Report on Univariate Inflation Forecasting from March 2014 to November 2024 with Hyperparameter Tuning Approaches

1. Introduction

This report aims to analyze the univariate inflation data from March 2014 to November 2024 and forecast future inflation rates for the next 3 months. Four different approaches have been employed to improve the accuracy and reliability of the forecasting model, specifically focusing on hyperparameter tuning techniques. The methods used are:

1. **Without Hyperparameter Tuning**
2. **With Hyperparameter Tuning using Grid Search CV**
3. **With Hyperparameter Tuning using Random Search CV**
4. **With Hyperparameter Tuning using Optuna**

The forecasted inflation values from each method are compared to determine the most effective approach for this dataset.

2. Data Overview

The dataset consists of univariate time series data on inflation, spanning from March 2014 to November 2024.

3. Methodology

3.1. Without Hyperparameter Tuning

In the first approach, the forecasting model was trained and tested without applying any hyperparameter tuning. The default parameters of the chosen model were used to establish a baseline for comparison with other approaches.

3.2. With Hyperparameter Tuning using Grid Search CV

Grid Search Cross-Validation (GridSearchCV) was applied to the univariate forecasting model to search for the best combination of hyperparameters.

3.3. With Hyperparameter Tuning using Random Search CV

Random Search Cross-Validation (RandomSearchCV) was used to explore hyperparameter values in a randomized fashion, which can be more efficient than GridSearchCV, especially when the hyperparameter space is large.

3.4. With Hyperparameter Tuning using Optuna

Optuna, an advanced hyperparameter optimization framework, was employed for this approach. Optuna uses efficient sampling techniques to optimize hyperparameters and search the space more effectively.

- **Optuna Setup**: The search space for each hyperparameter was defined, and an optimization objective was set. Optuna then explored the space to find the best hyperparameter configuration.

4. Results and Comparison

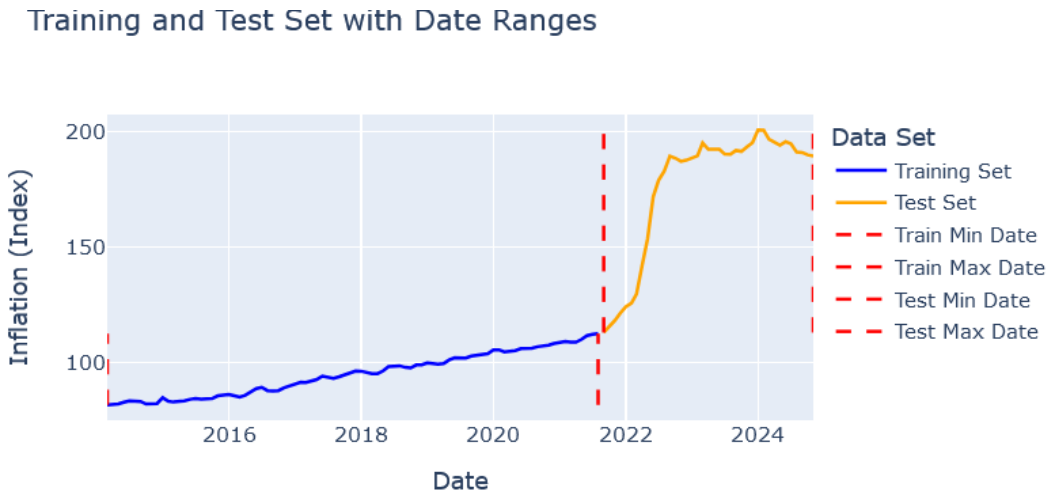
The forecasting results from the four approaches were evaluated using the following metrics:

- **Mean Absolute Error (MAE)**
- **Mean Squared Error (MSE)**
- **Root Mean Squared Error (RMSE)**
- **Mean Absolute Percentage Error (MAPE)**
- **R-Square**

```
df = pd.read_excel("univariatedf.xlsx")
df
```

