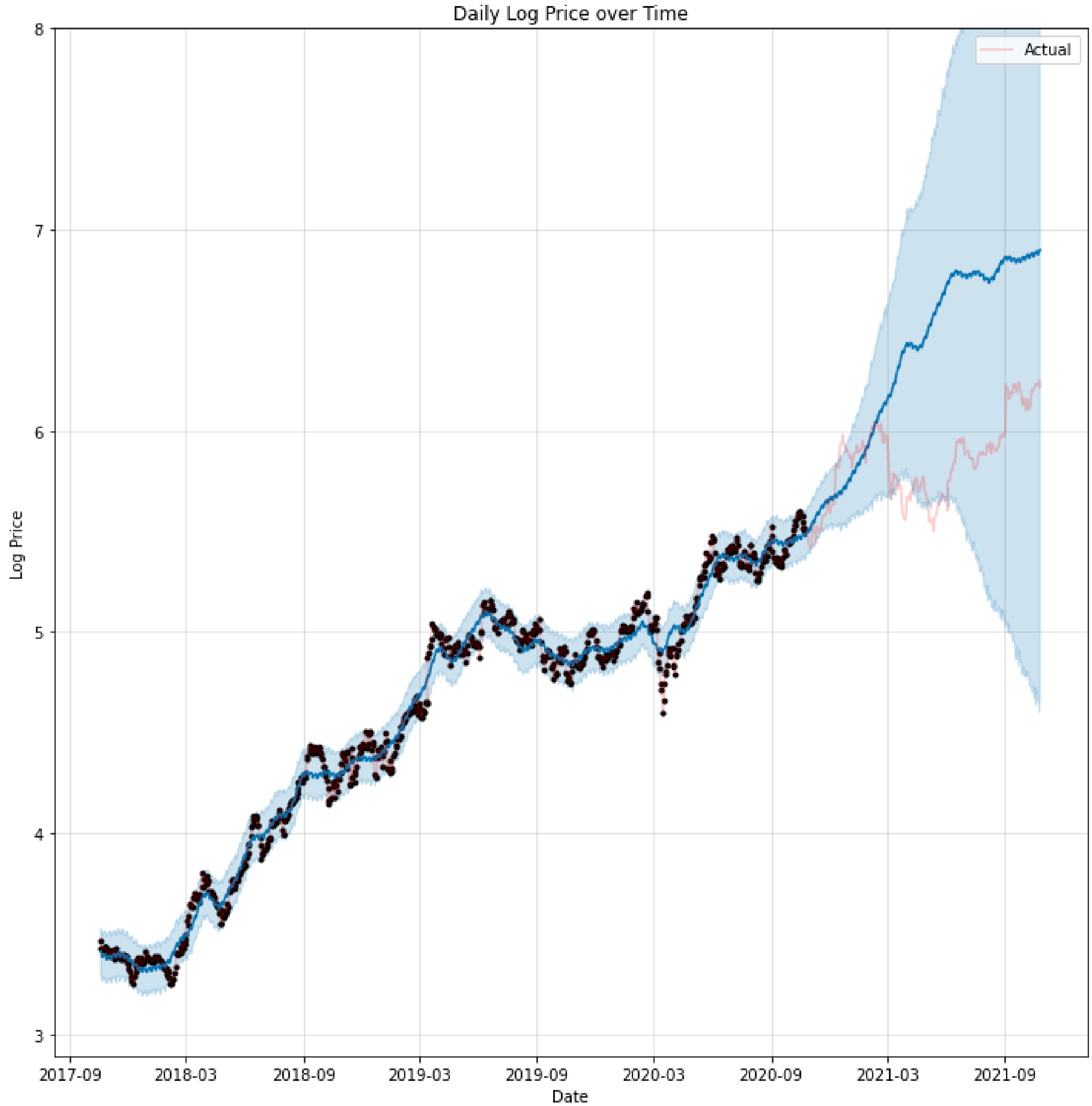
Facebook Prophet Model

In [22]:
```
fb = create_prophet(data=df,logged=False,plotting=True,mse=True)
```




```
Prophet Test RMSE: 65.78887755293908
```

In [23]:
```
fb_logged = create_prophet(data=df,logged=True,plotting=True,mse=True)
```




```
Logged Prophet Test RMSE: 369.84401898575334
```

