Department of Industrial Systems Engineering and Management

IE3100M Systems Design Project - Group 14 (AY2020/21)

Preventing Aging Stocks in Shopee's Cross Border E-Commerce Warehouses via Enhanced Strategic Management and Demand Forecasting

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INTRODUCTION

SHOPEE

- Founded in 2015
- Leading e-commerce platform in Southeast Asia and Taiwan
- Part of Sea Group, a global consumer internet company
- Empowers sellers from all over the world to sell into the region
- Helps sellers to market their products across 7 different markets
- Provides various enabling services (e.g. logistics, operations, payments, business intelligence and warehouse fulfillment)

PROBLEM DESCRIPTION

As part of **a new warehouse fulfillment strategy**, Shopee requires sellers to ship their goods in bulk to warehouses located in every city's capital in the region, in order to allow customer orders to be fulfilled more swiftly. However, the new approach has raised **concerns regarding aging stocks** as sellers ship their goods in advance, which introduces greater uncertainty given the unpredictable nature of demand. Aging stocks are stocks that spend a counterproductive amount of time in storage which results in **depreciating quality of goods, rising warehouse fees and shrinking profit margins**. Once aged, the stocks are deemed as unfit for sale. Additionally, the presence of aging stocks in the warehouses also means that space utilization is not optimal and additional storage costs are incurred.

PROJECT OBJECTIVES

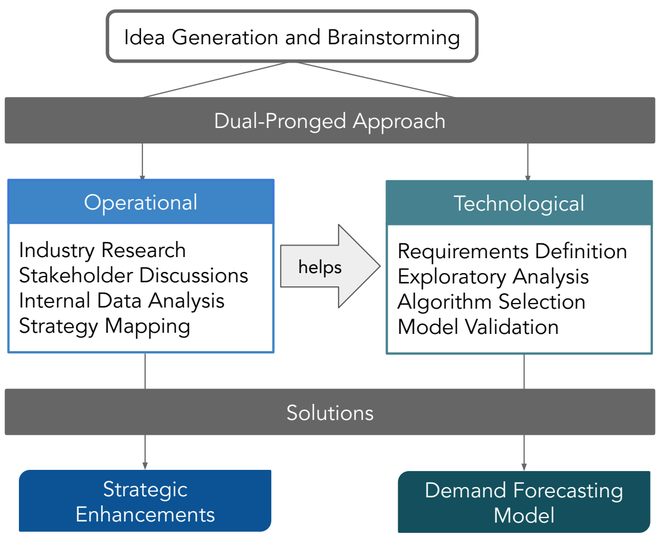
- Boost Shopee's operational effectiveness and cut costs by preventing aging stocks to enhance its competitive edge and strengthen its leading position in the industry

(1) Propose key **strategic enhancements** to boost operational effectiveness in the future to prevent aging stocks in warehouses

(2) Construct a **demand forecasting model** to predict demand for various product categories in the future to aid logistical and fulfillment planning

APPROACH

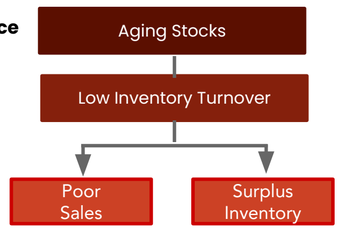
DUAL-PRONGED APPROACH



RESEARCH & DATA FINDINGS

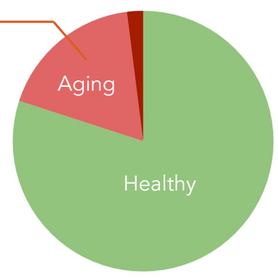
INDUSTRY RESEARCH

- Aim to **gain domain knowledge to understand the e-commerce industry's problem of aging stocks**
- Aging stocks widely accepted to be caused by low inventory turnover
- Poor sales commonly caused by lack of trust in sellers, ineffective pricing, unsatisfactory customer experience and excessive competition between sellers
- Surplus inventory commonly caused by simplistic inventory stocking methods, lack of demand forecasting capabilities and aiming for high service levels

