An Approach to Predict Demand for A Grocer's Most Challenging Products: Meat and Seafood

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ABSTRACT

This study analyzes the trend of demand for meat and seafood of a mid-west grocery chain and develops a comprehensive set of forecasting models with sophisticated workflow to improve the prediction accuracy. By using this set of forecasting, the grocery can gain a more in-depth view of where and how accuracy can be improved. Moreover, we provide the grocery with ready-to-use models that can help them ensure and improve prediction accuracy. We show 1) how feature engineering and variable selection affect the accuracy of modeling, 2) how our set of modeling properly predicts product demand accurately and helps the grocery make more strategic decisions to improve their future forecasting.

INTRODUCTION

Predicting the demand for seafood and meet accurately is challenging due to various factors including the perishable nature of the products and the drastic changes in the demand for seafood and meat combined with the change of customer behavior due to COVID-19. The difficulty of predicting seafood and meat demand is indicative of the grocery stores' challenges to cope up with the supply and demand chain. Therefore, the forecasting models need to be tuned so that the demand can be accurately captured by superstores. Using machine learning models helps to understand the various metrics and build the ecosystem of demand and supply. Moreover, the implement of high-performance cluster will benefit the process by improving the running speed of various experiments.

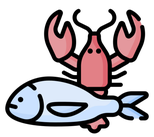

Fig 1a. Meat and Seafood

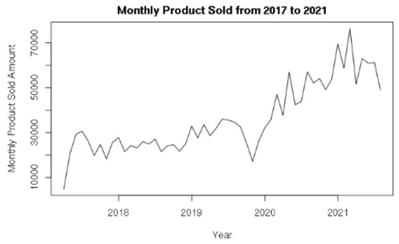

Fig 1b. Change of Trend from 2017 to 2021

Research Questions:

- What are the important features that affect the sales prediction and model accuracy?
- How to improve the accuracy of demand forecasting?

LITERATURE REVIEW

Previous studies have examined the complex relationship between promotions, trends, and seasonality to the demand using naive time-series models to advanced LSTMs to answer these research questions. Our methodology, ensemble of all such models is used to identify important features and improve forecasting accuracy.

Study	Prophet	LASSO	SVM	ARIMA	LSTM	KNN	GBM	RF
(Ali, et al., 2009)			✓					
(Ma, et al., 2015)		✓						
(Elmasdotter, et al., 2018)				✓	✓			
(Odegua, 2020)						✓	✓	✓
(Zunic, et al., 2021)	✓							
Our Study	✓	✓	✓	✓	✓	✓	✓	✓

