Artificial Intelligence/Machine Learning(AI/ML) in Demand Forecasting of Drugs and Consumables

Deepak Bansal SIO-NIC Haryana
Rahul Jain Technical Director, NIC Haryana
Prabhat Bisht, Scientist-B, NIC Haryana

1. Project Title Executive Summary

Demand planning plays important role in supply chain management of Drugs and Consumables, but to know the exact demand of institutions is a challenge specially in field of Health sector where factors effecting demand vary from epidemic areas, availability of doctors, Stock out, Health Melas/Campaigns and seasonal factors. With the advancement in forecasting methodology, attempts have been made to use AI/ML for near exact demand predication with inputs from medical practitioners.

Online Drug Inventory and Supply Chain management portal is functional since 2013. It is a comprehensive ICT solution for Drug Procurement, Distribution and Consumption. Since all the activities are performed through portal, which is workflow solution based, hence the quality of data is assured.

After doing detailed study of various time series forecasting models like ARIMA, SARIMA, Facebook Prophet, we finally selected Facebook **Prophet model** for drugs inventory forecasting.

Reason for Selection: Prophet model in comparison to other models in time series data is based on an additive model where **non-linear trends** align with yearly, weekly and daily **seasonality**, plus holiday effects. It works best with time series that has strong seasonal effect and historical data for several seasons.

Prophet is robust on missing data and shifts in the trends and typically handles the outliers as well. It's an **open source software** released by Facebook Core data science team.

2. Project Overview / history of Project

Everywhere, cost of health care is soaring, budgets are shrinking, and public expectations are rising from government health Institution. Better management of supply chain and inventory management is key to meet the requirement. NIC –Haryana has built an online Drug Inventory and supply Chain Management (ODISCM) System which includes all the work process of the Warehouses and Health Institutions. ODISCM links health facility with warehouses to collect and distribute supply chain data in real time. Knowing status on which medicines are used and which are required, helps supply chain stakeholders provide continuity of availability of medicine to patient, based on task assigned in portal (role & workflow), with external agency management (like supplies, laboratory emplaned for samples quality testing and Medical colleges). Randomization wherever applicable enforced for neutralize biasness (sample randomization, lab assigned for testing by randomized way).

However, demand forecasting remains a challenge for the procurement agency of for public distribution. Excessive procurement results in expiry of drugs and less procurement results

stockout. Understanding the urgent need, AI/ML methodology applied on data collected through ODISCM at phase -I to generate the near exact demand of the institution/District and State.

3. Implementation Methodology

3.1 Technology Platform

Description: AI/ML Methodology followed for product development.

Data Collection

1. The quantity & quality of data dictate how accurate our model is.
2. The outcome of this step is generally a representation of data which we will use for training.
3. We have collected 7-year (2013 to 2019) dataset of Top 10 generic drugs from online drugs inventory and supply chain management software (ODISCM) successfully running in Haryana as mentioned below.

S.No.	Drug code	Drug Name
1	2.1.8	Paracetamol Tablet 500 mg
2	2.1.17	Diclofenac Suppositories 50 mg
3	3.0.17	Levocetrizine Tablet 5 mg
4	16.1.4	Omeprazole Capsule 20 mg
5	16.1.12	Ranitidine Tablet 150 mg, Film Coated
6	9.1.12	Folic acid Tablet 5mg
7	27.0.13	B-Complex Tablet
8	6.1.1	Albendazole Chewable Tablet 400 mg
9	6.3.2	Amoxicillin Capsule 500 mg
10	2.1.15	Diclofenac + Paracetamol Tablet 50mg+325mg

Data Preparation

1. Data preparation for training by removing duplicates, correct errors, deal with missing values, normalization, data type conversions, etc.
2. Randomize data, which erases the effects of the particular order in which we collected and/or otherwise prepared our data. Dividing dataset into training, validation and testing sets.
3. Visualize data to help detect relevant relationships between variables or class imbalances (bias alert!), or perform other exploratory analysis using Python Matplotlib, Pandas and Seaborn Libraries.

Model Selection

Drugs issue dataset have seasonality and upwards downwards trends so after analysing various time series models finally we selected **Facebook Prophet** since its best fit for non-linear dataset.

Model Training

1. The goal of training is to make a prediction correctly as often as possible.
2. Each iteration of process is a training step.
3. Model is trained for different generic medicines issue dataset for forecasting.

Model Evaluation

Uses prophet performance evaluation metric or combination of metrics to "measure" performance of model

Parameter Tuning

Simple model hyper parameters may include: number of training steps, learning rate, initialization values and distribution, etc.

Predictions/Forecasting

Approximation of how the model will perform for future prediction.

3.2 Citizen Services

Citizens will be benefited as availability of drugs in warehouses /dispensaries will always be available, benefited in terms of quality of service, time, cost, effectiveness as right quantity of drugs will be available at right time to right person.

3.3 User Interfaces

Proposed: Web based portal developed in Python language with Bootstrap, CSS , Responsive webpages etc.

3.4 Efficiency Enhancements

Currently model is trained for 80% of accuracy in making prediction which is further enhanced above 90% of accuracy through parameter tuning, data sampling, cross validation and performance metrics

3.5 Impact on the Stakeholders/ Beneficiaries (G2G, G2B & G2C)

Artificial Intelligence (AI), automation and machine learning are being increasingly adopted into drugs supply chain management in the pharma industry. With the introduction of these technologies, drugs logistics, tracking, packaging and processing can get automated, giving less room for human error. This increases performance levels and reduces inventory carrying costs while improving accuracy and minimizing human intervention