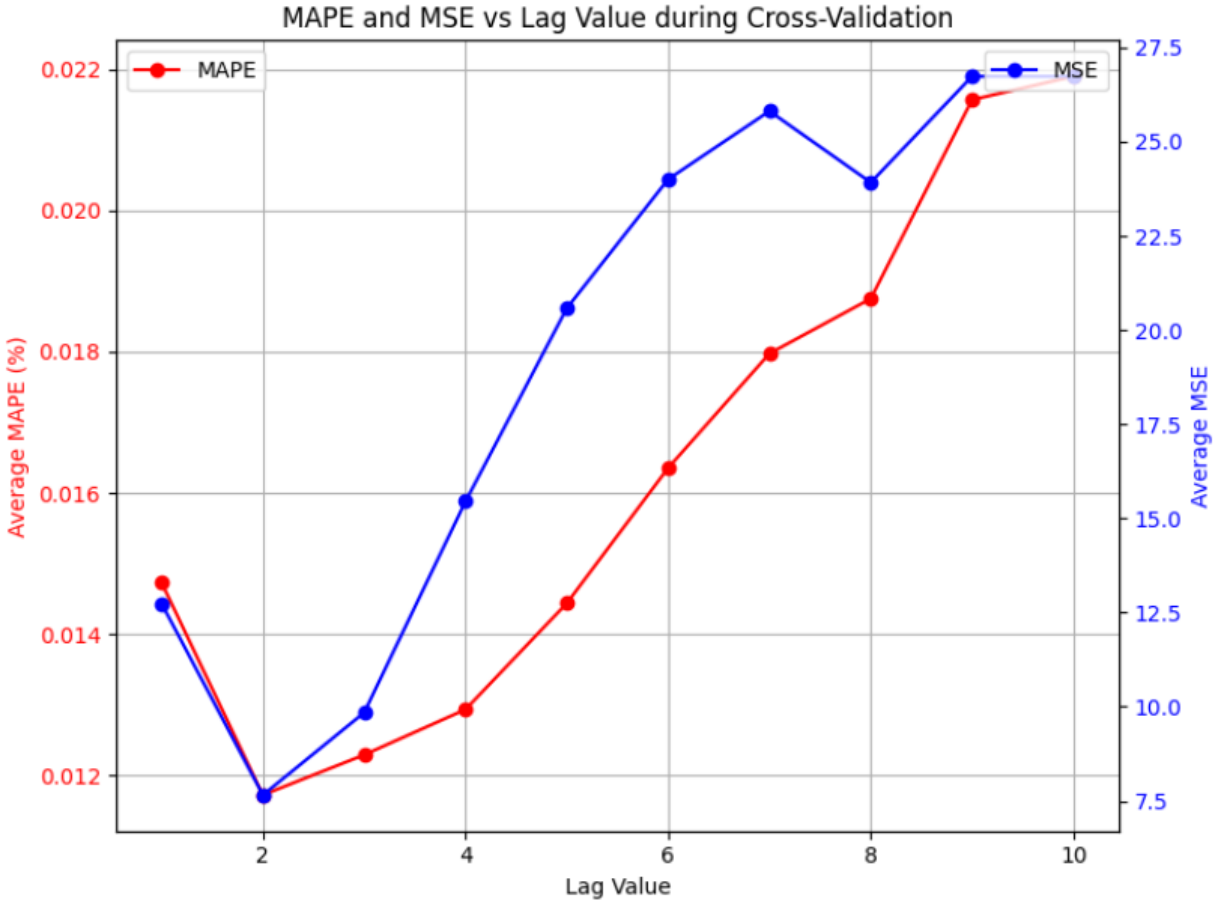
	Period	Month	Index
0	2014	January	81.768056
1	2014	February	81.768056
2	2014	March	81.768056
3	2014	April	81.925000
4	2014	May	82.238889
...	...	...	...
126	2024	July	194.700000
127	2024	August	191.100000
128	2024	September	190.900000
129	2024	October	189.900000
130	2024	November	189.400000

131 rows × 3 columns




```
Training Set Date Range: Min = 2014-03-01 00:00:00, Max = 2021-08-01 00:00:00
Test Set Date Range: Min = 2021-09-01 00:00:00, Max = 2024-11-01 00:00:00
```

```
Best lag value based on MAPE cross-validation: 2
Best lag value based on MSE cross-validation: 2
```



