SMART STORE: EMPOWERING DEPARTMENTAL STORE OWNERS THROUGH AI-DRIVEN RETAIL MANAGEMENT

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Abstract

The contemporary retail landscape demands efficient inventory management and strategic sales promotion to stay competitive. This abstract focuses on the integration of machine learning techniques to enhance product quality, optimize inventory management, and boost sales for departmental stores. The challenge lies in leveraging market segmentation analysis to tailor inventory strategies and promotional efforts effectively. By harnessing predictive analytics, and quality enhancement algorithms, this approach aims to improve inventory turnover rates, reduce wastage, and enhance customer satisfaction. The proposed solution not only addresses operational efficiency but also contributes to revenue growth and market positioning within the retail sector.

1.0 Problem Statement

The problem statement revolves around optimizing inventory management and promoting sales by leveraging machine learning to enhance product quality for departmental stores. Based on market segmentation analysis, the challenge is to enhance inventory management efficiency and boost sales for departmental stores.

2.0 Market/Customer/Business need Assessment

The "Smart Store" project addresses the pressing needs of both the retail market and its customers by leveraging advanced technology and data-driven strategies. Let's delve deeper into each aspect of the Market/Customer/Business Need Assessment:

2.1 Market:

There is a growing demand within the retail industry for efficient management solutions. This demand stems from the increasing complexity of modern retail operations, including inventory management, sales optimization, and customer engagement. Traditional methods often fall short in meeting these challenges, leading businesses to seek innovative technologies like AI and machine learning.

2.2 Customer Need:

- Simplified Inventory Tracking: Many store owners struggle with manual inventory tracking systems that are prone to errors and inefficiencies. Smart Store offers a digital platform that automates inventory management, providing real-time insights into stock levels and replenishment needs.

- Boosted Sales: Through predictive analytics, Smart Store strategically promotes products to customers through discounts or special offers. This approach not only minimizes waste but also drives sales by offering attractive deals on products that might otherwise go unsold.

- Quality Assurance: For consumers, quality is paramount. Smart Store ensures quality assurance by recommending products from suppliers, fostering a sense of trust and reliability in the store's offerings.

2.3 Business Need:

- Revenue Growth: By optimizing inventory turnover and promoting sales . Smart Store contributes directly to revenue growth.

- Cost Reduction: Efficient inventory management leads to reduced wastage and lower operational costs associated with overstocking or understocking. Smart Store also minimizes manual labor in inventory tracking and sales promotion, further reducing costs.

- Improved Customer Satisfaction: Ultimately, Smart Store's focus on data-driven decision-making, quality products, and personalized promotions enhances overall customer satisfaction. Satisfied customers are more likely to return, leading to increased loyalty and positive word-of-mouth referrals.

2.3 Target Specifications and Characterization

2.3.1 Customers:

- Departmental Store Owners: These are the primary users of the Smart Store app. They include owners or managers of grocery stores, supermarkets, and other retail outlets. Their main goal is to streamline operations, increase sales and enhance customer satisfaction.

2.3.2 Characteristics:

- User friendly Interface:Departmental store owners are expected to be comfortable with using technology. They should be able to navigate the app's interfaces, upload product information, monitor sales analytics, and respond to customer inquiries efficiently.

- Value Convenience: Convenience is a key factor driving adoption. Store owners appreciate the convenience of automated inventory management, predictive analytics.

- Seek Cost-Effective Solutions: Store owners are cost-conscious. They seek solutions that offer tangible benefits such as increased sales, and improved profitability. Smart Store's value proposition lies in its ability to deliver these benefits through data-driven insights and streamlined processes.