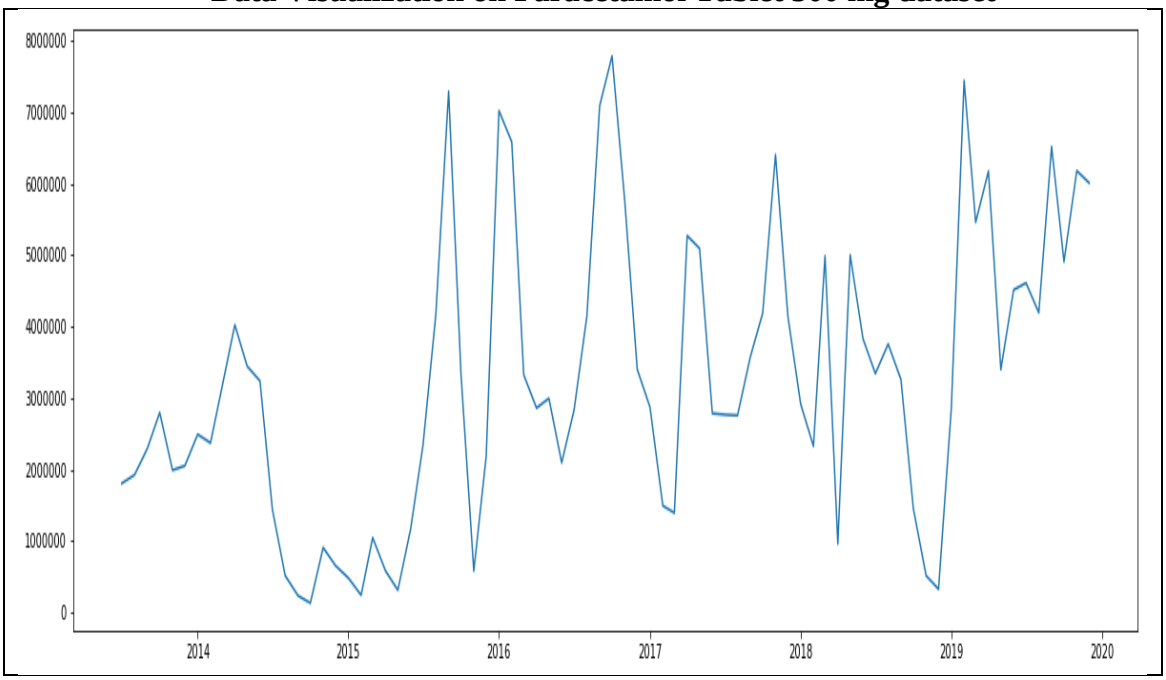
Forecasting and replenishment solution in the supply chain suite helps government in making best buying decisions and improves G2G and G2C services. The demand forecasting component automatically suggests order quantities as required in future and reduced user interactions provide significant productivity improvements. For example, buyers can plan the allergy season and make smarter purchasing decisions based on previous year’s trends

CASE STUDIES

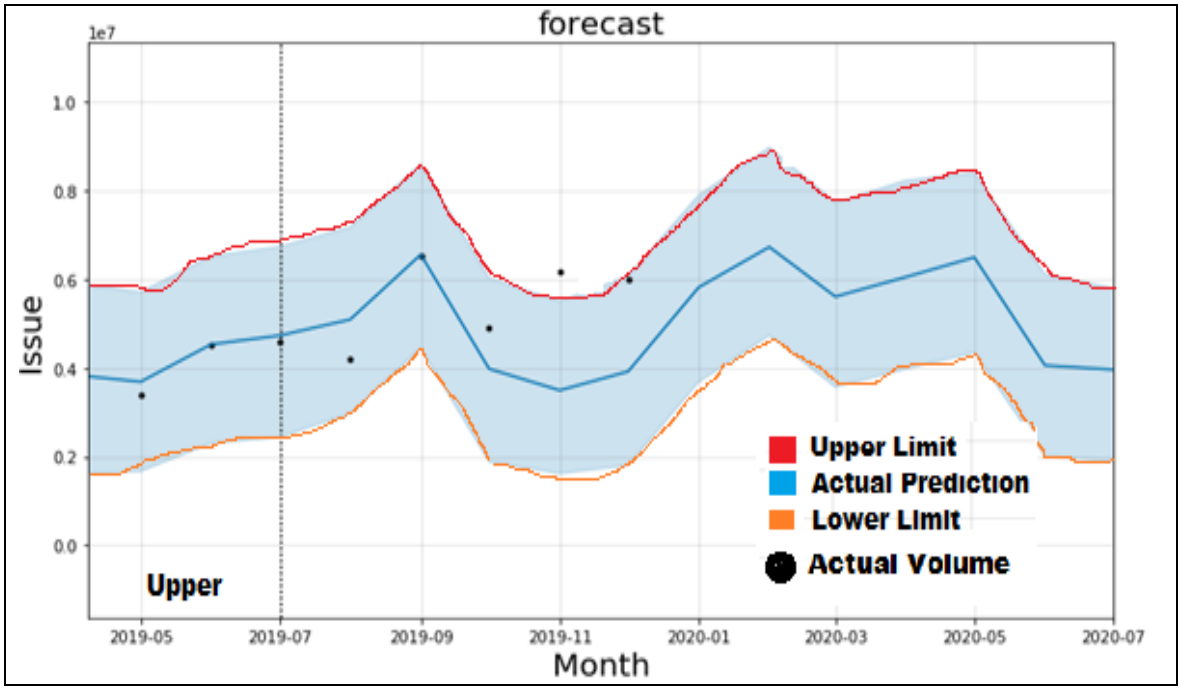
Time Series analysis using Machine Learning Algorithm (Health Sector).