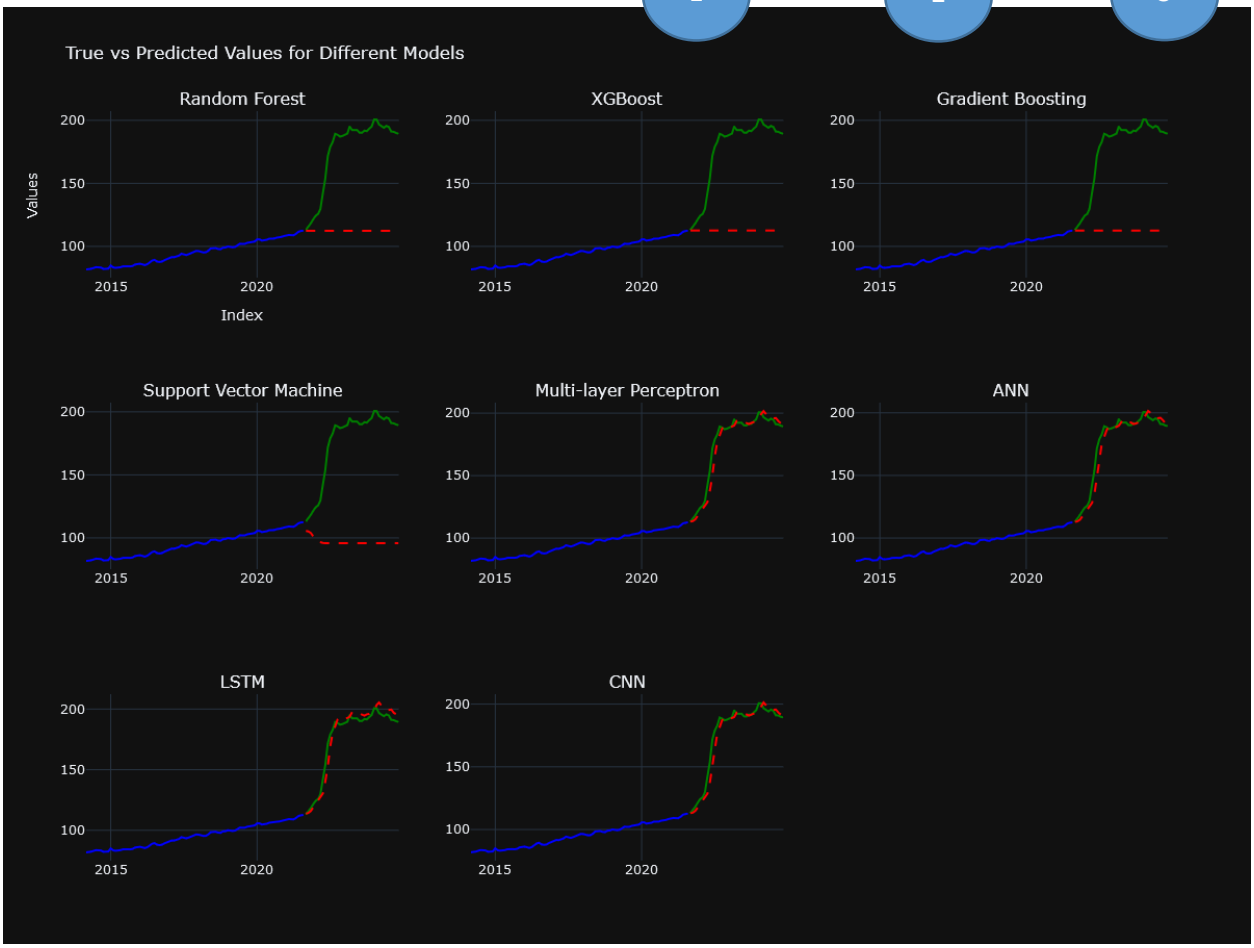

```
Training set size: 90
Test set size: 39

Training Data:
                Index      lag_1      lag_2
Date
2014-03-01  81.768056  81.768056  81.768056
2014-04-01  81.925000  81.768056  81.768056
2014-05-01  82.238889  81.925000  81.768056
2014-06-01  82.945139  82.238889  81.925000
2014-07-01  83.572917  82.945139  82.238889

Test Data:
                Index       lag_1       lag_2
Date
2021-09-01  113.078472  112.607639  112.293750
2021-10-01  115.275694  113.078472  112.607639
2021-11-01  118.257639  115.275694  113.078472
2021-12-01  121.396528  118.257639  115.275694
2022-01-01  124.300000  121.396528  118.257639
```

Case 1: Without Hyperparameter Tuning for Full univariate Data Set

Evaluation.