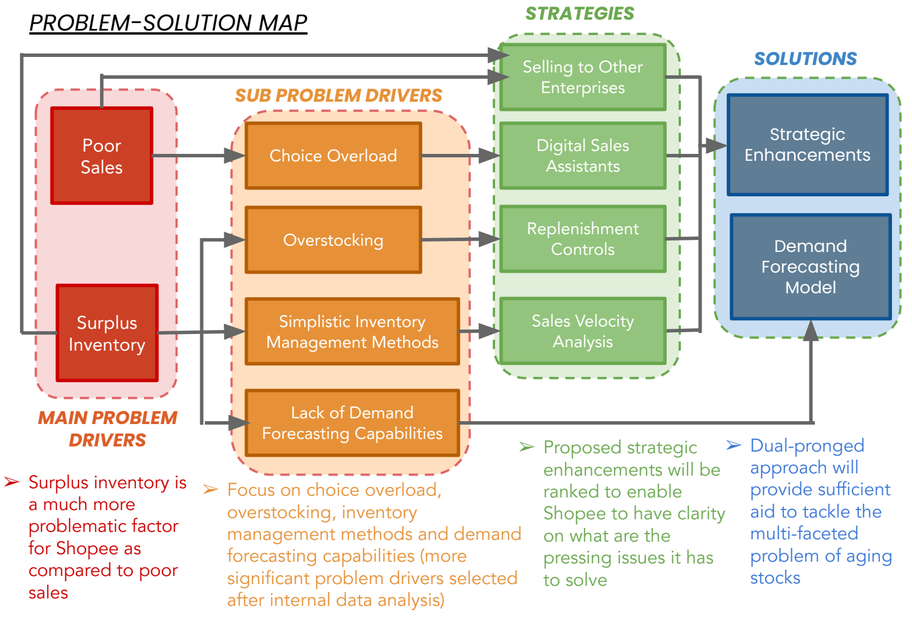


INTERNAL DATA ANALYSIS

- Aim to **gain specific knowledge about Shopee's situation**
- **~20% of Shopee's stocks are aging**
- Ineffective pricing and lack of trust in sellers do not seem to be problem drivers that Shopee faces based on trends and analysis
- Competition between sellers is inevitable and drives efficiency by boosting consumer welfare while impact of customer experience is difficult to quantify
- Choice overload - a potential problem driver given Shopee's extensive range of items and sellers that shoppers can choose from
- Key focus areas include **choice overload, overstocking, simplistic inventory management methods and lack of demand forecasting capabilities**



PROBLEM-SOLUTION MAP



➢ Surplus inventory is a much more problematic factor for Shopee as compared to poor sales

➢ Focus on choice overload, overstocking, inventory management methods and demand forecasting capabilities (more significant problem drivers selected after internal data analysis)

➢ Proposed strategic enhancements will be ranked to enable Shopee to have clarity on what are the pressing issues it has to solve

➢ Dual-pronged approach will provide sufficient aid to tackle the multi-faceted problem of aging stocks

STRATEGIC ENHANCEMENTS

Incorporating Sales Velocity Analysis

Ranked #1 in proposed strategies

$$Sales\ Velocity = \frac{Total\ Number\ of\ Website\ Visitors \times Average\ Order\ Value \times Conversion\ Rate}{Length\ of\ Chosen\ Timeframe}$$

Problem: **Shopee's reactionary approach to managing slow-moving stocks by using age of inventory as its primary indicator** - only begins nominating stocks for promotional campaigns when stocks approach 60 days in storage.

Recommendation: **Use sales velocity as it serves as a more dynamic metric to proactively manage slow-moving stocks**.

Benefits: ✓ Minimize inventory holding costs ✓ Prevent unnecessary discounting of fast-moving aging stocks ✓ Helps evaluate sales strategies effectively ✓ Cost-efficient marketing tool for mid-tail, lower-tail items on platform ✓ Mitigate choice overload

Limitations: ❌ Cumbersome to compute for large datasets ❌ More costly than using age of inventory metric

Implementing Replenishment Controls

Ranked #2 in proposed strategies

Problem: **Shopee's sellers given full autonomy to make replenishment decisions** - able to send over as many stocks as they wish to Shopee's warehouses.