Facebook Prophet Findings

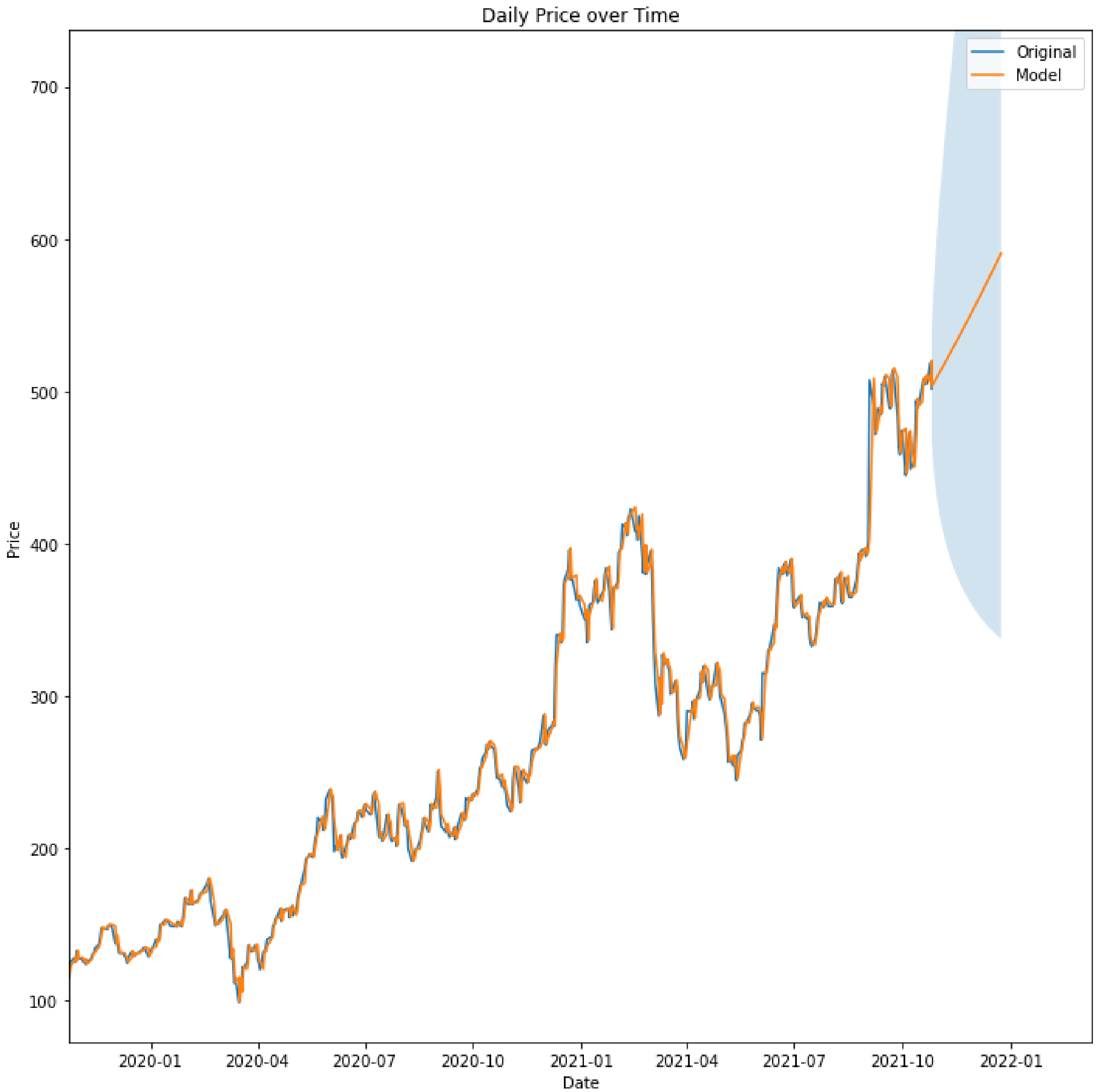
- Model with untransformed data has an RMSE of 65.8
- Model with log transformed data has a worse RMSE of 369.8
- In the vusualizations, the model with untransformed data provided a safe forecasting based on the trend
- However, the log transformed model overvalued the future prices