POC: Case Study 1 (Trend Analysis and Future Prediction of Issuance of Paracetamol Drug)

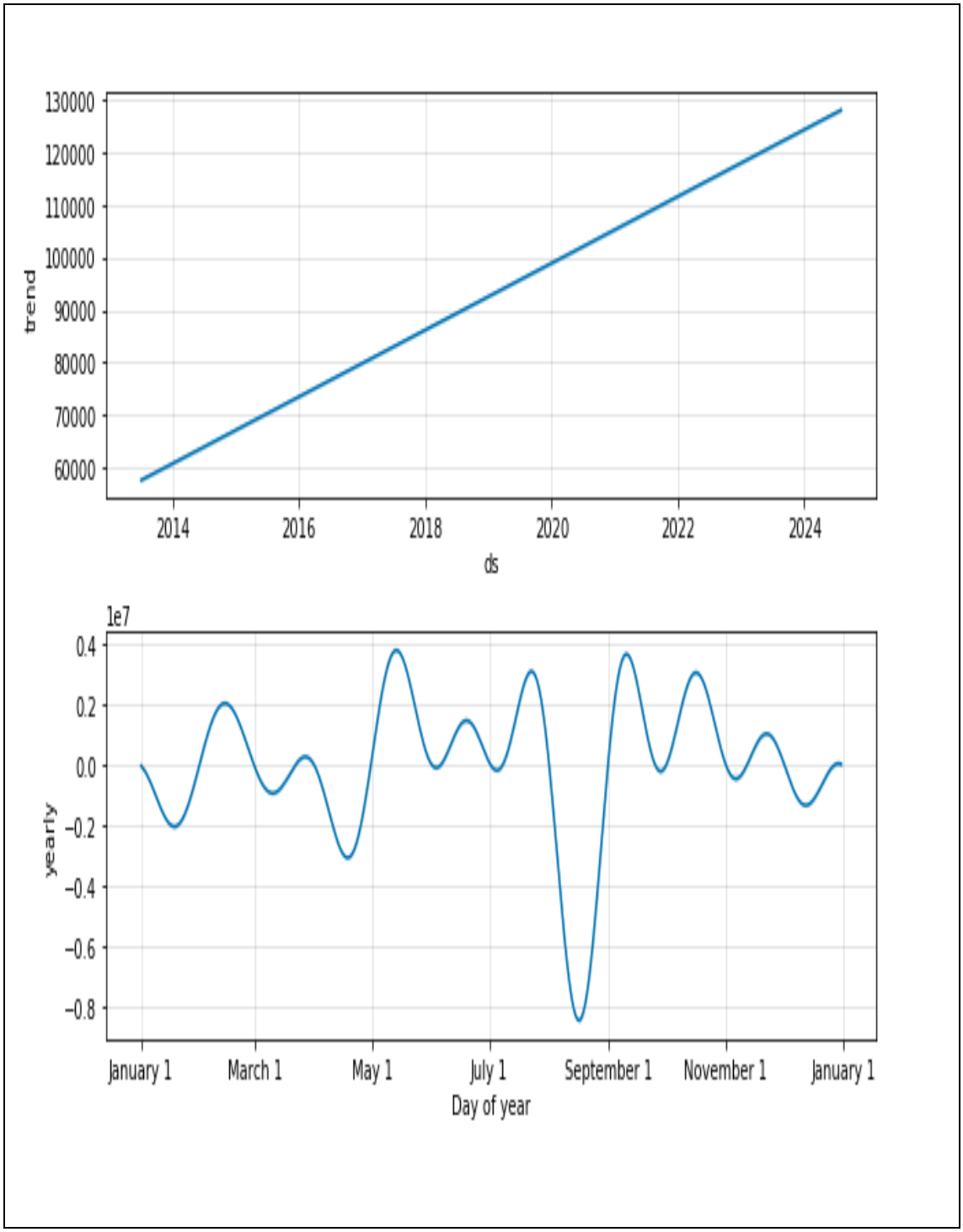
Data Visualization on Paracetamol Tablet 500 mg dataset