3.0 External Search

- Retail industry reports on inventory management and sales optimization.
- AI and ML applications in retail.
  https://www.techtarget.com/searchenterpriseai/feature/10-common-uses-for-machine-learning-applications-in-business
  https://www.datasciencecentral.com/common-applications-of-machine-learning-for-small-scale/

- Agriculture technology trends.
  https://www.ruralmutual.com/resource/farm-technology/3-emerging-trends-inagriculture-technology/

4.0 Benchmarking Alternate Products

- Compare with existing inventory management software.
  https://www.sortly.com/solutions/inventory-management-software/
  https://www.zoho.com/in/inventory/?network=g&device=c&keyword=inventory%20management%20software&campaignid=15061881800&creative=585829472520&matchtype=e&adposition=&placement=&adgroup=134162755852&targetid=kwd34829222&gad_source=1&gclid=CjwKCAjwzN-vBhAkEiwAYiO7oAUcFFbqn07i4ggjaEWWVfX-zhLbRFcuJvF2q-SLwuLNhoL3VdORhoCbMsQAvD_BwE
- Analyze competitor solutions in retail AI and farmer-to-store platforms.
  https://startups.epam.com/blog/artificial-intelligence-in-retail
  https://www.weforum.org/agenda/2023/01/here-s-how-artificial-intelligence-benefitretail-sector-davos2023/

5.0 Applicable Patents

- Patent 1: Purchase Intent Determination And Real Time In-store Shopper Assistance
  A method and a purchase intent determination and assistance management system (PIDAMS) for determining purchase intent of an anonymous shopper and providing assistance in a retail store are provided. The PIDAMS determines the purchase intent of the anonymous shopper by iteratively ranking the anonymous shopper based on section attributes, transmits alert notifications, renders information on target items and offers on the target items to a store assistant who accepted an alert notification to provide assistance to the anonymous shopper, and receives and stores feedback on a communication between the anonymous shopper and the store assistant for iteratively ranking the anonymous shopper in conjunction with conversion data extracted from the feedback.

6.0 Applicable Regulations

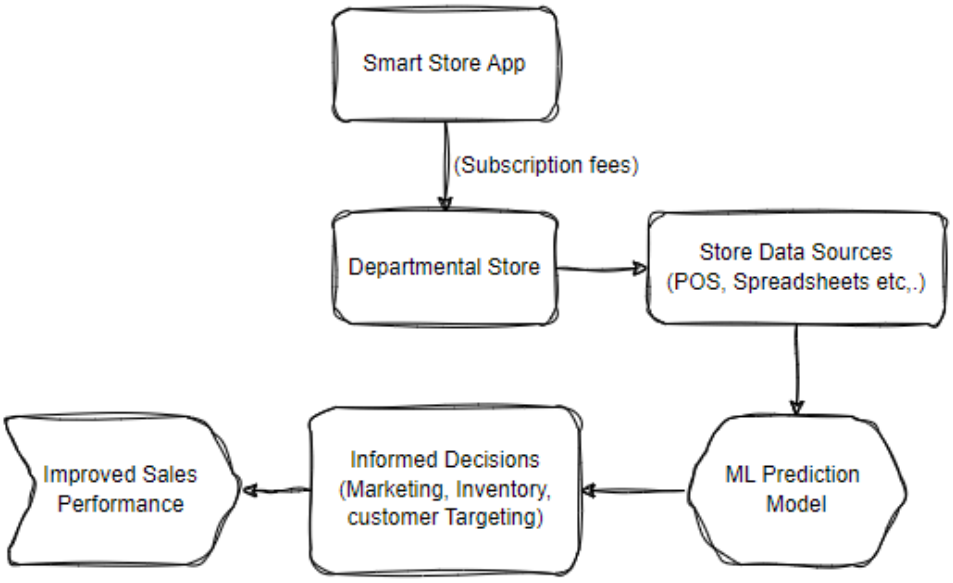
- Data collection and Privacy of Regulations of Customers.
- Government norms for Small Businesses and Street Vendors
- Rules against False Marketing
- Employment Schemes and laws created by government

7.0 Applicable Constraints

- Data Collection from shopkeepers and vendors
- Continuous data collection and maintenance
- Lack of technical knowledge for the store owners, customers .
- Taking care of rarely bought products
- Convincing the shopkeepers to implement the system in their shops.
- To address budget constraints, Smart Store may consider prioritizing essential features and functionalities, outsourcing certain development tasks to cost-effective providers or freelancers, leveraging open-source software components, and negotiating favorable terms with technology vendors and service providers. It may face limitations in terms of expertise, particularly in areas such as AI and machine learning development, database management, cybersecurity, and user experience design. This could impact the speed and quality of software development and deployment.