Recommendation: **Implement replenishment controls that will regulate the quantity that sellers' can send over**.

Benefits: ✓ Mitigate the problem of overstocking ✓ Protect sellers from excess unsold stocks that eventually become obsolete ✓ Minimize inventory holding costs ✓ Reduces burden of managing aging inventory by reducing occurrence of aging stocks

Limitations: ❌ Restricts sellers' decisions which may cause friction ❌ Increases risk of losing sellers to other platforms that give them greater autonomy ❌ Reduces safety stocks - may result in loss of sales

Introducing Digital Sales Assistants

Ranked #3 in proposed strategies

Problem: **Lack of effective support for shoppers to find the items that they are looking for in the vast range of available options** - can been overwhelming for many who tend to leave without making a purchase due to decision fatigue and choice deferral.

Recommendation: **Introduce intelligent, dialogue-based guides that will direct consumers to the items they are looking for**.

Benefits: ✓ Mitigate the problem of choice overload ✓ Enhance personalization and accuracy in shopping experience ✓ Increase consumers' decision-making confidence and satisfaction

Limitations: ❌ Possible cases where bot cannot resolve a query ❌ Cumbersome and costly to ensure accuracy across entire range of audience

Initiating Sales to Other Enterprises

Ranked #4 in proposed strategies

Problem: **Sellers are only able to reach out to individual consumers who may wish to buy their items** - serves solely as C2C and B2C.

Recommendation: **Initiate selling to other businesses/enterprises (e.g. suppliers, third parties) to boost sales of slow-moving stocks**

Benefits: ✓ Boost sales by introducing a new sales channel ✓ Provide assistance to struggling sellers ✓ Increase revenues for sellers through improved sales ✓ Minimize inventory holding costs

Limitations: ❌ High costs in launching new sales channel and dedicated sales desk for slow-moving stocks ❌ Stiff competition from other niche competitors in the B2B, wholesaler segment

DEMAND FORECASTING MODELS

DEFINE-MEASURE-ANALYZE-IMPROVE-CONTROL (DMAIC)

- DMAIC Cycle inspired the unique approach that was adopted for the predictive modelling process shown below
- Such an approach allows for complex processes to be improved systematically through structured change management

PREDICTIVE MODELLING PROCESS

Requirements Definition [DEFINE]	- Problem definition, scope definition - Discussions with industry stakeholders and professors - Online, credible industry research - Consolidating useful information for future reference
Current State Analysis [MEASURE]	- Collecting different types of datasets from Shopee - Utilizing R and Python to analyze datasets - Visualizing data to summarize key characteristics - Most analysis done in Operational solution will be used
Comparison of Design Alternatives [ANALYZE]	- Understanding all possible methods that can be used - Comparing the methods to gauge feasibility and effectiveness - Selecting most suitable method(s) for Shopee
Model Development [IMPROVE]	- Formulating conceptual model / system design - Selecting best-performing models and then integrating to form effective final models for each subcategory - Writing, debugging, verifying and validating code
Stocks Demand Prediction [CONTROL]	- Studying the MAE performance across different subcategories and overall problem resolution - Consolidating results for further enhancement - Providing actionable insights and recommendations

REQUIREMENTS DEFINITION

Regenerative Design
Allows the demand forecasting model to be used in the foreseeable future

Clear Box Model
Understanding of internal prediction logic of the developed model

Accurate and Effective
Considers trends, seasonality and special events while remaining largely accurate

CURRENT STATE ANALYSIS

- Shopee currently studies sales performance and is heavily dependent on historical transaction volumes which are both lagging indicators and do not sufficiently reflect magnitude of uncertainties in future demand
- Larger mismatch between expected demand actual demand results in greater surplus inventory

