

# Summary

The following results are summaries of the actual new deaths/cases per day and their predictions using different methods in Iran. The graphs are for the year 2021 and the legends addresses the following items and algorithms:

**Actual values:** The actual new deaths/cases per day.

**Auto SARIMA:** “Seasonal Autoregressive Integrated Moving Average” was used and to optimize the parameters, Auto ARIMA from pmdarima library was used.

**Simple ARIMA:** “Autoregressive Integrated Moving Average” was used and the parameters were extracted from the optimization carried out in a previous file.

**SARIMAX:** “Seasonal Auto Regressive Integrated Moving Average with eXogenous factors” was used with the parameters found in the above “Auto SARIMA”.

**ARIMAX:** “Auto Regressive Integrated Moving Average with eXogenous factors” was used and the parameters were extracted from the optimization carried out in a previous file.

In this part of the study, we used four models and compared the concept, implementation and the performance of the models. The ARIMA model with (p, d, q) parameters, can deliver good estimation of the studied values. Seasonality of the data was observed using seasonal\_decompose. The Auto ARIMA using the pmdarima library conducts a search on the parameters. It also takes seasonality input and find the best model. In the SARIMAX model, we have used total\_vaccination and stringency\_index as exogenous data. And finally, in ARIMAX, seasonality was ignored, and the total\_vaccination and stringency\_index were used as exogenous data.

The performance of the models was investigated in some sections known as test data. The results do not show improvement of the models using exogenous features in SARIMAX model over SARIMA or ARIMA. Both of the exogenous features have long term effects on the studied values. This implies that the use of total\_vaccination and stringency\_index as exogenous data requires further investigation on how to use them.

# Deaths

60% training:

Prediction results for 28 days followed by 409 days training samples:

Auto SARIMA

MAE: Mean Absolute Error = 178.75

MAPE: Mean Absolute Percentage Error = 51.5%

RMSE: Root Mean Squared Error = 201.59

Simple ARIMA

MAE: Mean Absolute Error = 190.29

MAPE: Mean Absolute Percentage Error = 54.9%

RMSE: Root Mean Squared Error = 214.44

SARIMAX

MAE: Mean Absolute Error = 162.14

MAPE: Mean Absolute Percentage Error = 46.6%

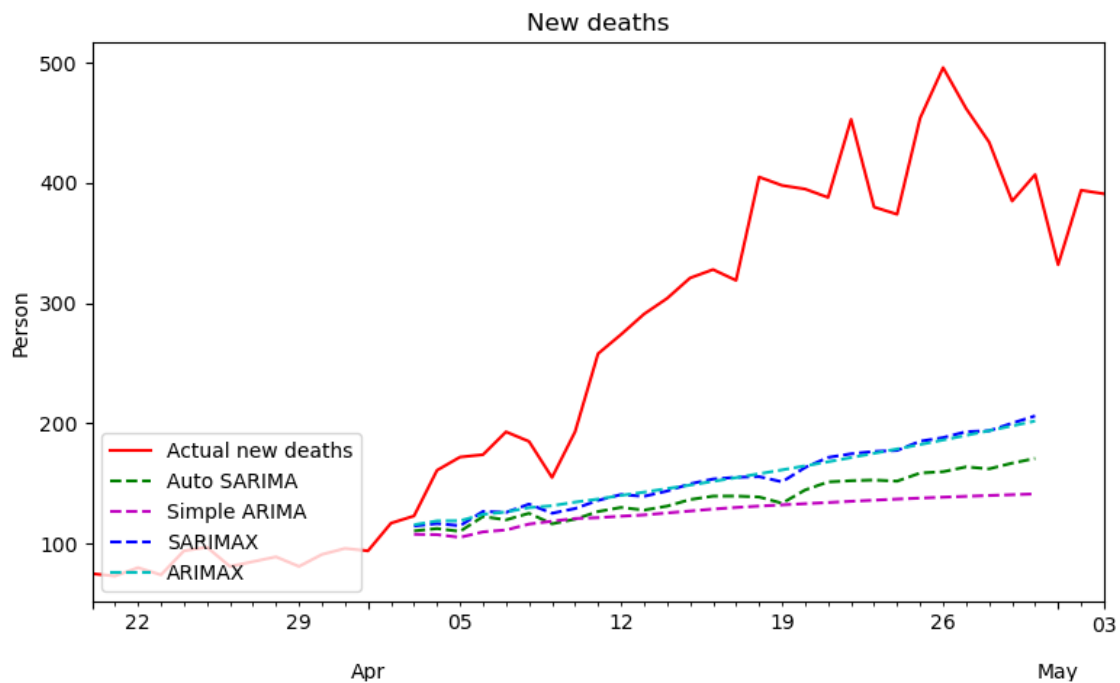
RMSE: Root Mean Squared Error = 183.22

ARIMAX

MAE: Mean Absolute Error = 161.81

MAPE: Mean Absolute Percentage Error = 46.4%

RMSE: Root Mean Squared Error = 183.41



70% training:

Prediction results for 28 days followed by 478 days training samples:

Auto SARIMA

MAE: Mean Absolute Error = 15.73

MAPE: Mean Absolute Percentage Error = 12.1%

RMSE: Root Mean Squared Error = 20.09

Simple ARIMA

MAE: Mean Absolute Error = 16.84

MAPE: Mean Absolute Percentage Error = 11.9%

RMSE: Root Mean Squared Error = 22.32

SARIMAX

MAE: Mean Absolute Error = 46.39

MAPE: Mean Absolute Percentage Error = 34.1%

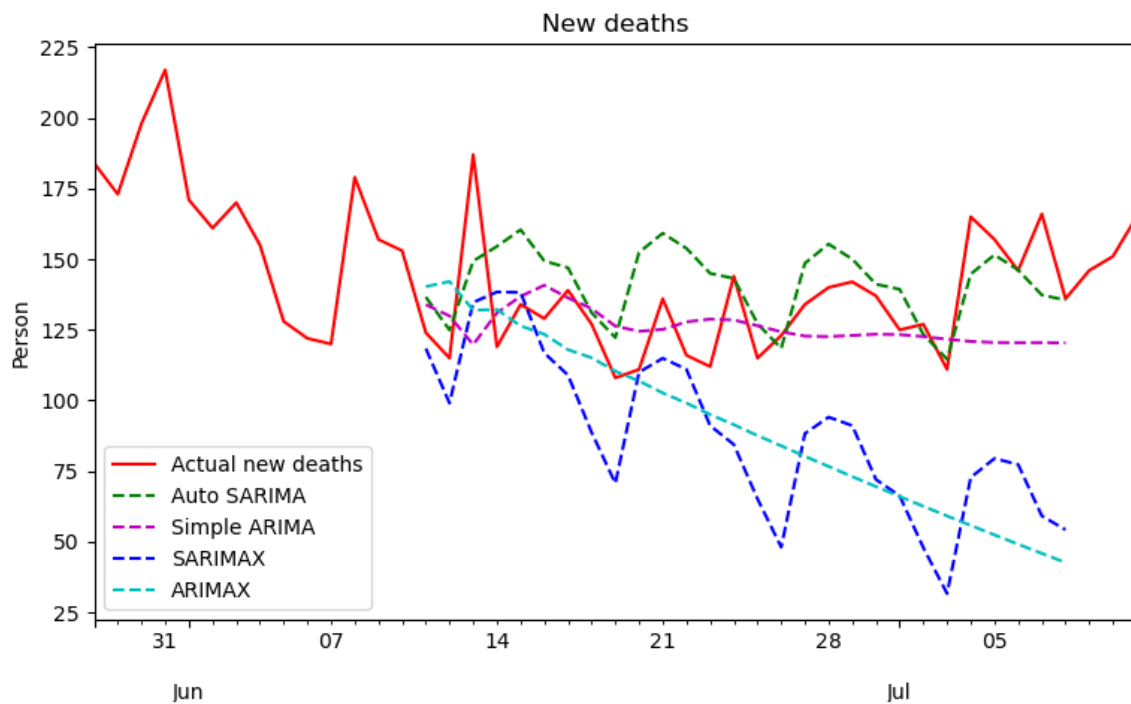
RMSE: Root Mean Squared Error = 54.83

ARIMAX

MAE: Mean Absolute Error = 46.54

MAPE: Mean Absolute Percentage Error = 33.3%

RMSE: Root Mean Squared Error = 57.79



80% training:

Prediction results for 28 days followed by 546 days training samples:

Auto SARIMA

MAE: Mean Absolute Error = 128.79

MAPE: Mean Absolute Percentage Error = 25.3%

RMSE: Root Mean Squared Error = 162.89

Simple ARIMA

MAE: Mean Absolute Error = 150.68

MAPE: Mean Absolute Percentage Error = 29.4%

RMSE: Root Mean Squared Error = 186.00

SARIMAX

MAE: Mean Absolute Error = 331.39

MAPE: Mean Absolute Percentage Error = 63.8%

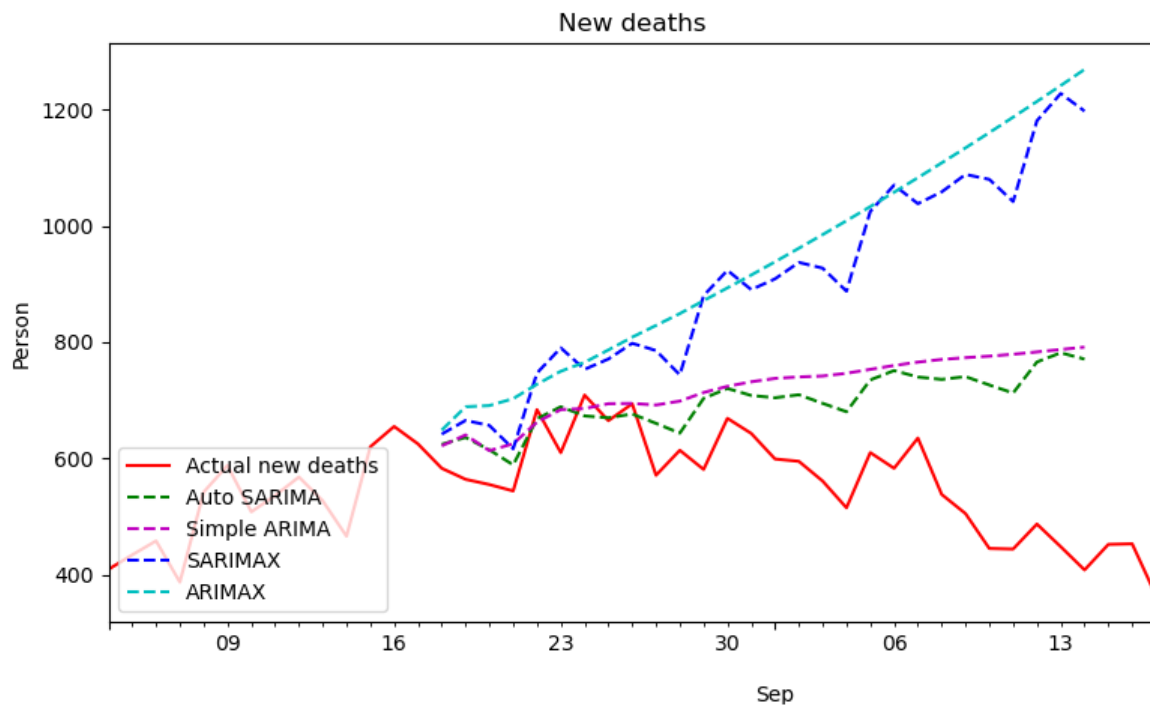
RMSE: Root Mean Squared Error = 401.61

ARIMAX

MAE: Mean Absolute Error = 366.33

MAPE: Mean Absolute Percentage Error = 70.6%

RMSE: Root Mean Squared Error = 439.82



90% training:

Prediction results for 28 days followed by 614 days training samples:

Auto SARIMA

MAE: Mean Absolute Error = 16.14

MAPE: Mean Absolute Percentage Error = 12.5%

RMSE: Root Mean Squared Error = 19.95

Simple ARIMA

MAE: Mean Absolute Error = 20.28

MAPE: Mean Absolute Percentage Error = 14.3%

RMSE: Root Mean Squared Error = 24.82

SARIMAX

MAE: Mean Absolute Error = 142.43

MAPE: Mean Absolute Percentage Error = 116.1%

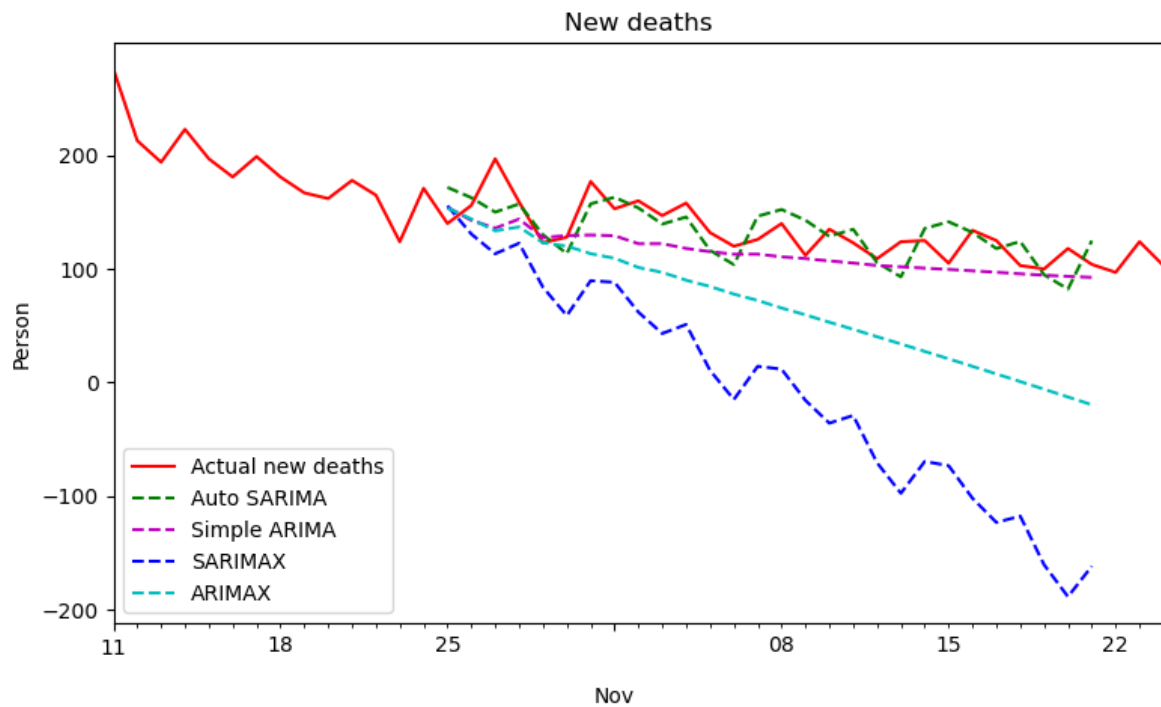
RMSE: Root Mean Squared Error = 162.45

ARIMAX

MAE: Mean Absolute Error = 66.83

MAPE: Mean Absolute Percentage Error = 53.4%

RMSE: Root Mean Squared Error = 75.76



95% training:

Prediction results for 28 days followed by 648 days training samples:

Auto SARIMA

MAE: Mean Absolute Error = 14.30

MAPE: Mean Absolute Percentage Error = 24.3%

RMSE: Root Mean Squared Error = 16.65

Simple ARIMA

MAE: Mean Absolute Error = 9.59

MAPE: Mean Absolute Percentage Error = 16.9%

RMSE: Root Mean Squared Error = 11.66

SARIMAX

MAE: Mean Absolute Error = 161.92

MAPE: Mean Absolute Percentage Error = 316.4%

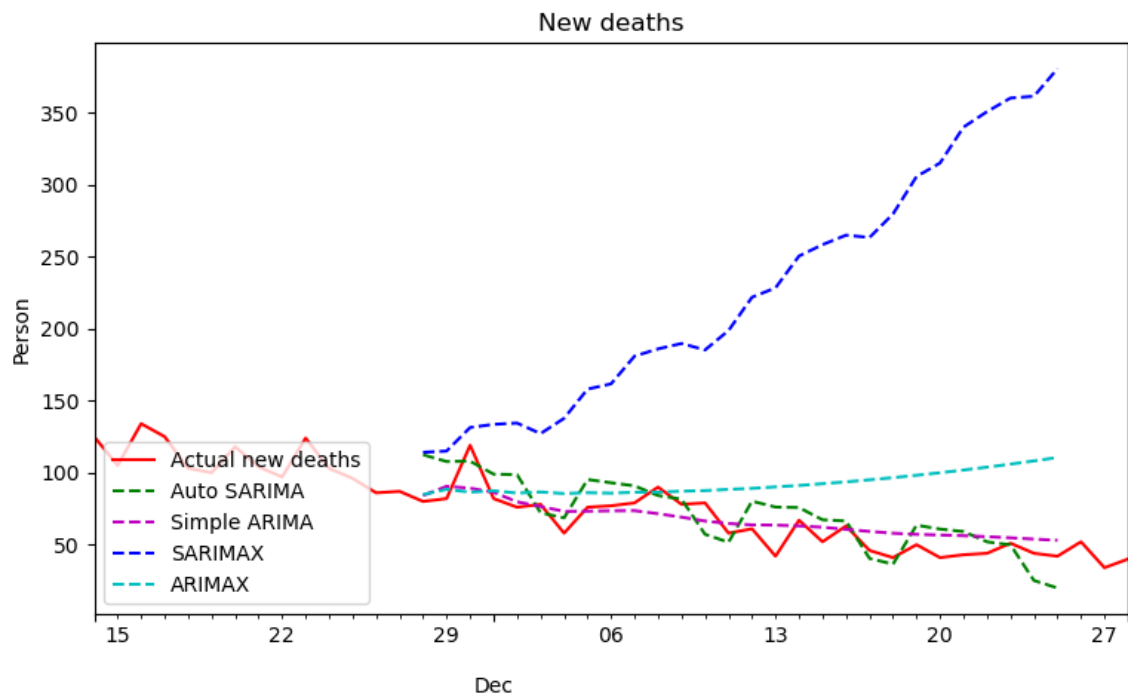
RMSE: Root Mean Squared Error = 189.86

ARIMAX

MAE: Mean Absolute Error = 30.79

MAPE: Mean Absolute Percentage Error = 61.6%

RMSE: Root Mean Squared Error = 37.70



# Cases

60% training:

Prediction results for 28 days followed by 409 days training samples:

Auto SARIMA

MAE: Mean Absolute Error = 5501.20

MAPE: Mean Absolute Percentage Error = 24.3%

RMSE: Root Mean Squared Error = 6354.98

Simple ARIMA

MAE: Mean Absolute Error = 4258.06

MAPE: Mean Absolute Percentage Error = 19.8%

RMSE: Root Mean Squared Error = 4851.17

SARIMAX

MAE: Mean Absolute Error = 5717.29

MAPE: Mean Absolute Percentage Error = 25.3%

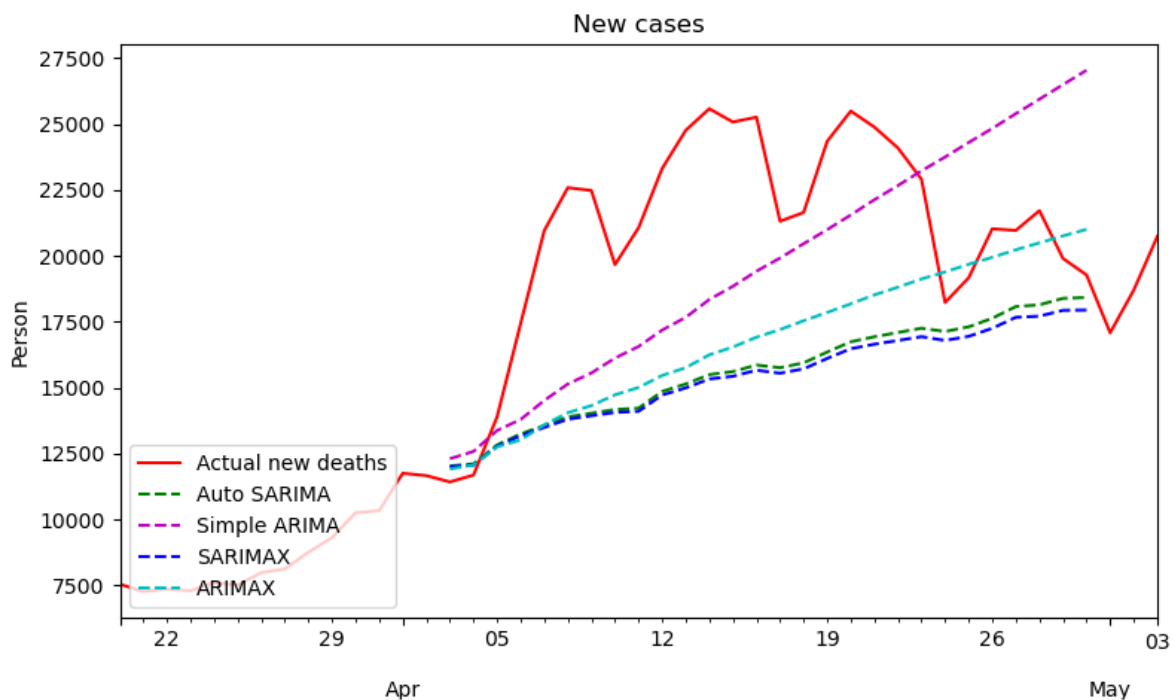
RMSE: Root Mean Squared Error = 6530.24

ARIMAX

MAE: Mean Absolute Error = 4619.62

MAPE: Mean Absolute Percentage Error = 20.4%

RMSE: Root Mean Squared Error = 5572.77



70% training:

Prediction results for 28 days followed by 478 days training samples:

Auto SARIMA

MAE: Mean Absolute Error = 2314.59

MAPE: Mean Absolute Percentage Error = 21.1%

RMSE: Root Mean Squared Error = 2901.38

Simple ARIMA

MAE: Mean Absolute Error = 2990.94

MAPE: Mean Absolute Percentage Error = 29.7%

RMSE: Root Mean Squared Error = 3573.86

SARIMAX

MAE: Mean Absolute Error = 2732.93

MAPE: Mean Absolute Percentage Error = 20.6%

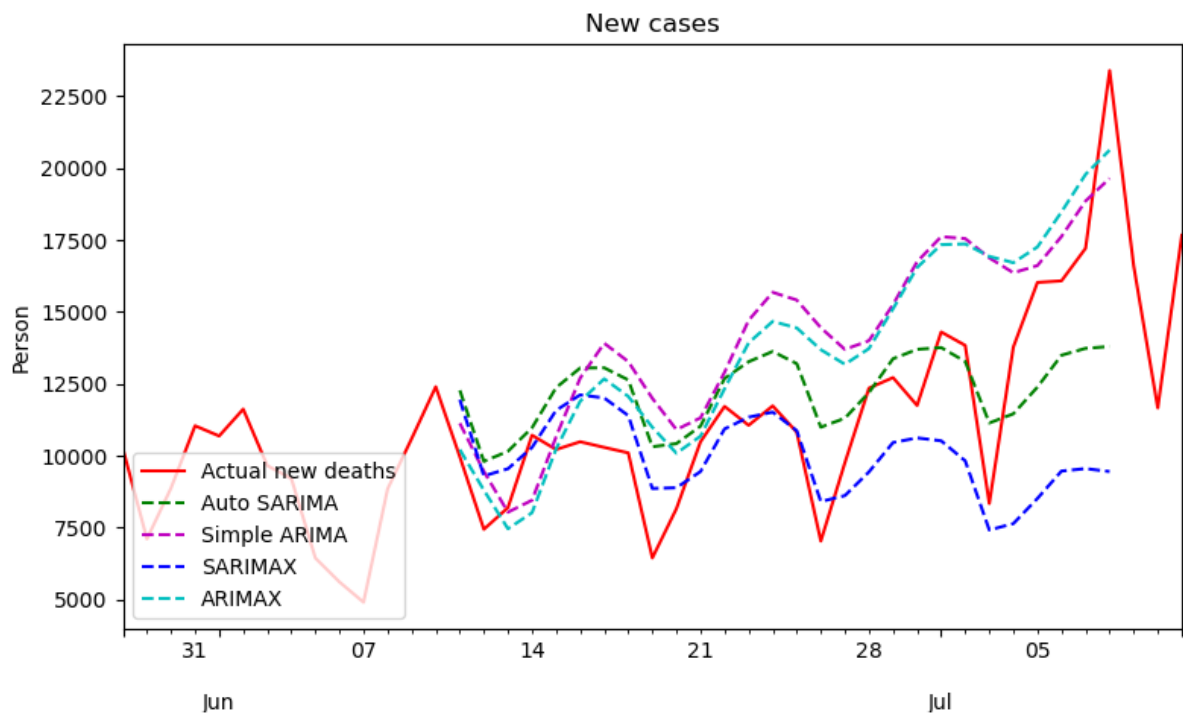
RMSE: Root Mean Squared Error = 4082.92

ARIMAX

MAE: Mean Absolute Error = 2614.47

MAPE: Mean Absolute Percentage Error = 25.6%

RMSE: Root Mean Squared Error = 3207.61





80% training:

Prediction results for 28 days followed by 546 days training samples:

Auto SARIMA

MAE: Mean Absolute Error = 24521.93

MAPE: Mean Absolute Percentage Error = 94.2%

RMSE: Root Mean Squared Error = 26853.96

Simple ARIMA

MAE: Mean Absolute Error = 27193.41

MAPE: Mean Absolute Percentage Error = 106.0%

RMSE: Root Mean Squared Error = 30122.25

SARIMAX

MAE: Mean Absolute Error = 23673.63

MAPE: Mean Absolute Percentage Error = 90.8%

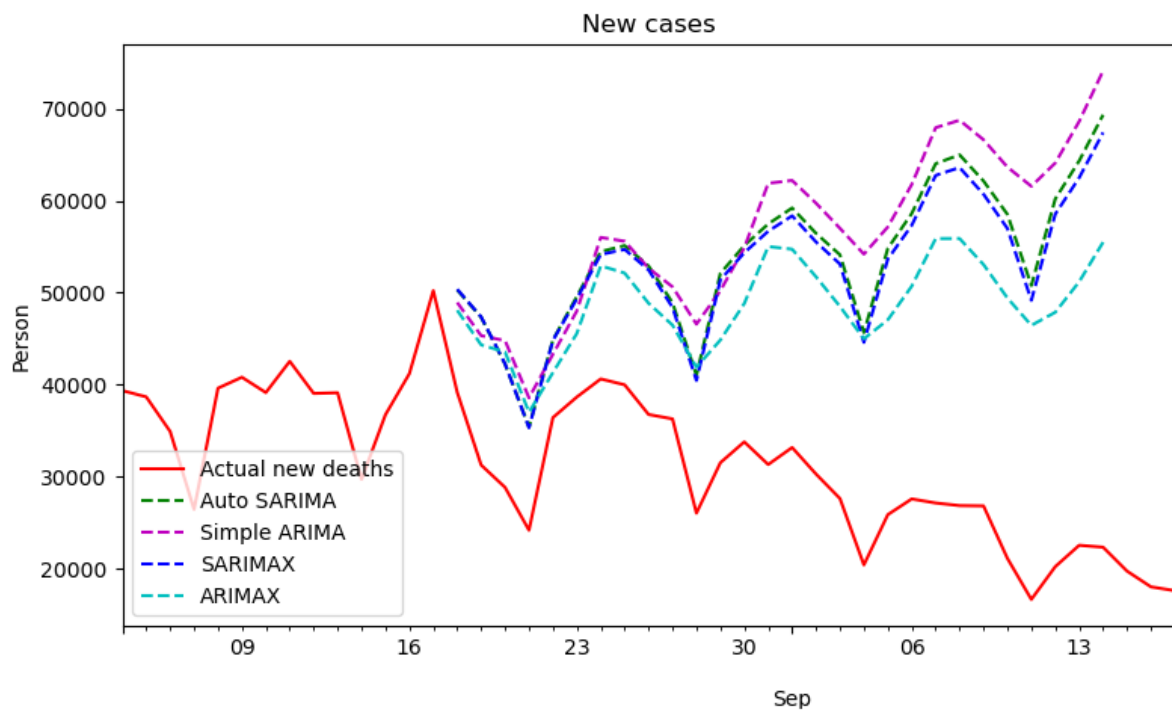
RMSE: Root Mean Squared Error = 25848.10

ARIMAX

MAE: Mean Absolute Error = 19297.71

MAPE: Mean Absolute Percentage Error = 74.3%

RMSE: Root Mean Squared Error = 20829.96



90% training:

Prediction results for 28 days followed by 614 days training samples:

Auto SARIMA

MAE: Mean Absolute Error = 1180.81

MAPE: Mean Absolute Percentage Error = 17.0%

RMSE: Root Mean Squared Error = 1466.61

Simple ARIMA

MAE: Mean Absolute Error = 1551.12

MAPE: Mean Absolute Percentage Error = 21.4%

RMSE: Root Mean Squared Error = 1674.30

SARIMAX

MAE: Mean Absolute Error = 2540.55

MAPE: Mean Absolute Percentage Error = 39.6%

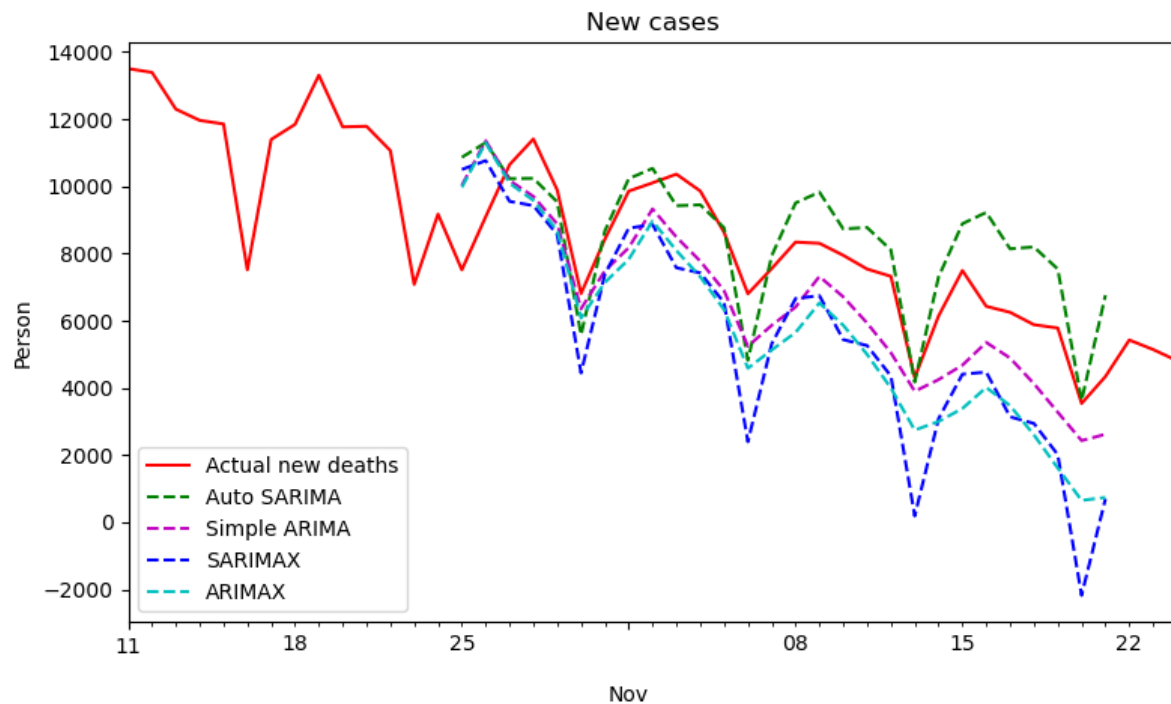
RMSE: Root Mean Squared Error = 2764.87

ARIMAX

MAE: Mean Absolute Error = 2340.87

MAPE: Mean Absolute Percentage Error = 34.4%

RMSE: Root Mean Squared Error = 2505.03



95% training:

Prediction results for 28 days followed by 648 days training samples:

Auto SARIMA

MAE: Mean Absolute Error = 343.28

MAPE: Mean Absolute Percentage Error = 14.9%

RMSE: Root Mean Squared Error = 408.31

Simple ARIMA

MAE: Mean Absolute Error = 789.31

MAPE: Mean Absolute Percentage Error = 35.6%

RMSE: Root Mean Squared Error = 934.26

SARIMAX

MAE: Mean Absolute Error = 1938.38

MAPE: Mean Absolute Percentage Error = 86.0%

RMSE: Root Mean Squared Error = 2200.75

ARIMAX

MAE: Mean Absolute Error = 329.39

MAPE: Mean Absolute Percentage Error = 17.1%

RMSE: Root Mean Squared Error = 432.89