8.0 Product Prototype with Schematic Diagram

- The idea emerged from market research highlighting inefficiencies in traditional retail practices and the potential of ML and digital platforms to transform the sector.
- Understanding the problems faced by the departmental stores.



9.0 Concept Development

Features for Departmental Stores:

- Inventory management, sales tracking, and promotions.
- Affordable subscription plans for small stores.
- Improved efficiency and competitiveness.

Customer Experience:

- Seamless purchasing, promotions, and rewards.
- Focus on customer satisfaction and retention.

10.0 Product Details

- **Sales Tracking:**
  The platform (Smart Store) tracks data for products listed by suppliers. This includes information such as product ID, quantity sold, sales price, and transaction details.
  Data sources for sales tracking include the platform's database, transaction logs, and sales reports generated by the platform's analytics tools.

- **Revenue Calculation:**
  Based on the sales data tracked, the platform calculated the total revenue generated from the sales of each supplier's products over a specific period (e.g., monthly, quarterly).
  Revenue Calculation includes multiplying the quantity sold by the sales price for each product, summing up the total sales revenue for each supplier.

Data Sources:

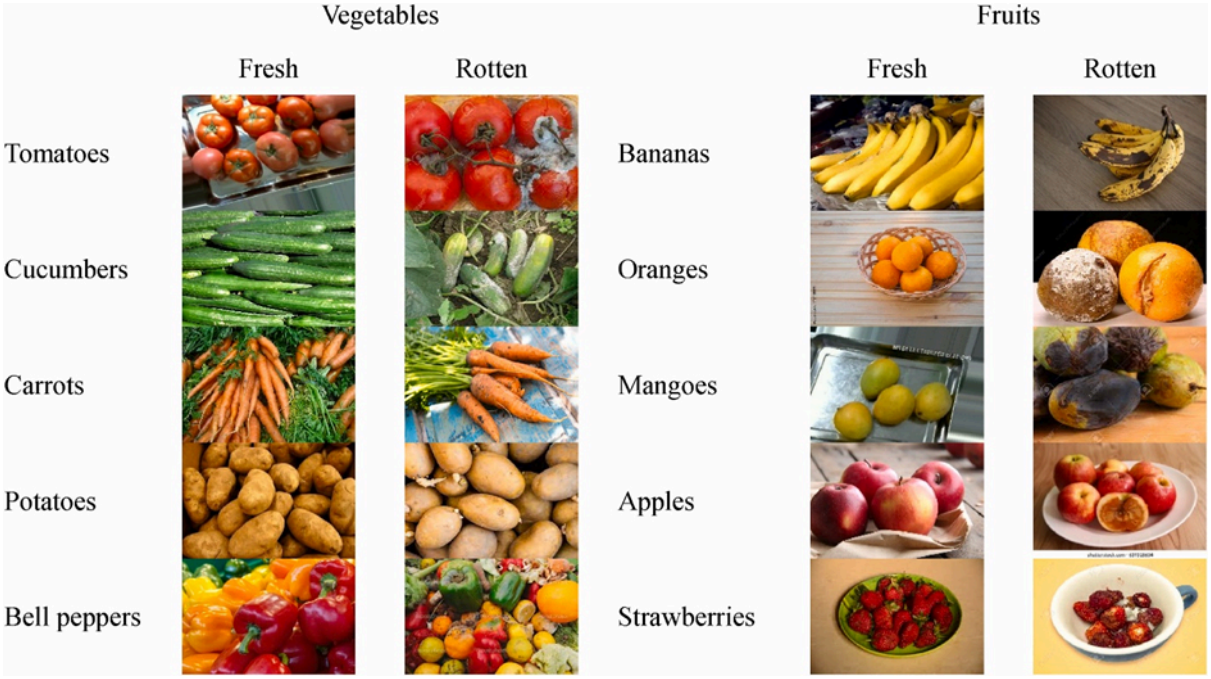
- **Platform Database:** Contain all sales data, supplier information.
- **Transaction Logs:** Record every transaction processed through the platform, including product sales and payment information.
- **Sales Reports:** Generated by the platform's analytics tools to provide insights into sales performance, revenue generated .

