

## Model Optimization and Tuning Phase Template

Date	24 June 2025
Team	AS PS VS VV
Project Title	Unemployed Insurance Beneficiary Forecasting
Maximum Marks	10 Marks

### Model Optimization and Tuning Phase

The Model Optimization and Tuning Phase involves refining machine learning models for peak performance. It includes optimized model code, fine-tuning hyperparameters, comparing performance metrics, and justifying the final model selection for enhanced predictive accuracy and efficiency.

### Hyperparameter Tuning Documentation (6 Marks):

Model	Tuned Hyperparameters	Optimal Values
ARIMA	p, d, q	(5, 0, 0)
SARIMA	p, d, q, seasonal_order	(5, 0, 0), (0, 1, 2, 3)
AutoReg	lags	10
VAR	maxlags	10
Prophet	NA	Default (no tuning)

- ARIMA (p, d, q):
  - p: Number of autoregressive terms (how many past values are used for prediction).
  - d: Number of times the data is differenced to achieve stationarity.
  - q: Number of moving average terms (how many past forecast errors are used).
- SARIMA (p, d, q, seasonal\_order):
  - p, d, q: Same as ARIMA, applied to the non-seasonal part.
  - seasonal\_order (P, D, Q, s):
    - P: Seasonal autoregressive terms.
    - D: Seasonal differencing.
    - Q: Seasonal moving average terms.
    - s: Length of the seasonal cycle (e.g., 12 for monthly data with yearly seasonality).
- AutoReg (lags):
  - lags: Number of previous time steps used as input features for forecasting.
- VAR (maxlags):
  - maxlags: Maximum number of previous time steps considered for all variables in the multivariate time series.
- Prophet:
  - No hyperparameters were tuned in this workflow; default settings were used.

### Performance Metrics Comparison Report (2 Marks):

Model	Baseline Metric (MSE/MAE/R2)	Optimized Metric
ARIMA	MSE: (initial) NA	MSE: 102,763,733.35 MAE: 5,691.37 R2: -8.18e-05
SARIMA	MSE: (initial) NA	MSE: 103,407,466.65 MAE: 5,833.08 R2: NA
AutoReg	MSE: (initial) NA	MSE: 102,771,796.73 MAE: 5,692.99 R2: NA

VAR	MSE: NA	NA
Prophet	MSE: (initial) NA	MSE: 49,080,877.3 MAE: 4,541.66 R2: 0.003

*Note: Baseline metrics are marked NA as only optimized models were evaluated in this workflow.  
R2 is not always applicable for all models, especially for multivariate or differenced series.*

**Final Model Selection Justification (2 Marks):**

Final Model	Reasoning
Prophet	Prophet achieved the lowest MSE and MAE among all tested models, indicating better predictive accuracy. It also handled trends and seasonality automatically, required minimal tuning, and provided interpretable forecasts. Despite the R2 score, its absolute error metrics were superior, making it the most suitable choice for this forecasting task.