Random Forest Evaluation:	XGBoost Evaluation:	Gradient Boosting Evaluation:	Support Vector Machine Evaluation:	Multi-layer Perceptron Evaluation:	ANN Evaluation:	Convolutional Neural Network (CNN) Evaluation:	LSTM Evaluation:
RMSE: 69.6824 MSE: 4855.6347 MAE: 63.8118 MAPE: 34.10% R-squared: -5.1959	RMSE: 69.4487 MSE: 4823.1153 MAE: 63.5565 MAPE: 33.95% R-squared: -5.1544	RMSE: 69.5268 MSE: 4833.9754 MAE: 63.6418 MAPE: 34.00% R-squared: -5.1682	RMSE: 84.8092 MSE: 7192.6059 MAE: 79.3212 MAPE: 42.95% R-squared: -8.1779	RMSE: 6.0471 MSE: 36.5679 MAE: 3.8727 MAPE: 2.31% R-squared: 0.9533	RMSE: 6.8762 MSE: 47.2826 MAE: 4.3472 MAPE: 2.6061% R-squared: 0.9396	RMSE: 6.1913 MSE: 38.3325 MAE: 3.9204 MAPE: 2.35% R-squared: 0.9511	RMSE: 6.1931 MSE: 38.3546 MAE: 4.9687 MAPE: 2.82% R-squared: 0.9511

1 2 3



3 Months Ahead Forecasting

```
Next datetime indices for forecasts:
DatetimeIndex(['2024-12-31', '2025-01-31', '2025-02-28'], dtype='datetime64[ns]', freq='M')
        Date  CNN Forecast  LSTM Forecast  ANN Forecast  MLP Forecast
0 2024-12-31    190.968185     194.711624    191.292267    191.375205
1 2025-01-31    191.569000     196.777115    191.926849    192.158822
2 2025-02-28    191.866318     200.077911    192.466782    192.765539
```

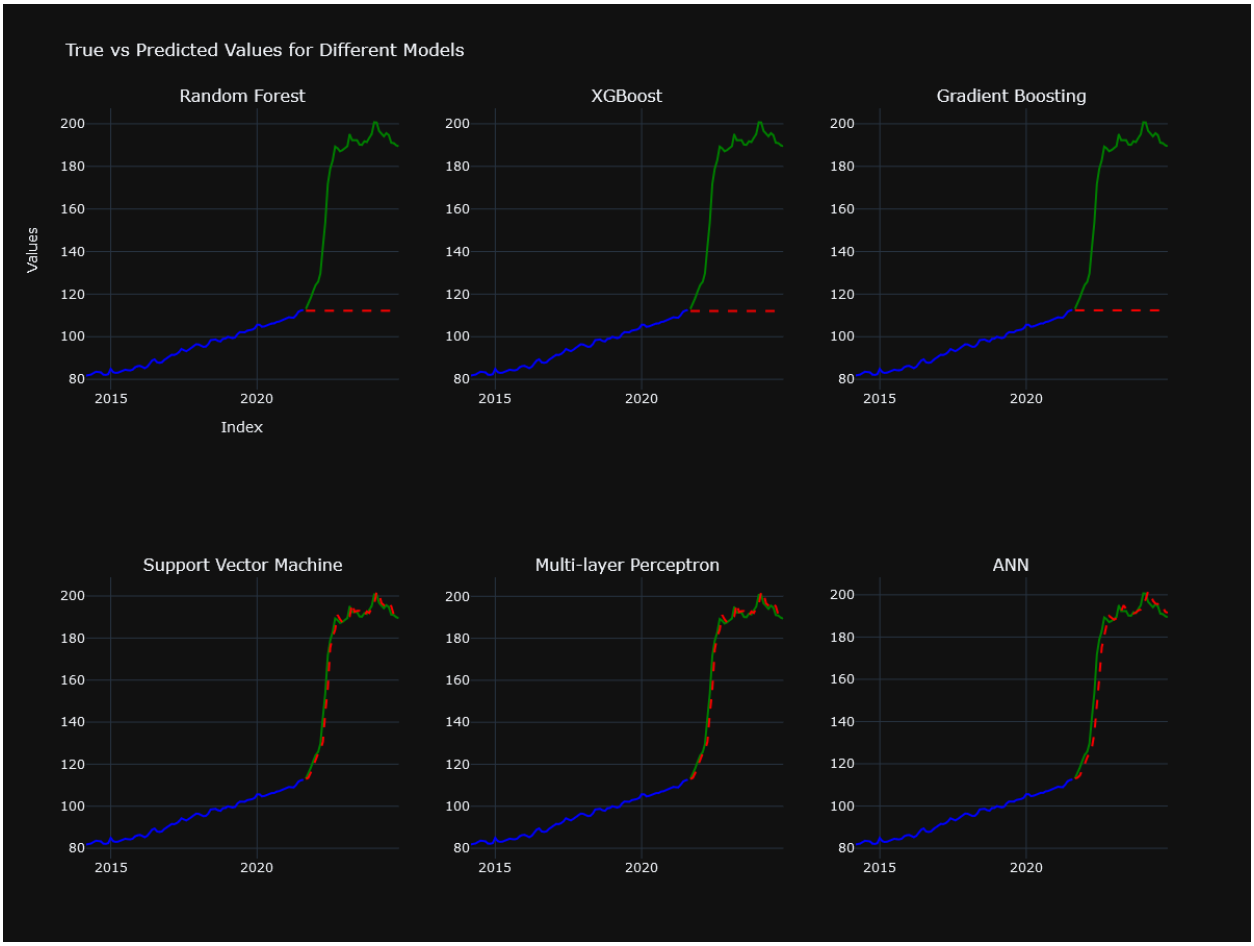
6 Months Ahead Forecast

```
Next datetime indices for forecasts:
DatetimeIndex(['2024-12-31', '2025-01-31', '2025-02-28', '2025-03-31',
               '2025-04-30', '2025-05-31'],
              dtype='datetime64[ns]', freq='M')
        Date  CNN Forecast  LSTM Forecast  ANN Forecast  MLP Forecast
0 2024-12-31    190.968185     194.711624    191.292267    191.375205
1 2025-01-31    191.569000     196.777115    191.926849    192.158822
2 2025-02-28    191.866318     200.077911    192.466782    192.765539
3 2025-03-31    192.337509     202.666199    193.045639    193.478044
4 2025-04-30    192.710007     205.815979    193.610458    194.131686
5 2025-05-31    193.139420     208.696182    194.182281    194.822376
```