11.0 Prototype Development

For this we came up with an ML model that can predict if the produce are fresh or rotten, Rather than building and training the model from scratch we utilize the method called transfer learning so that existing pre-trained models can be trained on the custom datasets to better fit even with a smaller training data size, in this case we use a pre-trained model called resnet50, which is a 50 layer CNN model best suited for our needs,

The Dataset:

This dataset includes images of the five most popular vegetables (tomatoes, cucumbers, carrots, potatoes, and bell peppers) and five fruits (bananas, oranges, mangoes, apples, and strawberries), where each vegetable and fruit is divided into two categories: fresh and rotten, with a total of 20 categories. The dataset contains 12,000 images, approximately 600 images per category (Fruits (5997 images for 10 classes), Vegetables (6003 images for 10 classes)). The dataset gathered from different online sources such as Google Images, Bing Images, Kaggle, Fruit360, which provided samples of the pure-fresh category and a single item with a white background, respectively.

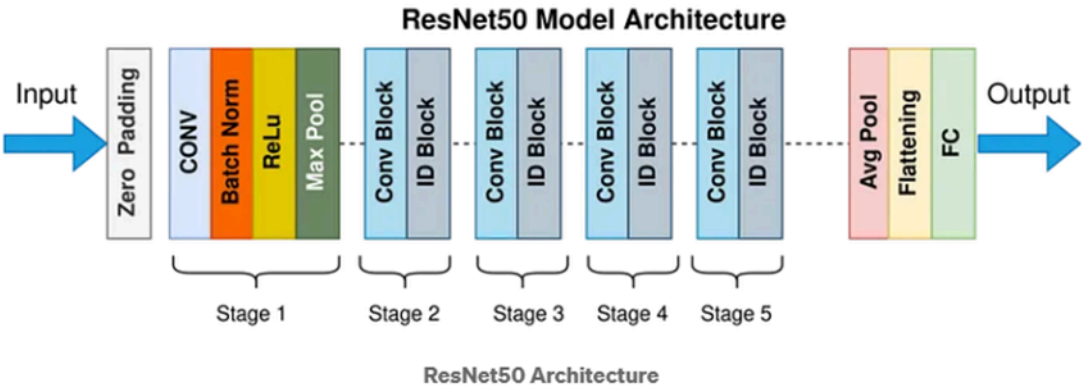


Preparing the Dataset:

The pre-trained model's input criteria cannot be met by the photos in the dataset due to their variable sizes, which were sourced from various internet sources. Consequently, in order to meet the pre-trained model's input size criteria, the sizes of the dataset's images of fruits and vegetables must be reconstructed before being fed into the model to extract deep features.

About the model:

The CNN architecture known as ResNet-50 is a member of the ResNet (Residual Networks) family, a group of models created to tackle the difficulties involved with deep neural network training. ResNet-50, a deep learning model developed by researchers at Microsoft Research Asia, is well-known for its effectiveness in picture categorization tasks. ResNet architectures are available in multiple depths, including ResNet-18, ResNet-32, and so on. ResNet-50 is a mid-sized version of the architecture.