Highest Growths in 60 Days

- Utilizing the best version of each model above, the models will be refit using the entire data set and forecasting the growth after 60 days

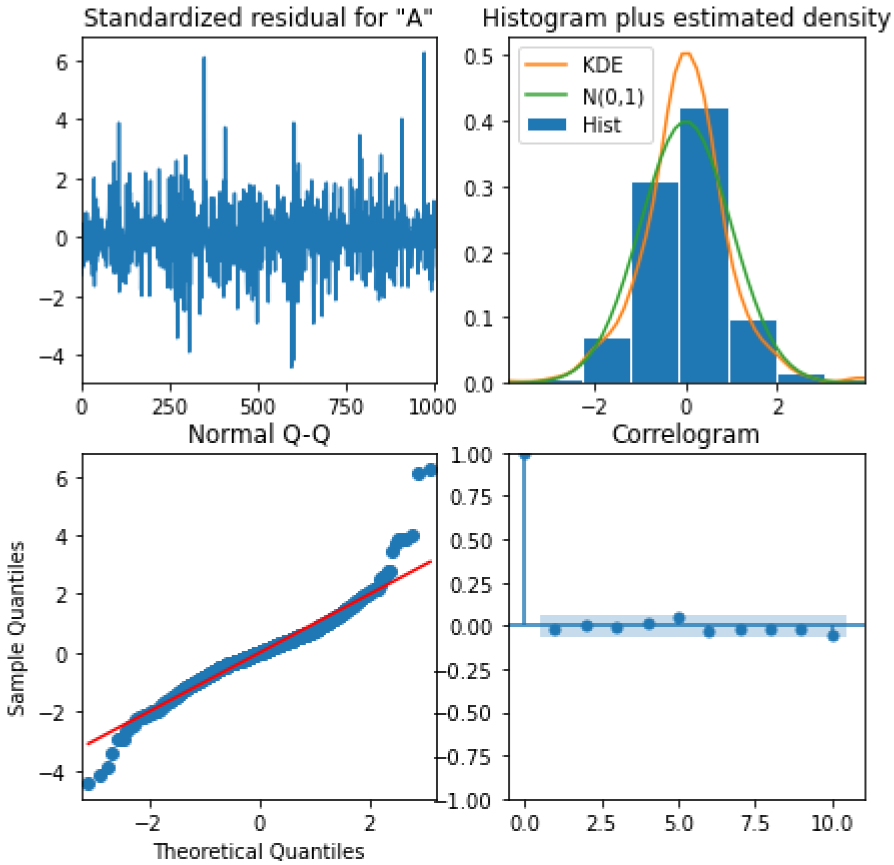
Base Model Growth

In [24]:
```
arima_60, arima_roi = base_model(df,exog=True,logged=True,
                                 plotting=True,summary=True,
                                 full=True,roi=True, return_roi=True)
```




```
                               SARIMAX Results
==============================================================================
Dep. Variable:              Adj Close   No. Observations:                 1012
Model:               SARIMAX(0, 1, 0)   Log Likelihood                1902.632
Date:                Mon, 15 Nov 2021   AIC                          -3801.265
Time:                        20:36:30   BIC                          -3791.428
Sample:                             0   HQIC                         -3797.528
                               - 1012
Covariance Type:                  opg
==============================================================================
                 coef    std err          z      P>|z|      [0.025      0.975]
------------------------------------------------------------------------------
intercept      0.0027      0.001      2.315      0.021       0.000       0.005
sigma2         0.0014   3.41e-05     39.866      0.000       0.001       0.001
=====================================================================================
```

