An Analytics-Driven Holistic Stocking and Replenishment Strategy

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ABSTRACT

The study builds prediction models to forecast the demand and replacement rate of over 20,000 automobile spare parts and recommends a stocking strategy to a leading auto repair company. The motivation of this research is to set up inventory thresholds to reduce part movement, reduce inventory holding cost and increase margins. The demand of each stock keeping unit is forecasted monthly by clustering and time series. The replacement rate, forecasted annually, along with the cars sold can be used to calculate the demands for spare parts of new cars in the market. This forecast, along with the business KPIs, lay the basis of a decision model that provides the stocking strategy. This decision model considers inventory holding cost, pallet quantity, predicted demand quantity, alternative part availability and local emergency buyout variance to recommend buying options and answer whether the company should activate or deactivate the stock keeping units.

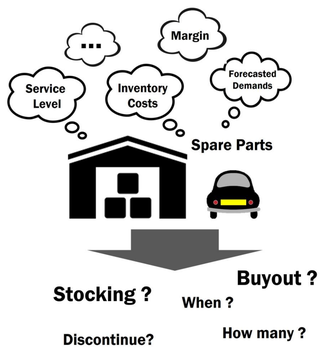
INTRODUCTION

The auto glass repair and replacement service segment are continually increasing in overall value. A high number of SKUs with low volume makes it empirical for auto part companies to lay emphasis on demand prediction to reduce dead inventory and overhead costs. The company wants to maintain a 100% service level and has options to stock a part in the warehouse from a supplier at a high margin or buy it out locally at a low margin as the need arises. Predicting the demand of the stocking strategy will answer the following questions:

- When should the new parts be stocked, and how much?
- When should the company discontinue a low volume part?

Research questions:

- How can we best predict the demand of spare parts for new introductions of car models?
- Can we determine optimal threshold levels to activate/discontinue SKUs?
- Can we strategize to maintain a high service level while being more profitable?



LITERATURE REVIEW

The table below has the summarized the prediction models used in previous research. In this study, we use clustering, time series and regression to forecast parts demands. Unlike previous studies which only focused on very limited SKUs, we apply the prediction flow and models to more than 25,000 SKUs in this study. Botter, R, & Fortuin L. (2000) suggest to divide the parts according to volume, margins and functionality. Diaz, D. A., Hennequin, S., & Roy, D. (2019) suggest to develop an integer linear mathematical model to find the optimal quantity to order using Analytical Hierarchical Process (AHP).

Study	Time Series	LSTM	ANN	RNN	Regression	Clustering	Ensemble
Chen, Y., Zhao, H., & Yu, L. (2010)	✓						
Yang, Q., & Chen, Y. (2012)	✓				✓		
González Vargas, C. A., & Elizondo Cortés, M. (2017)			✓				✓
Liu, Q., Miao, K., & Lin, K. (2019)		✓				✓	
Liao, W., Ye, G., Yin, Y., Yan, W., Ma, Y., & Zuo, D. (2020)		✓					
Zeng, R. (2020)	✓						
Alalawin, A., Arabiyat, L. M., Alalaween, W., Qamar, A., & Mukattash, A. (2020)					✓		
Our Study, 2021	✓				✓	✓	