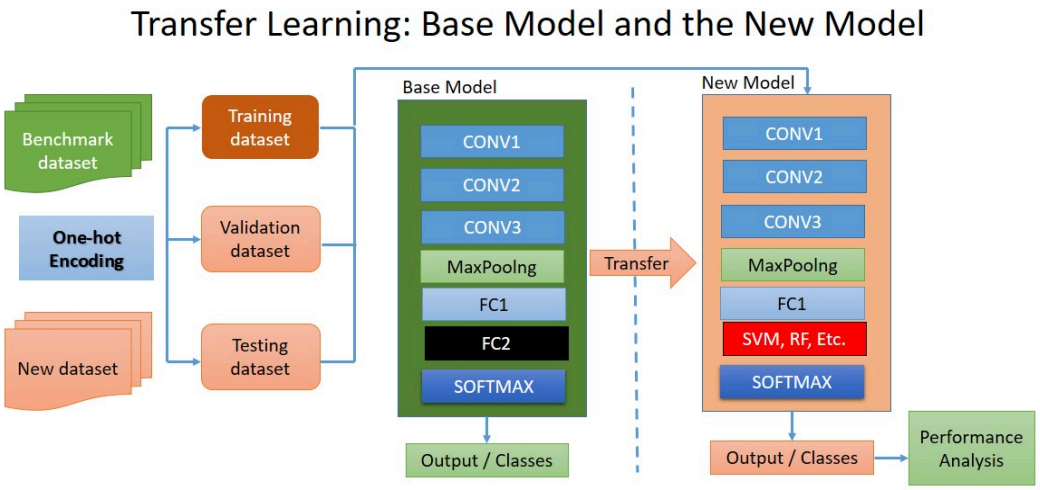
ResNet50 Architecture

The model takes in the rgb values of the images in a n-dimensional array also known as a tensor, and gives out a array of values between 0 and 1 specifying the class the result belongs to

Transfer learning:

Transfer learning allows us to use the knowledge and learned representations of a pre-trained model, which has already been trained on a large quantity of data, usually from a related task, instead of building a CNN from scratch for our daily computer vision tasks.

Thus, what is the process of transfer learning? After feature extraction from pre-trained models, fine tweaking according to requirements is carried out, and finally the final layers are trained.

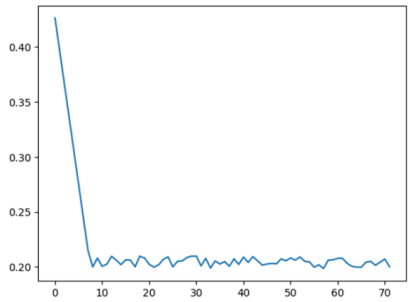


Model performance:

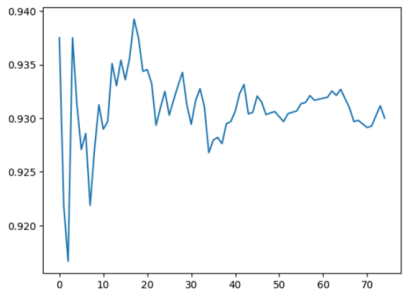
Our model works well since ResNet50 is a per-trained model, and we use our data to fit into its pre-existing weights and biases to create a faster, more accurate model.

In just 10 epochs, accuracy increases dramatically and loss is minimized.

```
Loss: 0.42105623761812844
Loss: 0.3507101824382941
Loss: 0.30655696882555883
Loss: 0.2716888934870561
Loss: 0.27039161971459785
Loss: 0.24090960549811521
Loss: 0.22150823950767518
Loss: 0.22637407542516788
Loss: 0.22243790106227002
 Loss: 0.19891267604505022
```



Accuracy: 93.4



12.0 Business Model

This model tackles the problem of optimizing inventory management and boosting sales for departmental stores using machine learning.

12.1. Departmental Stores:

- Reduce inventory holding costs through optimized ordering and minimized waste.
- Increase sales with accurate product availability and dynamic pricing strategies through some seasonal sales or discounts.
- Gain valuable data insights for better decision-making.

12.2. Revenue Model:

Subscription Fees: Structured as a flexible pricing model, offering tiered subscription plans based on the level of features and usage.

Revenue Sharing: Suppliers receive a predetermined share of revenue generated from their sales, fostering strong partnerships and mutual growth.

12.3. Revenue Streams:

- **SaaS (Software-as-a-Service) Model:** Departmental stores pay a subscription fee (monthly or annual) for access to the cloud-based platform with features like:
    - Machine learning-powered inventory optimization with alerts for expiring products and suggested ordering quantities.
    - Dynamic pricing recommendations based on real-time data like demand, competitor pricing, and historical sales.
    - Data visualization dashboards to track sales performance, and analyze trends.

