

Prophet – structural time series model

Prophet = Trend + Seasonality + Holiday + error

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

- Trend models non periodic changes in the value of the time series.
- Seasonality is the periodic changes like daily, weekly, or yearly seasonality.
- Holiday effects the time series which occur on irregular schedules over a day or a period of days.
- Error terms is what is not explained by the model.

Trend Model

$$g(t) = \frac{C(t)}{1 + \exp(-k(t)(t - m))}$$

- Borrow the concept of population growth model
- $C(t)$ is a time varying carry capacity
- $k(t)$ is a time varying growth rate that has several changing points
- m is the offset parameter

Seasonal Model

$$s(t) = \sum_{n=1}^N \left(a_n \cos\left(\frac{2\pi nt}{P}\right) + b_n \sin\left(\frac{2\pi nt}{P}\right) \right)$$

- It is based on a standard Fourier Series.
- The parameters are selected by model performance, such as AIC
- For yearly and weekly seasonality we have found $N = 10$ and $N = 3$ respectively to work well for most problems.

Holiday and Event Model

$$Z(t) = [\mathbf{1}(t \in D_1), \dots, \mathbf{1}(t \in D_L)]$$

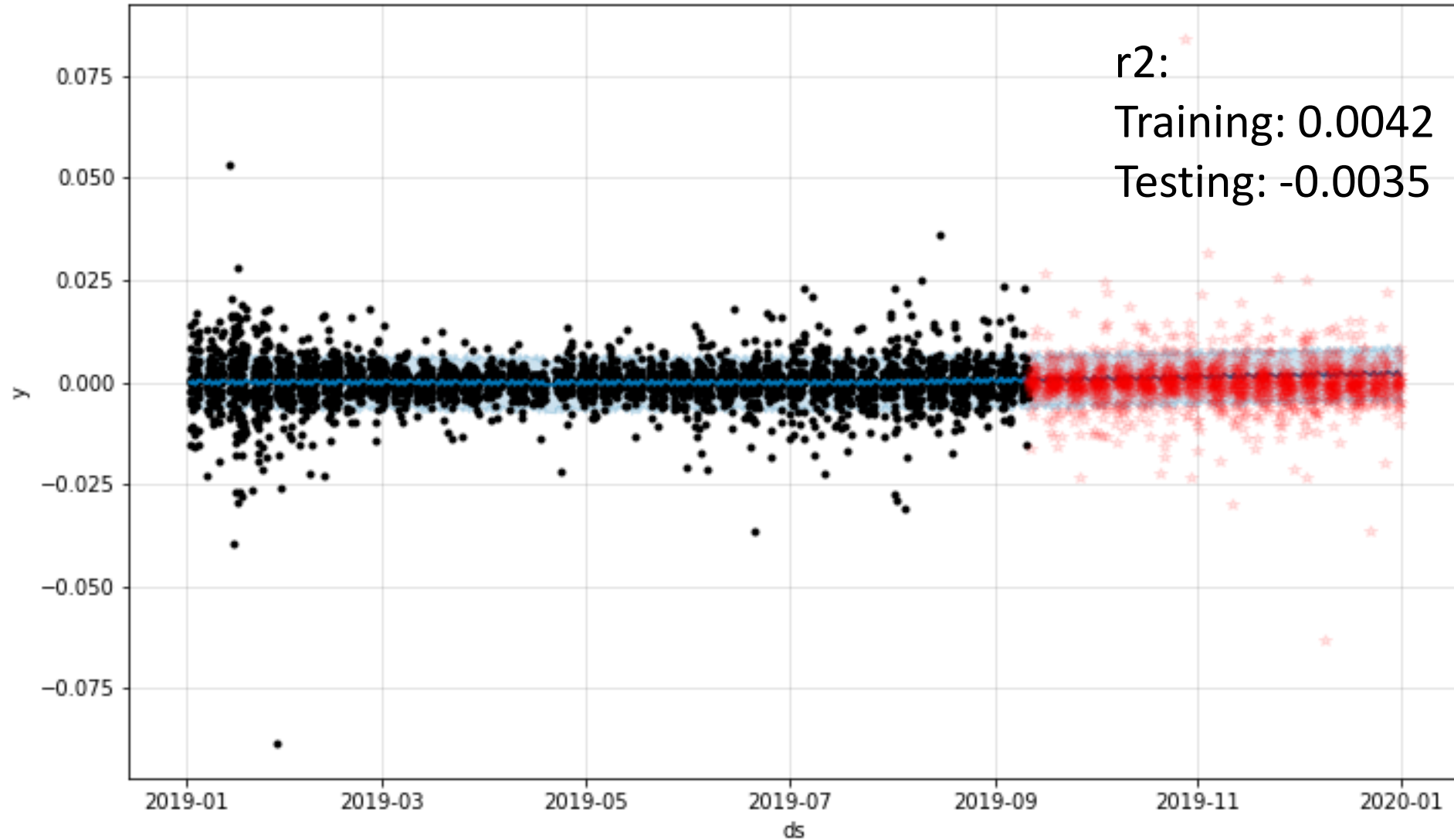
$$h(t) = Z(t)\kappa$$

- by assuming that the effects of holidays are independent, it uses indicator function (whether the date is holiday or not) to model the time series.
- κ is a prior to adjust for seasonality
- For days around the holiday, it labels them as a holiday itself.

Advantages

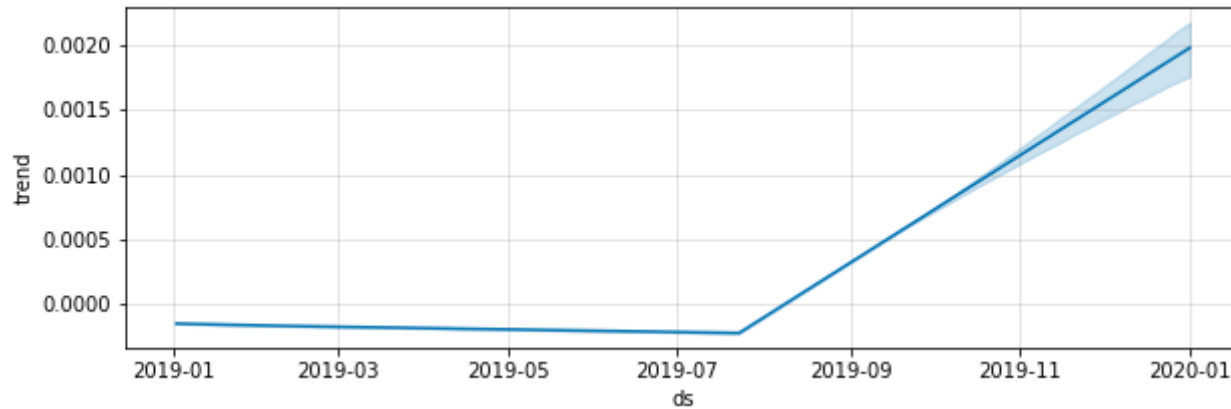
- Decompose easily and Fitting of the model is fast
- Flexibility: Accommodates seasonality with multiple periods
- Intuitive hyper parameters which are easy to tune
- Easy to interpret the model