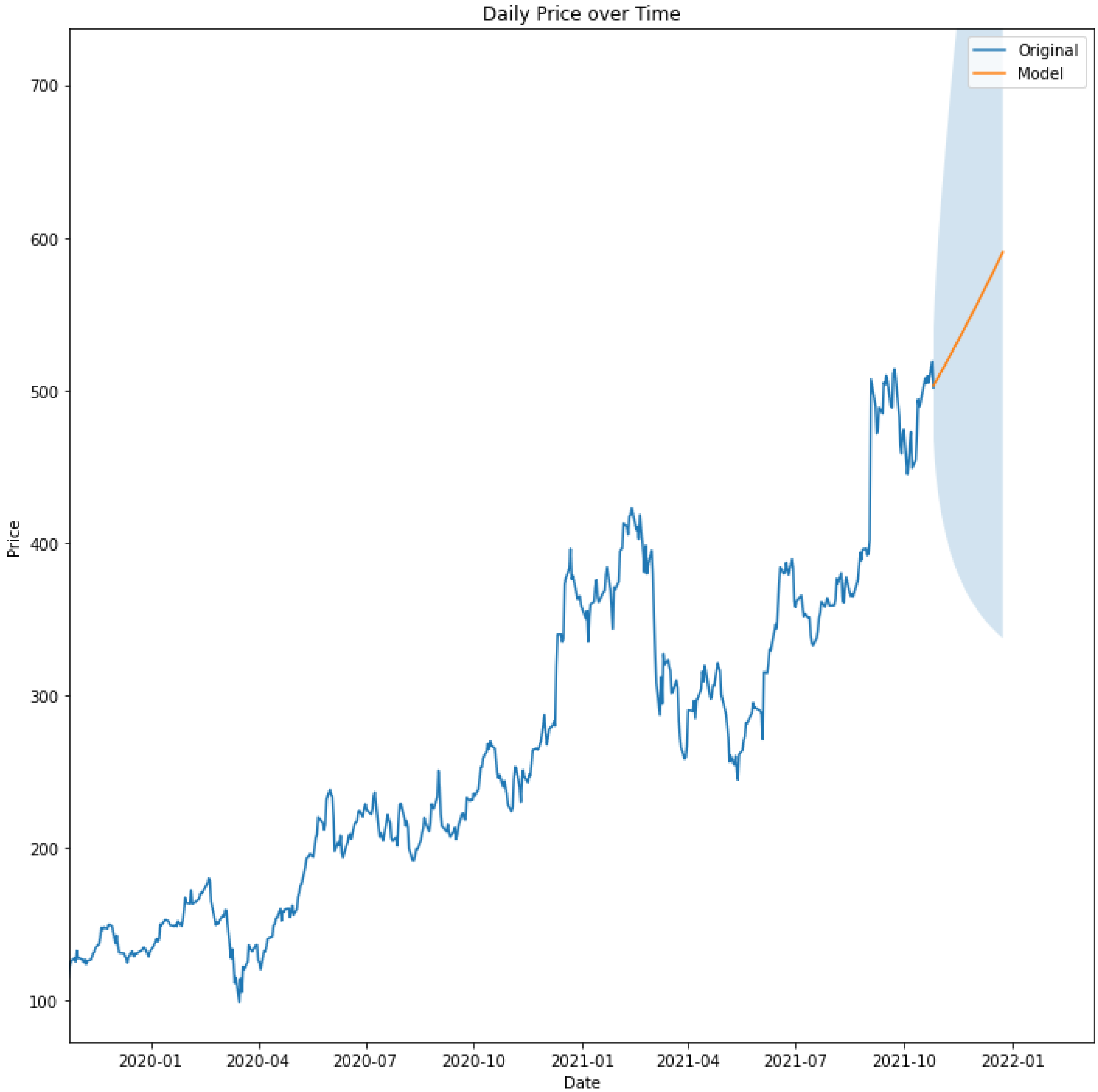
```
Ljung-Box (L1) (Q):                   0.49   Jarque-Bera (JB):               869.35
Prob(Q):                              0.48   Prob(JB):                         0.00
Heteroskedasticity (H):               0.99   Skew:                             0.42
Prob(H) (two-sided):                  0.92   Kurtosis:                         7.46
===================================================================================

Warnings:
[1] Covariance matrix calculated using the outer product of gradients (complex-step).
ROI:  17.41 %
```