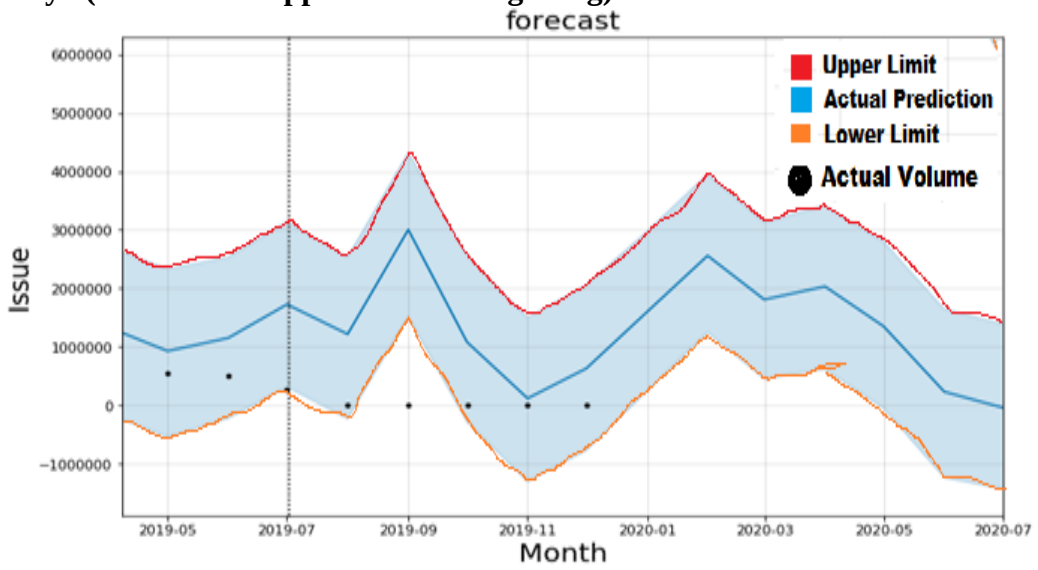
Forecasting Graph



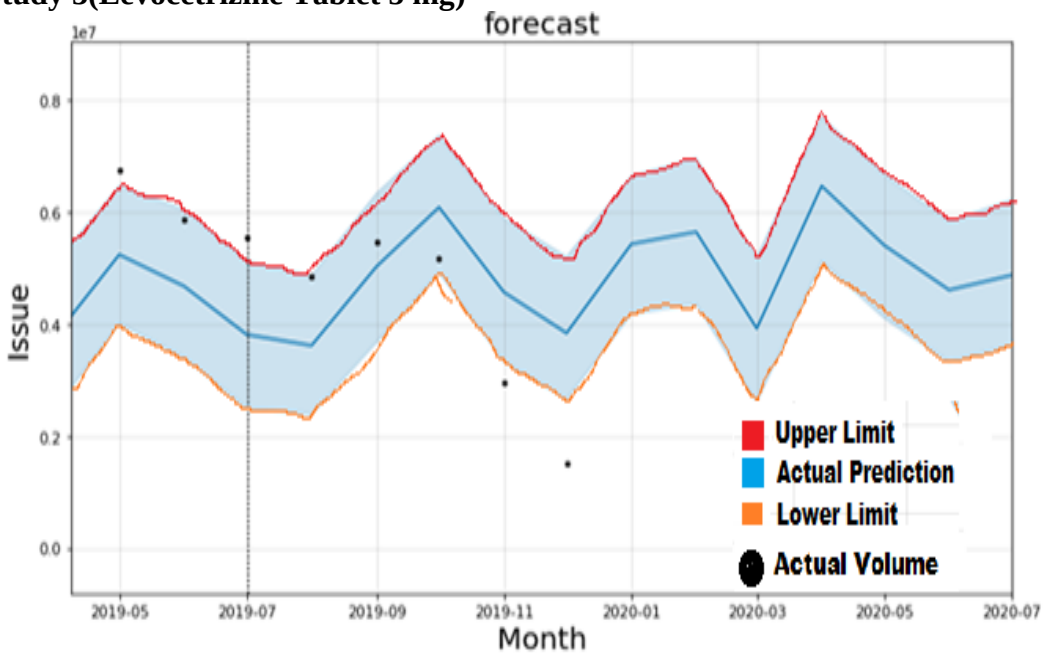
Seasonality and Trend Analysis



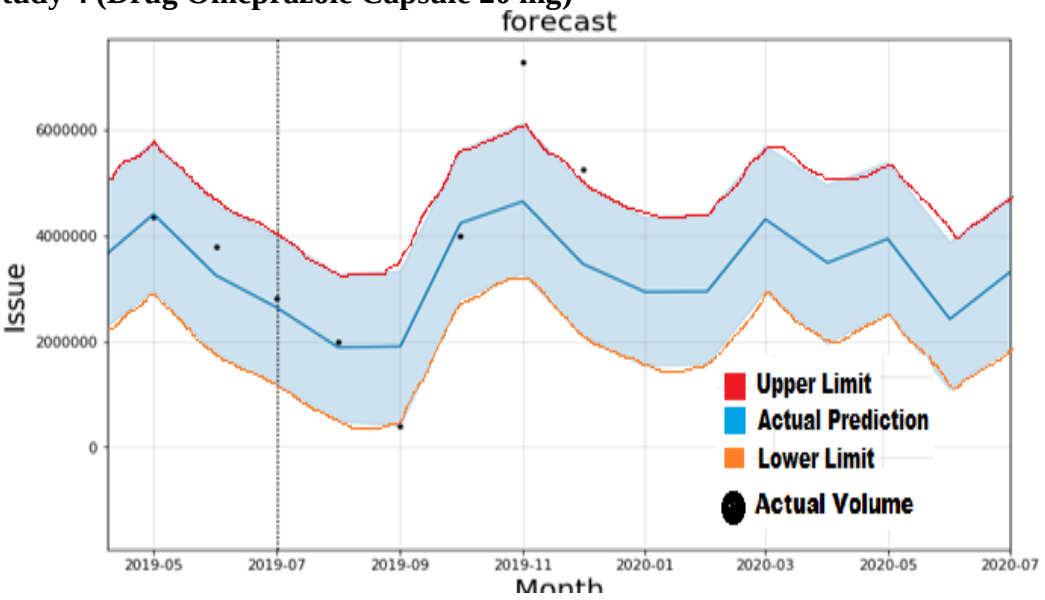
Case Study 2(Diclofenac Suppositories 50 mg Drug)



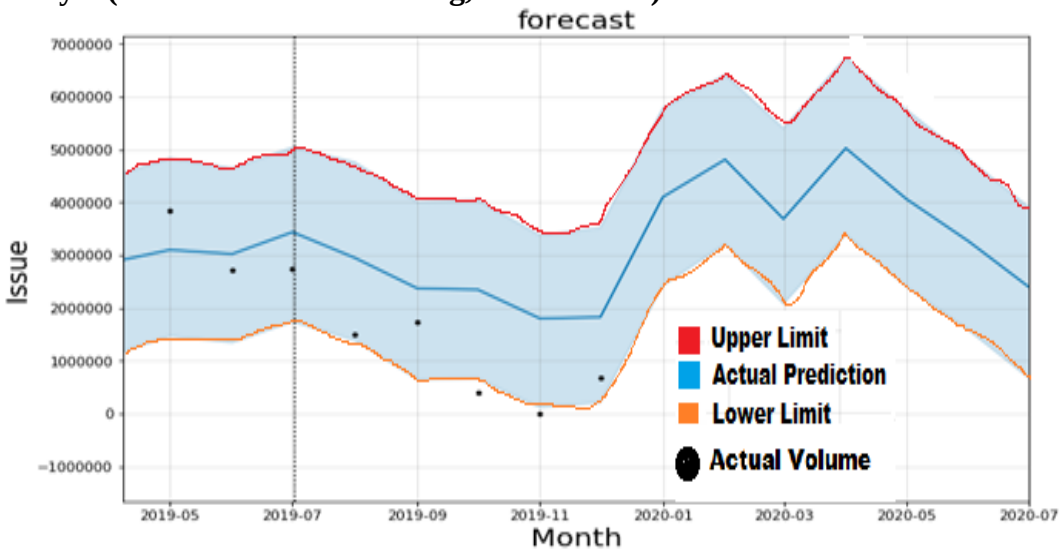
Case Study 3(Levocetrizine Tablet 5 mg)