METHODOLOGY

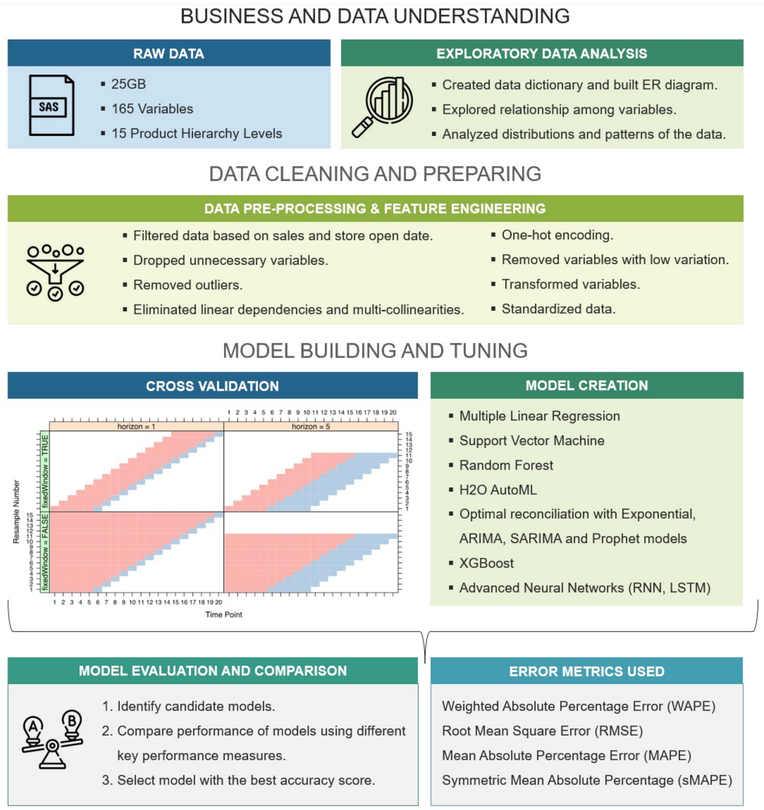

Fig 2. Study Design

STATISTICAL RESULTS

Because the product level sales can be high, low, or intermittent, WAPE was the main model metric we used in our evaluation. WAPE weights errors based on their significance. Based on this study, we observed that the XGBoost model produced the best results. Moreover, we plan to examine deep neural networks like LSTM and RNN to further improve the model's performance.

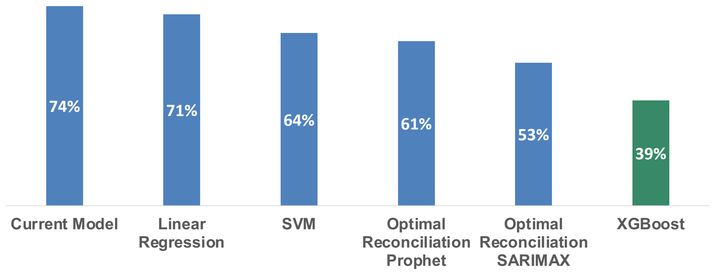

Fig 3. Summary of best model results (WAPE Metric)

IMPORTANT FEATURES

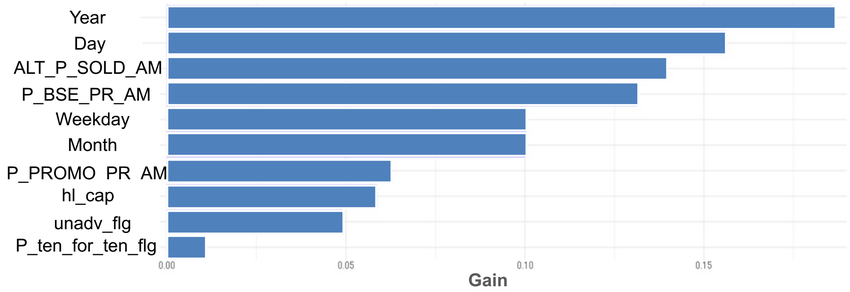

Fig 4. Most Important Features

PURDUE UNIVERSITY'S BELL CLUSTER

With large amount of data provided by the client, we used the high-performance Bell Cluster developed by Purdue University to perform data processing and to conduct thousands of forecasting experiments. By parallelizing tasks, we were able to process the data quickly, enhancing our team's productivity by 50%.

EXPECTED BUSINESS IMPACT

With the new model, we reduced the error metric by ~35%. The substantial decrease in error metrics results in better accuracy of the model, which would allow clients to make better decisions. As a result, for the products in meat and seafood segments, clients will be benefitted with below:

- Efficient inventory management
- Efficient demand and supply channels
- Increase in sales of products by ~10%
- Reduction in cost resulting in profitability by ~5%
- Better resource management leading to enhanced productivity

Fig 5. Business Impact

CONCLUSIONS

- We have developed a predictive modeling workflow that will allow thousands of forecasting experiments to be performed on meat and seafood products.
- By using XGBoost model, we have improved the error metric by ~35%
- Promotions and seasonality are the significant features that affect the sales prediction and model accuracy.
- Using a novel technique, we have designed a way to process massive datasets, capture and share results, and summarize key findings of areas where product forecast performance can be improved.
- Through cooperation with the grocery store's Analytics team, we have analyzed performance across various metrics, and therefore provided new capabilities.

ACKNOWLEDGEMENTS

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