Auto ARIMA Growth

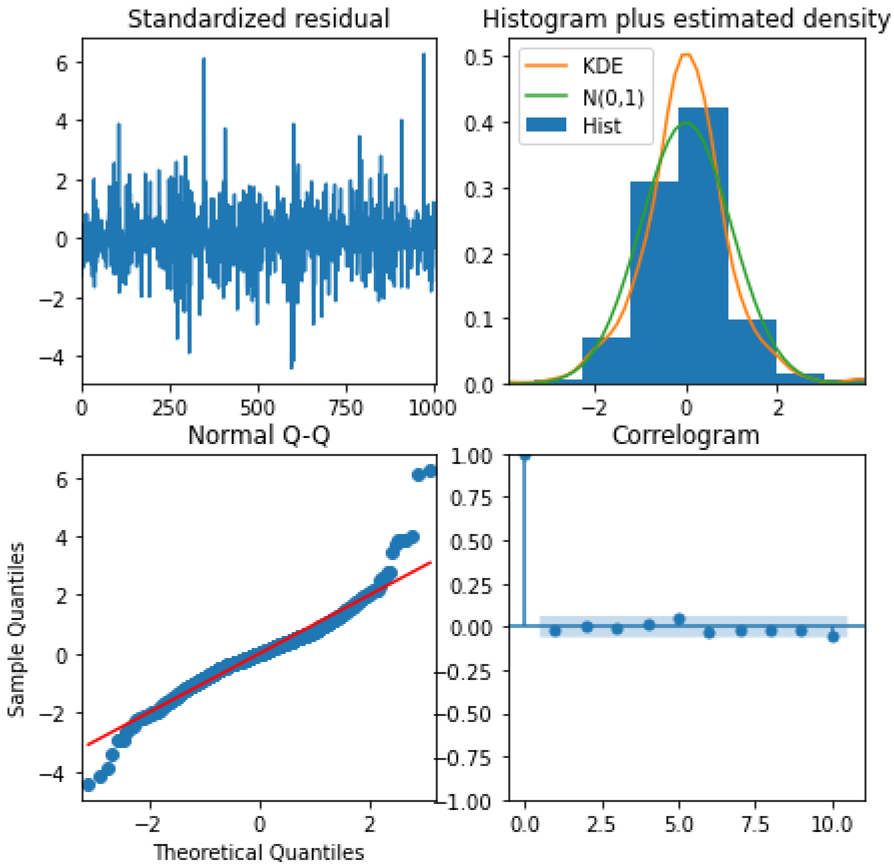
In [25]:
```python
autoarima_60, autoarima_roi = create_auto_arima(df,exog=True,logged=True,
                                                plotting=True, trace=True,
                                                summary=True,full=True,
                                                roi=True,return_roi=True)
```

```
Performing stepwise search to minimize aic
 ARIMA(2,1,2)(0,0,0)[0] intercept   : AIC=-3793.776, Time=0.34 sec
 ARIMA(0,1,0)(0,0,0)[0] intercept   : AIC=-3801.265, Time=0.13 sec
 ARIMA(1,1,0)(0,0,0)[0] intercept   : AIC=-3799.756, Time=0.09 sec
 ARIMA(0,1,1)(0,0,0)[0] intercept   : AIC=-3799.751, Time=0.13 sec
 ARIMA(0,1,0)(0,0,0)[0]             : AIC=-3797.772, Time=0.06 sec
 ARIMA(1,1,1)(0,0,0)[0] intercept   : AIC=-3797.736, Time=0.29 sec

Best model:  ARIMA(0,1,0)(0,0,0)[0] intercept
Total fit time: 1.041 seconds
```