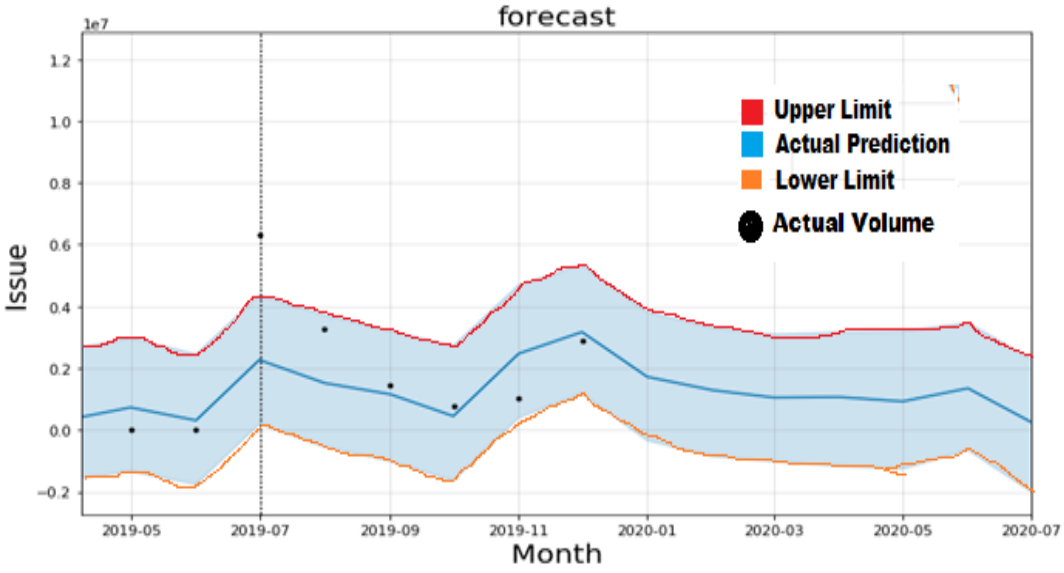
Case Study 4 (Drug Omeprazole Capsule 20 mg)



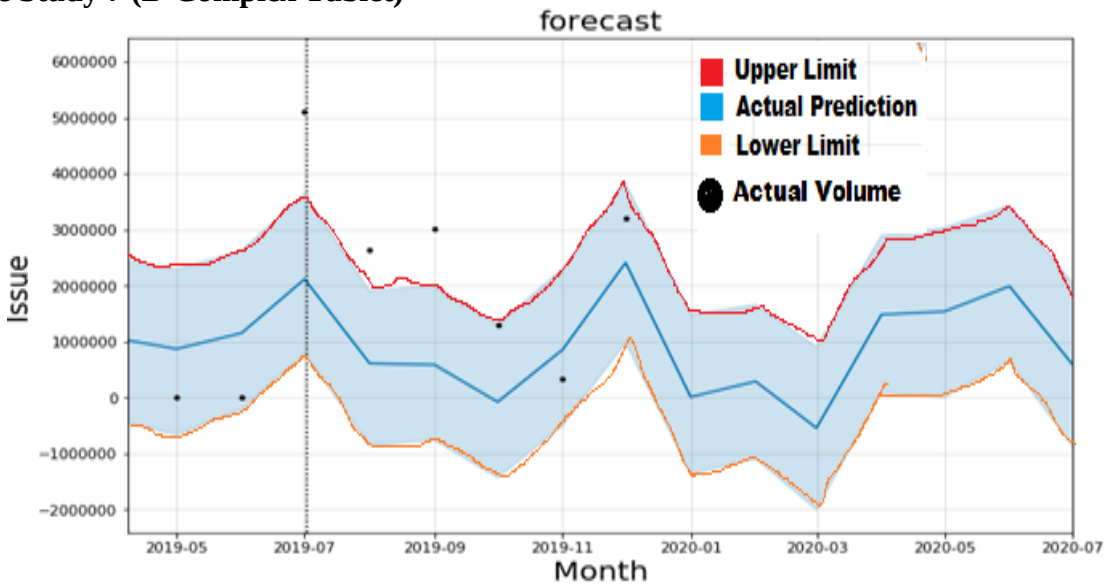
Case Study 5 (Ranitidine Tablet 150 mg, Film Coated)



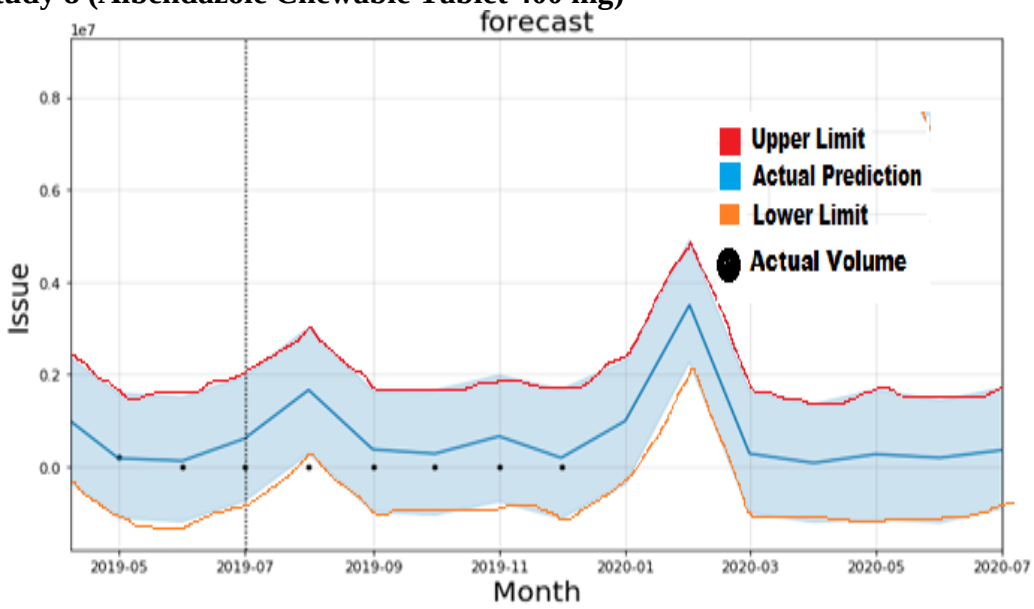
Case Study 6 (Folic acid Tablet 5mg)