Case 2: Hyperparameter Tuning using RandomSearchCV for Full univariate Data Set

Evaluation.

Random Forest Evaluation:	XGBoost Evaluation:	Gradient Boosting Evaluation:	Support Vector Machine Evaluation:	Multi-layer Perceptron Evaluation:	ANN Evaluation:
RMSE: 69.8199 MSE: 4874.8191 MAE: 63.9619 MAPE: 34.19% R-squared: -5.2203	RMSE: 69.9555 MSE: 4893.7744 MAE: 64.1099 MAPE: 34.27% R-squared: -5.2445	RMSE: 69.6440 MSE: 4850.2836 MAE: 63.7698 MAPE: 34.07% R-squared: -5.1890	RMSE: 4.1434 MSE: 17.1675 MAE: 2.6972 MAPE: 1.61% R-squared: 0.9781	RMSE: 4.2070 MSE: 17.6991 MAE: 2.7383 MAPE: 1.63% R-squared: 0.9774	RMSE: 7.0459 MSE: 49.645139 MAE: 4.4761676 MAPE: 2.679348% R-squared: 0.936652



6 Months ahead forecasting

Forecast Table:

	Date	SVM Forecast	ANN Forecast	MLP Forecast
0	2024-12-31	190.309297	192.155640	191.676519
1	2025-01-31	192.177295	193.563049	192.831222
2	2025-02-28	193.293651	194.911591	194.294739
3	2025-03-31	194.780566	196.301437	195.624792
4	2025-04-30	196.104708	197.685120	197.031656
5	2025-05-31	197.519615	199.085266	198.415546

Case 3: Hyperparameter Tuning using GridSearchCV for Full univariate Data Set

Evaluation.

Random Forest Evaluation:	XGBoost Evaluation:		Support Vector	Multi-layer Perceptron Evaluation:

		Gradient Boosting Evaluation:	Machine Evaluation:	
RMSE: 69.7169 MSE: 4860.4433 MAE: 63.8494 MAPE: 34.12% R-squared: -5.2020	RMSE: 69.4487 MSE: 4823.1153 MAE: 63.5565 MAPE: 33.95% R-squared: -5.1544	RMSE: 69.4530 MSE: 4823.7129 MAE: 63.5612 MAPE: 33.95% R-squared: -5.1551	RMSE: 3.9211 MSE: 15.3751 MAE: 2.5592 MAPE: 1.52% R-squared: 0.9804	RMSE: 4.1162 MSE: 16.9435 MAE: 2.6917 MAPE: 1.60% R-squared: 0.9784