12.4. Target Market:

- Departmental stores of all sizes (franchise or independent)

12.5. Cost Structure:

- Development and maintenance of the machine learning models and platform.
- Cloud infrastructure for data storage, processing, and platform access.
- Sales and marketing to acquire departmental store subscribers.

12.6. Key Resources:

- Expertise in machine learning for inventory forecasting, demand prediction, and potentially quality analysis.
- Secure cloud infrastructure for data management and platform scalability.
- User-friendly platform for departmental stores to interact with the system.

12.7. Key Activities:

- Continuously improve the machine learning models for accurate forecasting and recommendations.
- Partner with potential data providers (e.g., historical sales data, market trends).
- Onboard departmental stores and provide ongoing customer support and training.
- Market and promote the platform to acquire new departmental store subscribers.

12.8. Future Outlook:

- Investing in research and development to enhance platform features, scalability, and performance.
- Exploring new markets, strategic partnerships, and vertical integrations to broaden the customer base and revenue streams.

- Incorporating sustainable practices and ethical sourcing principles to align with evolving consumer preferences and industry standards.

13.0 Exploratory Data Analysis

13.1 Market segmentation

Smart stores in retail management refer to the integration of advanced technologies and data analytics to enhance the shopping experience, streamline operations, and drive business growth.

13.2 Data Collection

The dataset consists of order information from a retail store, including details such as Order ID, Customer Name, Category, Sub Category, City, Order Date, Region, Sales, Discount, Profit, and State.
This data covers the retail stores in the state of TamilNadu.

The following is the link for the dataset used:
https://www.kaggle.com/datasets/mohamedharris/supermart-grocery-sales-retail-analytics-dataset

	Order ID	Customer Name	Category	Sub Category	City	Order Date	Region	Sales	Discount	Profit	State
0	OD1	Harish	Oil & Masala	Masalas	Vellore	11-08-2017	North	1254	0.12	401.28	Tamil Nadu
1	OD2	Sudha	Beverages	Health Drinks	Krishnagiri	11-08-2017	South	749	0.18	149.80	Tamil Nadu
2	OD3	Hussain	Food Grains	Atta & Flour	Perambalur	06-12-2017	West	2360	0.21	165.20	Tamil Nadu