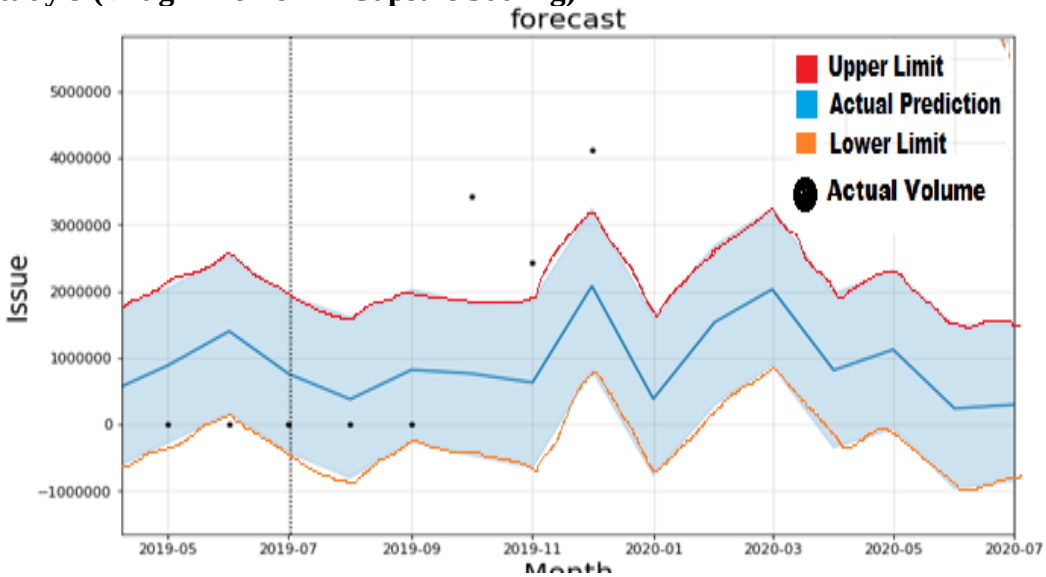
Case Study 7 (B-Complex Tablet)



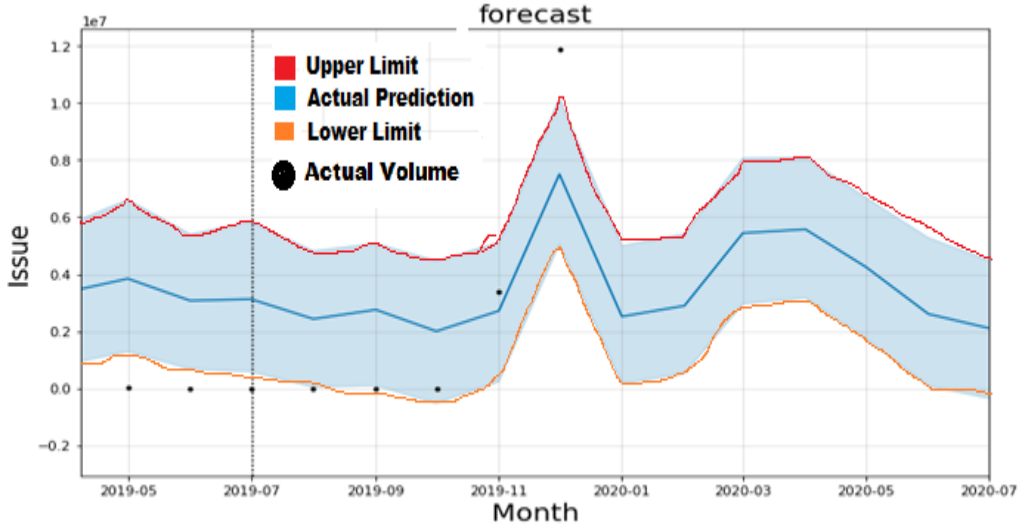
Case study 8 (Albendazole Chewable Tablet 400 mg)



Case study 9 (Drug Amoxicillin Capsule 500 mg)