METHODOLOGY

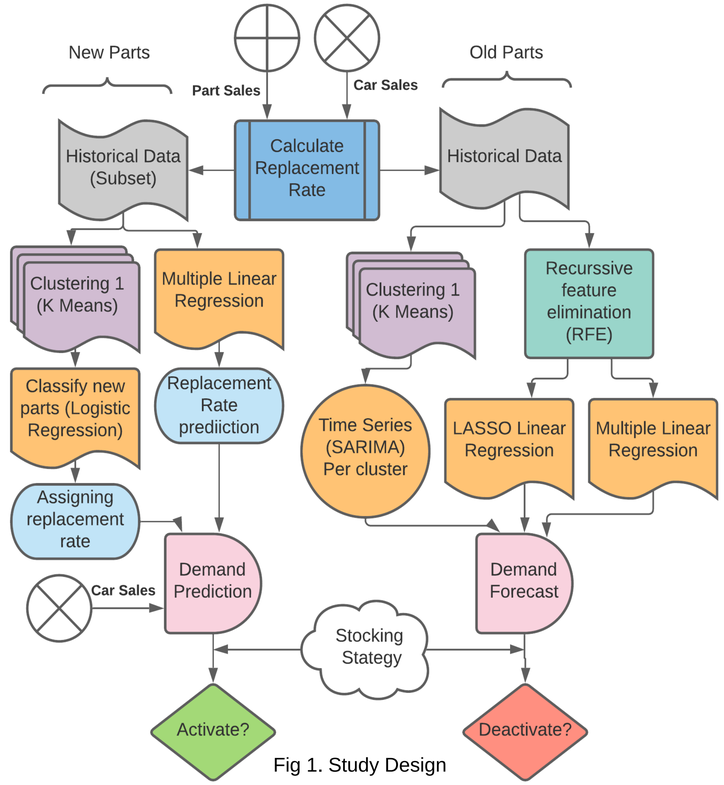


Fig 1. Study Design

STOCKING STRATEGY

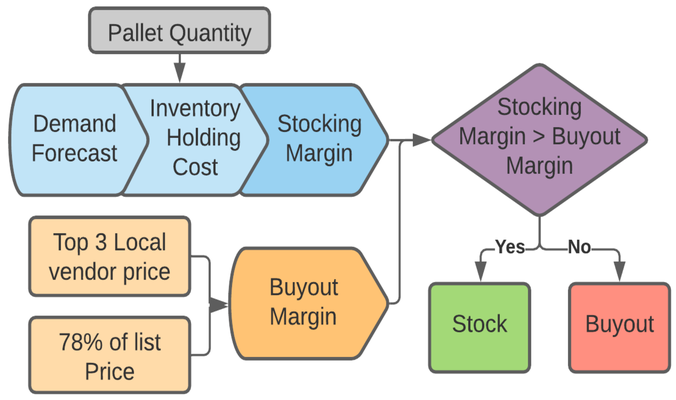


Fig 2. Stocking Strategy

STATISTICAL RESULTS

For monthly demand forecasting of old parts, Regression and Time series models are compared in Figure 3. Mean Absolute Percent Error and Root Mean Square Error emphasises on the large errors which are particularly undesirable. Large errors in this monthly forecasting will translate into higher capital investment, and therefore MAPE & RMSE is used to compare the models. For New parts, the annual replacement rate prediction uses XGBoost Regressor and Figure 4 showcases its feature importance output..

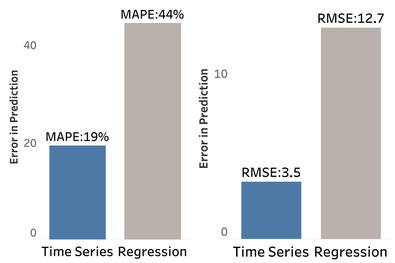


Fig 3. Model Results Comparison

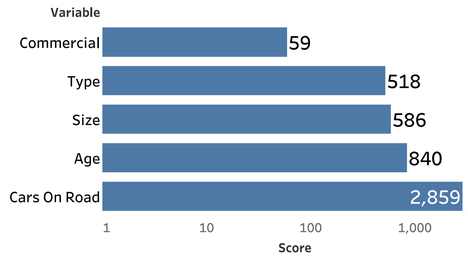


Fig 4. Variable Importance for Replacement Rate

CONCLUSIONS & FUTURE WORK

- Demand of Automobile parts is majorly impacted by the number of vehicles on road and in turn the auto-industry.
- Adding external data like the GDP of the country, growth of automobile market, etc. would enhance the demand prediction.
- Attributes like **make, price segment and vehicle category** can be used to cluster parts with similar replacement rate.
- Replacement rate prediction of new parts added with cars on road translate to forecasted demand.
- Stocking strategy suggests to buyout around 45K units per quarter out of 1.4M units.
- Buying out 5% of the SKUs, which is around 3.2% in Units, leads to 1.5% increase in total profits.

EXPECTED BUSINESS IMPACT

- Increased market share and profit margins by stocking up for only potentially profitable new spare parts based on forecasted demand.
- Reduced inventory holding and ordering costs by $3.5M per quarter by implementing strategic stocking decisions.
- Prevent obsolescence by discontinuing any unprofitable parts. This eradicates dead inventory for old parts, saving the company costs on enormous warehouse space.
- Ordering based on forecasted quantity to help decision-makers, increasing efficiency and prevent over-ordering.

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