DESIGN ALTERNATIVES

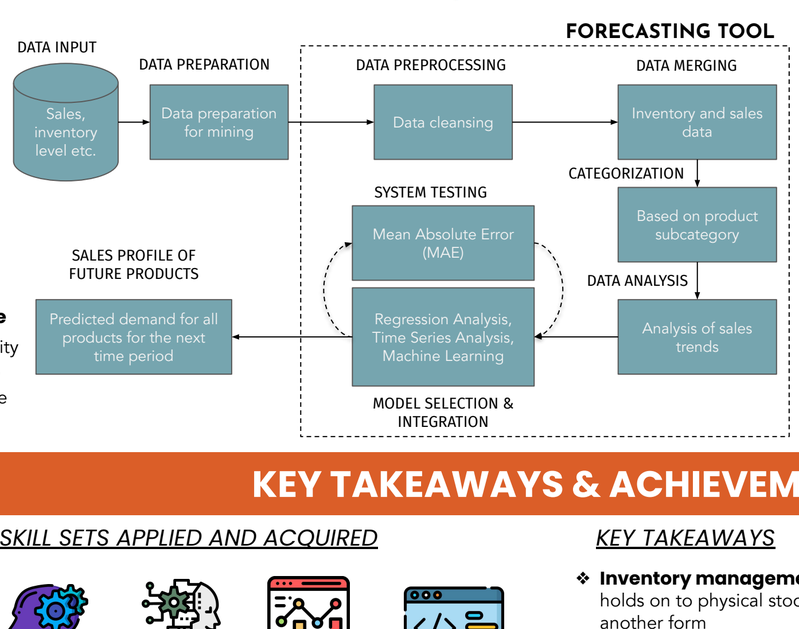
- **8 methods** identified across linear regression (Ridge Regression), time series analysis (Simple Exponential Smoothing, Holt's Exponential Smoothing, Autoregressive Integrated Moving Average) and machine learning (k-Nearest Neighbours, Neural Network, Random Forest, Stochastic Gradient Descent)
- These models were less robust on their own than when the best-performing ones for each subcategory were combined to form an integrated model.

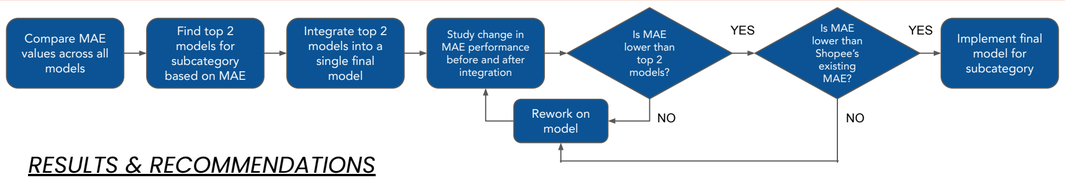
MODEL DEVELOPMENT

- Each model was **built incrementally and iteratively** to continuously enhance performance
- Only subcategories that were suitable for model development were selected (34 out of 130 subcategories qualified)
- Consolidated dataset was split into training and testing sets in a 80:20 ratio
- **Mean Absolute Error (MAE)** selected as key performance indicator of models
- Ultimate focus on building integrated models for each subcategory based on Top 2 performing models (i.e. two models with the minimum MAEs) as they are more robust

$$\text{MAE} = \frac{\sum_{i=1}^{n} |y_i - x_i|}{n}$$

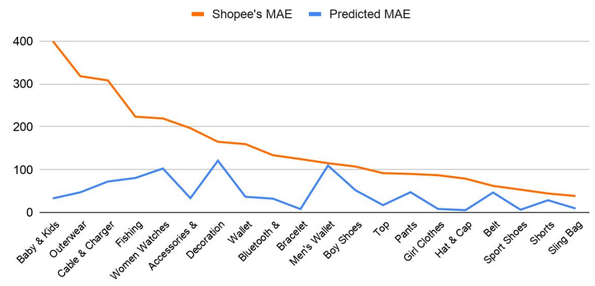
MAE = mean absolute error
y_i = prediction
x_i = true value
n = total number of data points