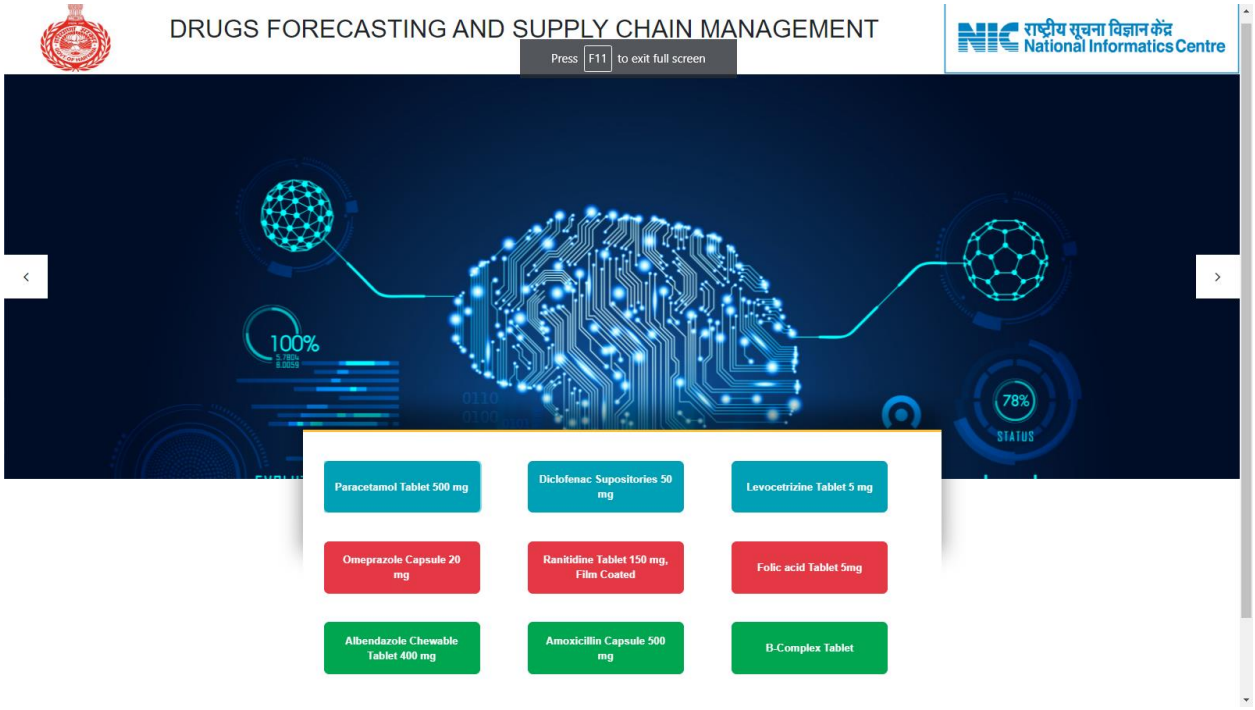


Case study 10 (Drug Diclofenac + Paracetamol Tablet 50mg+325mg)