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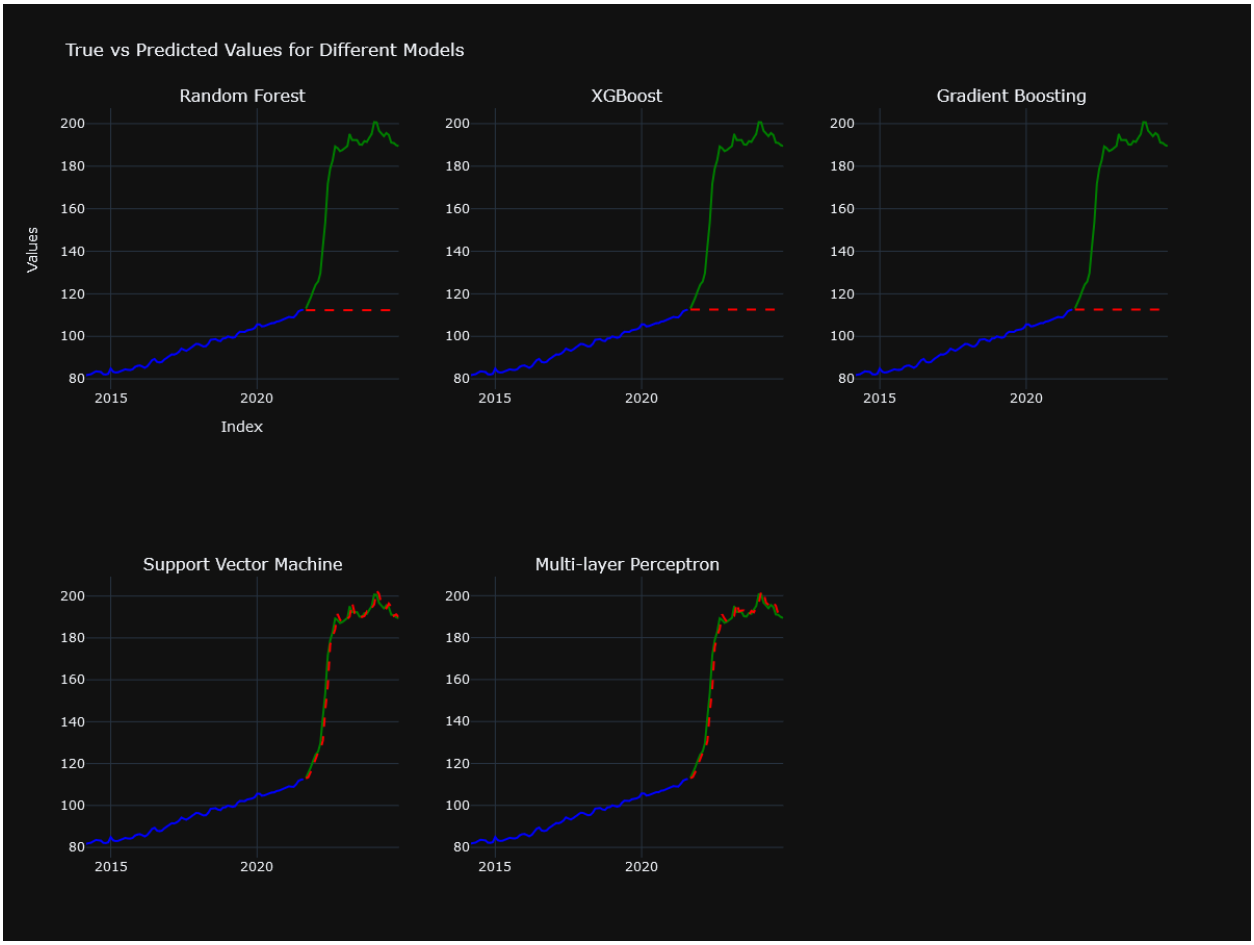

	Date	SVM Forecast	MLP Forecast	ANN
0	2024-12-31	189.313038	190.602656	191.25848
1	2025-01-31	189.015133	191.482265	192.01630
2	2025-02-28	188.403017	192.625134	192.52966
3	2025-03-31	187.322945	194.159749	193.19684
4	2025-04-30	185.546038	196.279135	193.77145
5	2025-05-31	182.731088	199.213759	194.40591

Case 4: Hyperparameter Tuning using Optuna for Full univariate Data Set

Evaluation.