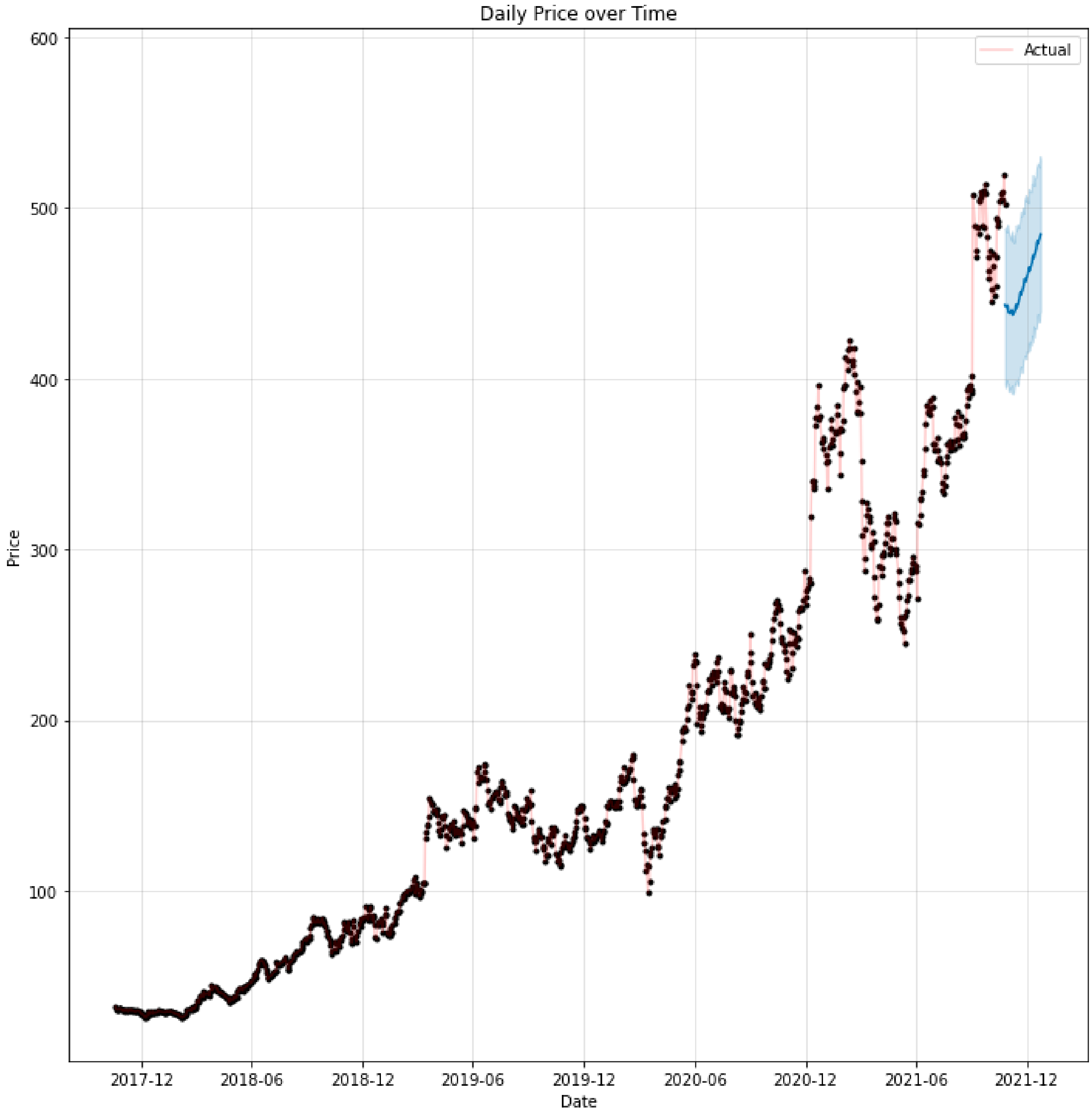

```
                               SARIMAX Results
==============================================================================
Dep. Variable:                      y   No. Observations:                 1012
Model:               SARIMAX(0, 1, 0)   Log Likelihood                1902.632
Date:                Mon, 15 Nov 2021   AIC                          -3801.265
Time:                        20:36:31   BIC                          -3791.428
Sample:                             0   HQIC                         -3797.528
                               - 1012
Covariance Type:                  opg
==============================================================================
                 coef    std err          z      P>|z|      [0.025      0.975]
------------------------------------------------------------------------------
intercept      0.0027      0.001      2.315      0.021       0.000       0.005
sigma2         0.0014   3.41e-05     39.866      0.000       0.001       0.001
===================================================================================
Ljung-Box (L1) (Q):                   0.49   Jarque-Bera (JB):               869.35
Prob(Q):                              0.48   Prob(JB):                         0.00
Heteroskedasticity (H):               0.99   Skew:                             0.42
Prob(H) (two-sided):                  0.92   Kurtosis:                         7.46
===================================================================================

Warnings:
```

```
[1] Covariance matrix calculated using the outer product of gradients (complex-step).
ROI:  17.41 %
```



Facebook Prophet Growth

In [26]:
```
fb_60, fb_roi = create_prophet(df,exog=False,logged=False,
                               plotting=True,full=True,
                               roi=True,return_roi=True)
```




```
ROI:  -3.42 %
```

Conclusions

- The ARIMA models expect a growth of ~ 17% after 60 days
- The Facebook Prophet model expects to lose ~3% after 60 days. However, it maintains a positive growth rate over time.
- Based on the models above, it looks like MongoDB would be a safe buy