Product Pattern Ratio Optimization and Customer Demand Prediction for Pattern Making Company

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ABSTRACT

Prediction and optimization methods are used to find the optimal ratio of pattern-to-solid for a pattern-making company. This will allow them to maximize sales under the control of specific conditions in their business. Prediction and optimization models from python libraries are applied to determine the quantity for each product category and maximize sales by controlling the pattern-to-solid ratio and other variables.

INTRODUCTION

Product assortment and its inventory problem are critical issues in the fast-changing fashion industry. These are especially true for the pattern-making fashion company where the importance of seasonality is greater than that of the solid item-based fashion company.

We recognized the difference in the pattern-to-solid ratio of each product category and leveraged them into the sales optimization problem. Also, the discount rate is different between pattern and solid product, and that of the pattern is higher. This is an important issue that a pattern-making company should focus on. So, we used these parameters to optimize to maximize the sales.

For the demand prediction, the time series approach and ensemble models, which include bagging and boosting methods are used. For the optimization, non-linear programming methods are used.

RESEARCH OBJECTIVES

- What predictors play an important role in predicting sales quantity?
- Which model performs best in predicting customers' demand?
- What is the optimal retail price, discount rate, and pattern-to-solid ratio for each product category that maximizes sales?

LITERATURE REVIEW

We referred to the following papers regarding demand forecasting and optimization for our study.

Prediction: ARIMA time series modeling (Shuyun Ren et al., 2017), customer churn prediction (Andrés Martínez et al., 2020), forecasting retail sales deploying ARIMA and GLM (Ilan Alon et al., 2001)
Optimization: Price optimization for an online fashion retailer (Hanwei Li)
We chose the models with the best performance to predict the demand and adapted into the optimization function.

Study	Prediction					Optimization	
	ARIMA	LSTM	RF	GB	GLM	CP	GD
Shuyun Ren et al. (2017)	V						
Andrés Martínez et al. (2020)				V			
Ilan Alon et al. (2001)	V				V		
Hanwei Li et al. (2021)		V				V	
Our Study (2022)		**V**	**V**	**V**	**V**		**V**

Table 1. Literature Summary

METHODOLOGY

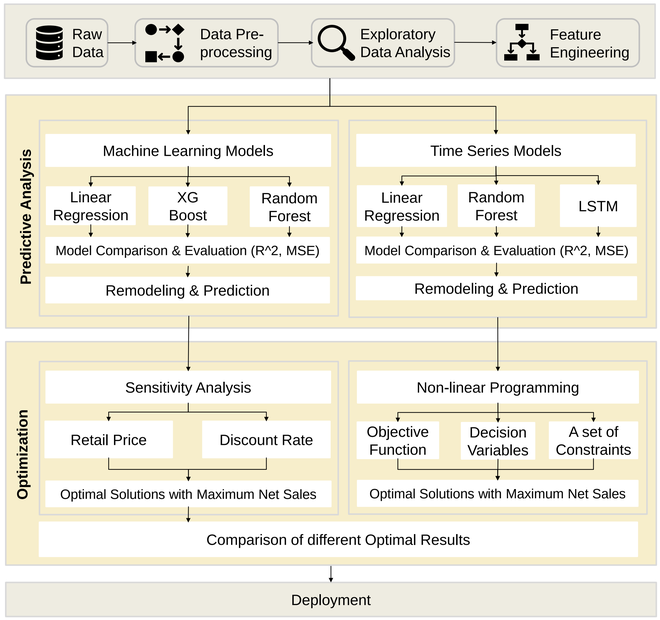

Fig 1. Methodological Framework

STATISTICAL RESULTS

Method 1
(1) Predict sales quantity of each category using time series modeling on python
(2) Optimize the price, discount rate, and pattern-to-solid ratio using non-linear programming on SAS

Fig 2. Sales Trend (Time Series) and Prediction Model (Random Forest)

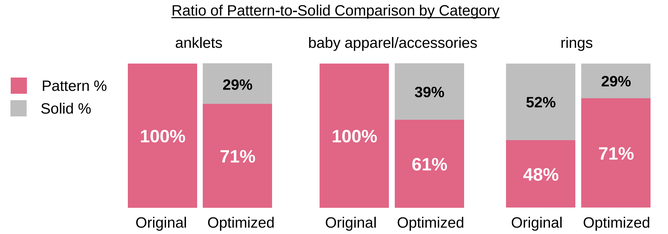

Fig 3. Pattern-to-Solid Ratio by each category Before and After Optimization

Mehtod2
(1) Predict sales quantity of each category using various machine learning models on python.
(2) Select models with the highest R-square value.
(3) Optimize price, discount rate, and pattern-to-solid ratio to maximize the net sales on python.

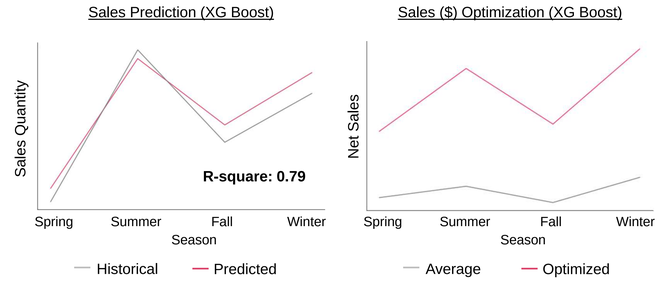

Fig 4. Sales Prediction and Optimization Model (XGBoost)

EXPECTED BUSINESSIMPACT

We aim to optimize the products' pattern-to-solid ratio and the price of each item category. This will help the pattern-making company to maximize the sales with the best product mix decision, secure their loyal customer group, and attract new customers with the optimal discount rate without harming their business.

- Optimize the products' pattern-to-solid ratio and a healthy product portfolio.
- Set an optimal retail price and discount rate for each category to maximize the net sales ($).

Based on the optimal ratio of pattern-to-solid for each category, the company can plan which product categories to focus on and how the pattern-to-solid ratio should be for the following year.

- Help our clients to make the best decision on the items to maximize the sales.
- Assist the decision-making in campaign or promotion planning.

CONCLUSIONS

To maximize the revenue for a fashion company, which has a specific business problem, we conducted two methods to optimize some decision variables-the pattern-to-solid ratio and price: Time series with non-linear programming optimization model and machine learning models with sensitivity analysis.

In the sales prediction, time series analysis performed the best with an accuracy rate of 86.4%. Also, we found the different ratios of pattern-to-solid by each category, which can be utilized in the product planning for the future.

Based on our study, the fashion company can determine the optimal price, discount rate, and pattern-to-solid ratio of each category that maximize that revenue.

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