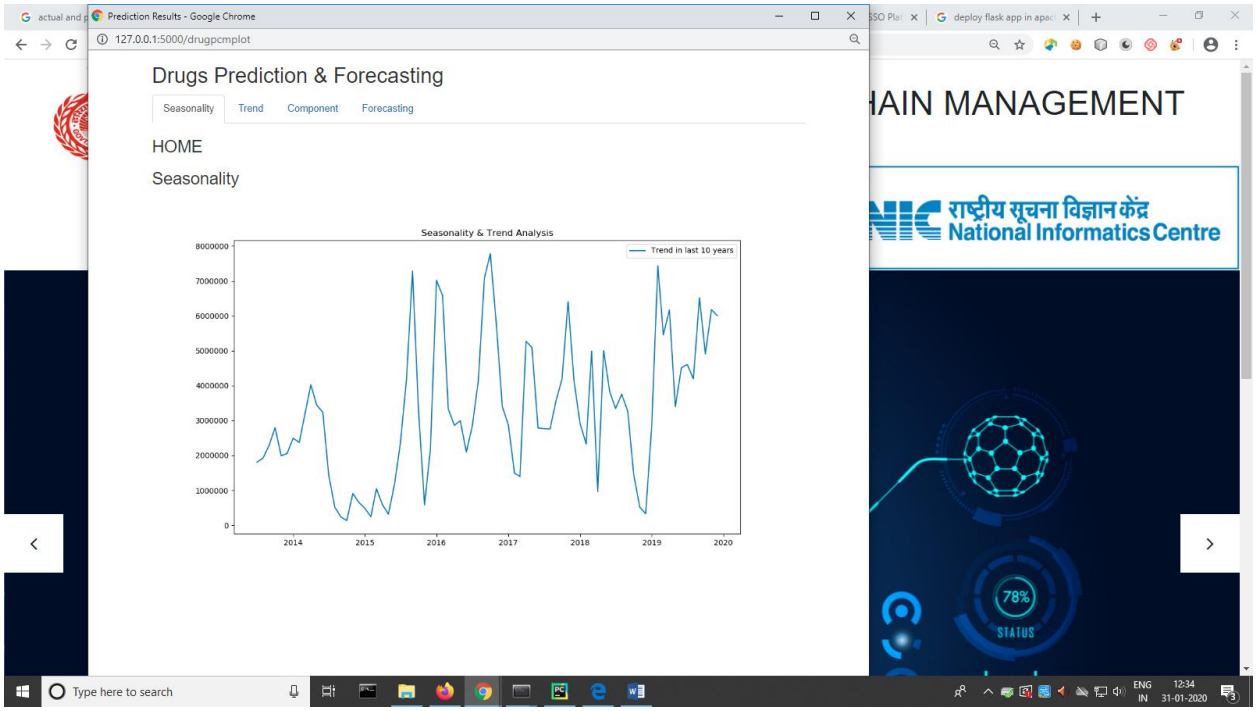


IMPLEMENTATION

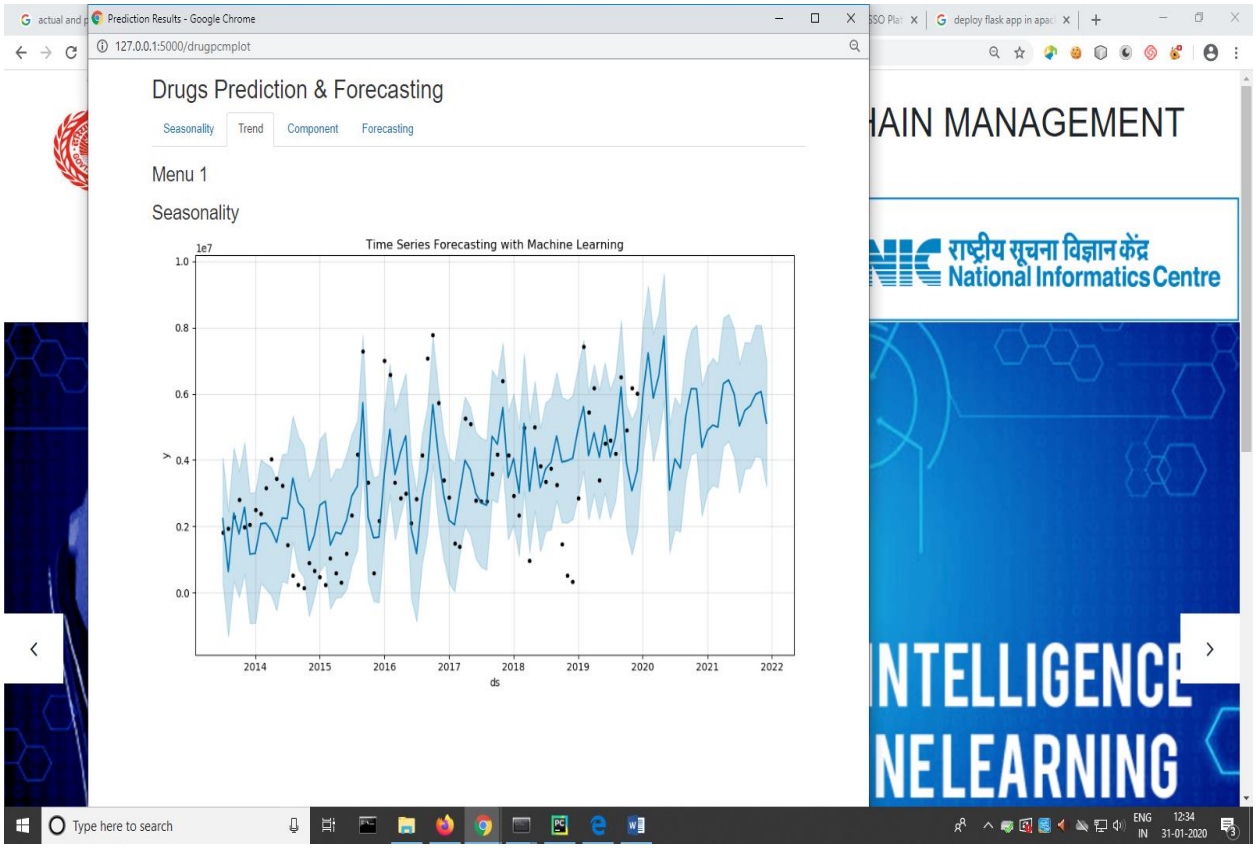
Home Screen (Dashboard)



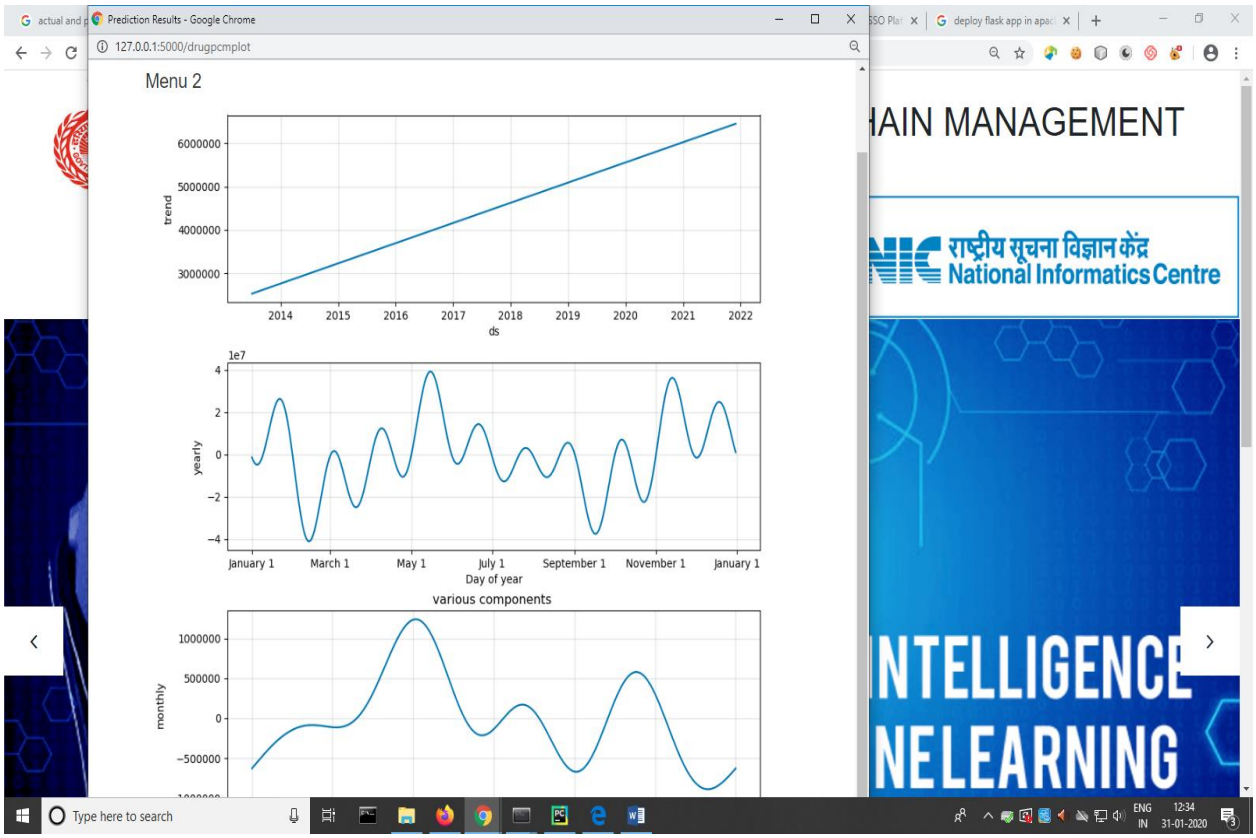
Data Visualization on PARACETAMOL 500mg Drug



Seasonality & Trend Analysis



Trend Analysis Components (yearly ,monthly)



Forecasting