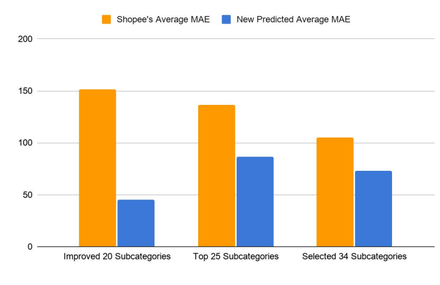




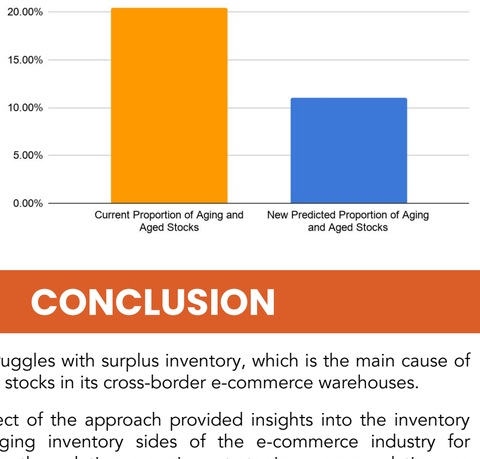
RESULTS & RECOMMENDATIONS

- The unique integrated forecasting models created had lower, better MAEs for 20 out of 25 of the top subcategories that were contributing the most to Shopee's aging stocks problem compared to Shopee's original MAEs
- **On average, MAEs were reduced by 70.1% across the 20 improved subcategories, 36.7% across the 25 categories and 30.4% across the 34 selected subcategories**





- The 20 subcategories whose MAEs were reduced by the integrated model approach contribute to over 65.9% (two-thirds approximately) of the total quantity of aging and aged stocks in Shopee's warehouse
- By focusing on just these 20 subcategories, Shopee can target two-thirds of the problem at hand effectively since MAEs were reduced by 70.1% across these subcategories specifically
- **Overall, Shopee can almost halve the quantity of slow-moving aging and aged stocks in its warehouse from 20.44% to 11.00% by using the integrated model approach on these 20 subcategories**
- Hence, it is strongly recommended for them to target these 20 subcategories first before the other 110 subcategories



FUTURE DIRECTION

STRATEGIC ENHANCEMENTS

- Internal evaluation and prioritization of recommendations
- Further quantitative analysis of strategies (e.g. cost-benefit analysis)
- Look at real data that has not been desensitized or altered

DEMAND FORECASTING TOOL

- Factor in more variables in addition to historical sales data (e.g. day in week, time, campaign dates)
- Utilize real, high-volume data that has not been desensitized or altered
- Utilize a larger range of data that spans across several years

Internal Planning | **Quantitative Evaluation** | **More Variables** | **Real Data** (100% AUTHENTIC)

KEY TAKEAWAYS & ACHIEVEMENTS

SKILL SETS APPLIED AND ACQUIRED

Systems Thinking | **Machine Learning** | **Statistical Learning** | **Programming & Development**

ACHIEVEMENTS

★ Multi-faceted operational enhancements catered to Shopee's needs

★ Various sets of demand forecasting models to aid logistical and fulfillment planning in different scenarios, for various product types

★ Both strategic recommendations and developed software will form the bedrock of Shopee's future plans for inventory management

★ Implementation to take place where and when applicable

KEY TAKEAWAYS

❖ **Inventory management** is a crucial aspect of any business that holds on to physical stocks as it is equivalent to managing money in another form

❖ **Systematic application of industrial engineering concepts** can be immensely effective in solving real-world problems through enabling operational optimization and aiding technological advancements

❖ **Project management and stakeholder management** are imperative for timely, effective implementation and execution of plans while satisfying the needs of relevant stakeholders

Inventory Management | **Industrial Engineering Application** | **Project Management** | **Stakeholder Management**

CONCLUSION

Currently, Shopee struggles with surplus inventory, which is the main cause of the problem of aging stocks in its cross-border e-commerce warehouses.

The operational aspect of the approach provided insights into the inventory management and aging inventory sides of the e-commerce industry for Shopee. It assisted in the solution mapping, strategic recommendations as well as the technological aspect later on to develop a robust forecasting tool that will greatly benefit Shopee.

As aging inventory for Shopee is largely caused by surplus inventory, both the operational and technological solutions are geared heavily towards mitigating surplus inventory.

The models generate realistic and reasonable forecast with significantly reduced error. Different models have been identified to aid Shopee with predictions for different product types and scenarios.

Overall, introducing such operational enhancements and technological solutions can benefit Shopee, its sellers as well as its customers largely.