Result – Final Model

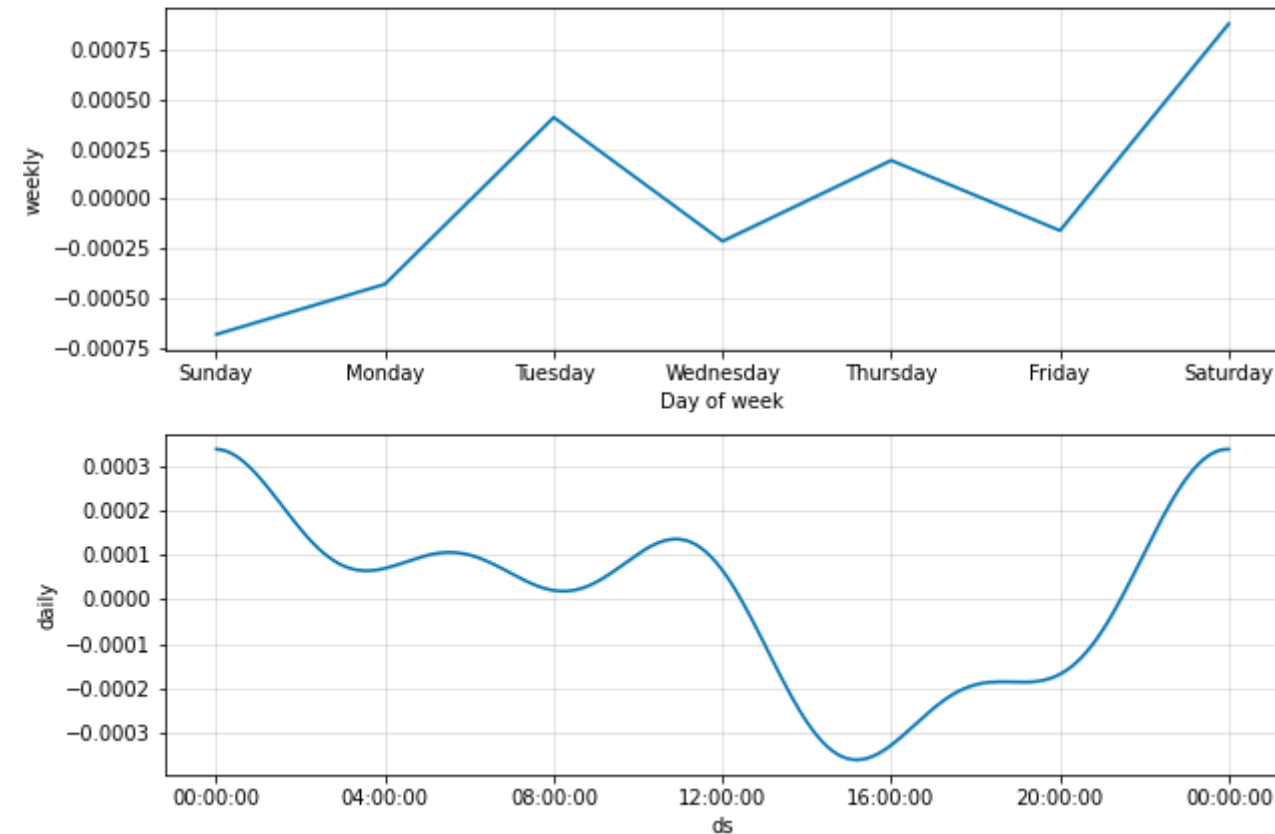


Result – Final Model

Trend



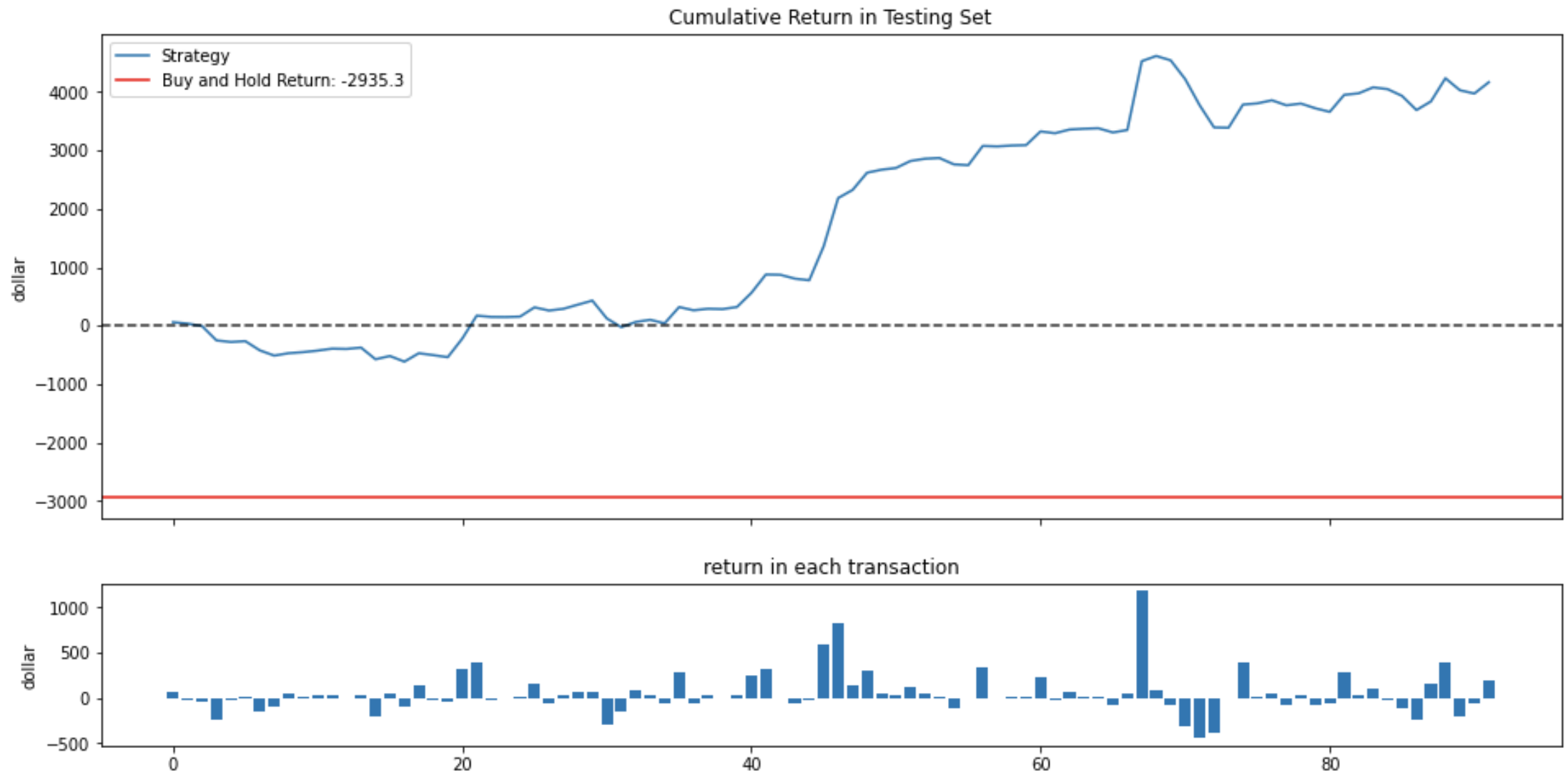
Seasonality (weekly & daily)



Strategy

- Long and Short strategy:
 - Long: when three consecutive prediction of log return are larger than zero
 - Short: when three consecutive prediction of log return are smaller than zero
 - Hold: otherwise
- If the long signal appears, we buy one unit of BTC. And if the short signal appears, we sell one unit of BTC.
- Our deposit starts with 10,000.

Performance in Testing Set – Rate of Return: 41.7%



Conclusion

- The performance of prophet on log return wasn't ideal, but it can still make profitable strategy after doing some adjustment.
- The result may be different if we take tax and trading cost into account.
- Prophet is good at modelling time series with strong seasonality and with critical changing points. Prophet might perform better on market Index, which has an apparent trend.

Reference

- Paper: <https://peerj.com/preprints/3190/>
- Package: <https://facebook.github.io/prophet/>
- Medium blog: <https://towardsdatascience.com/time-series-prediction-using-prophet-in-python-35d65f626236>