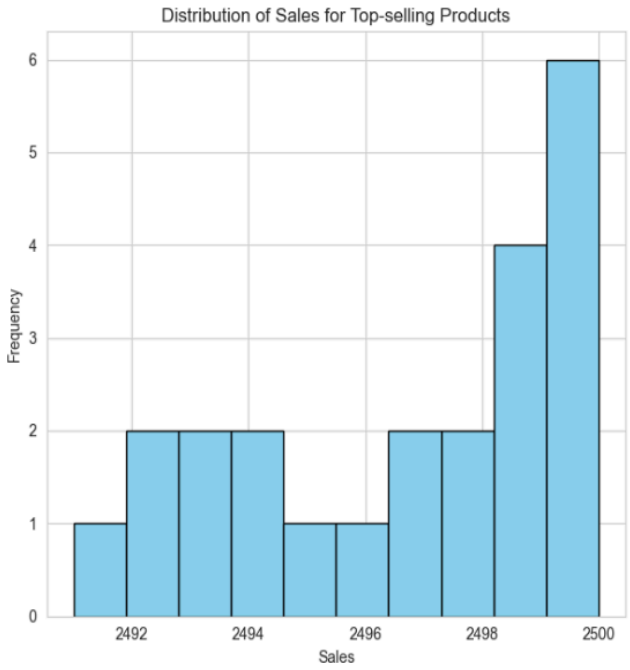
13.3 Data Pre-processing

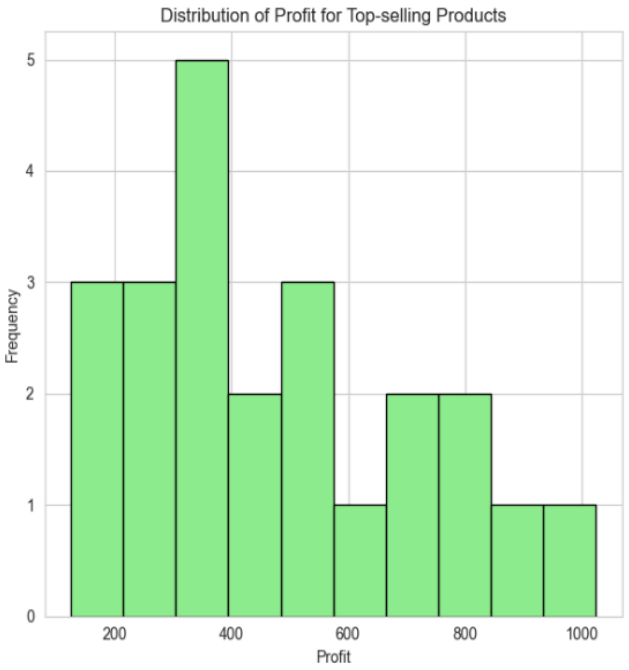
- Loading Data
- Exploratory Data Analysis
- Standardization of data
- Segmentation

Libraries Used : Numpy , Pandas , Seaborn , Matplotlib , Scikit-learn

13.4 Analysis

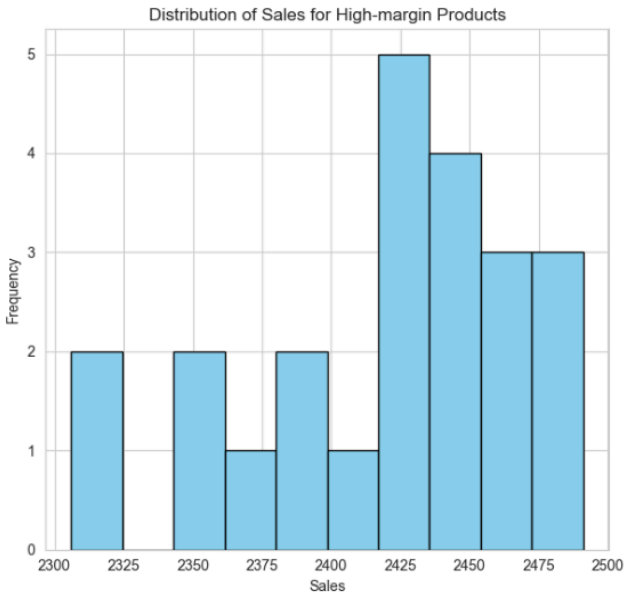
Top Selling Products

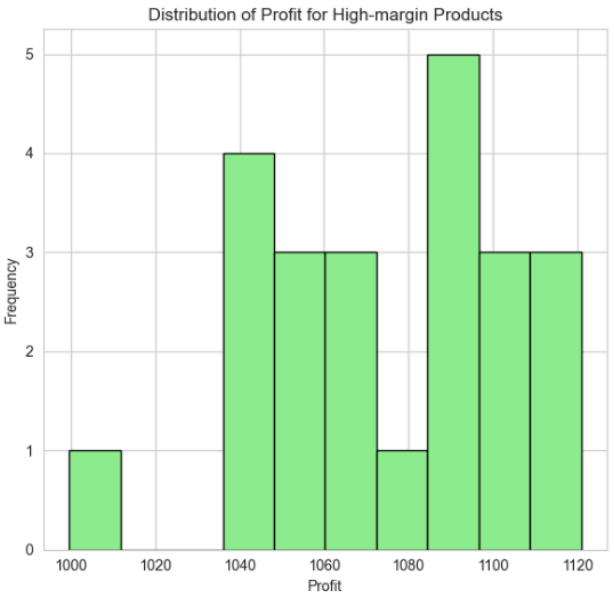




- This segmentation includes segmentation on top-selling products and high-margin products and can be seen which products are dominant.

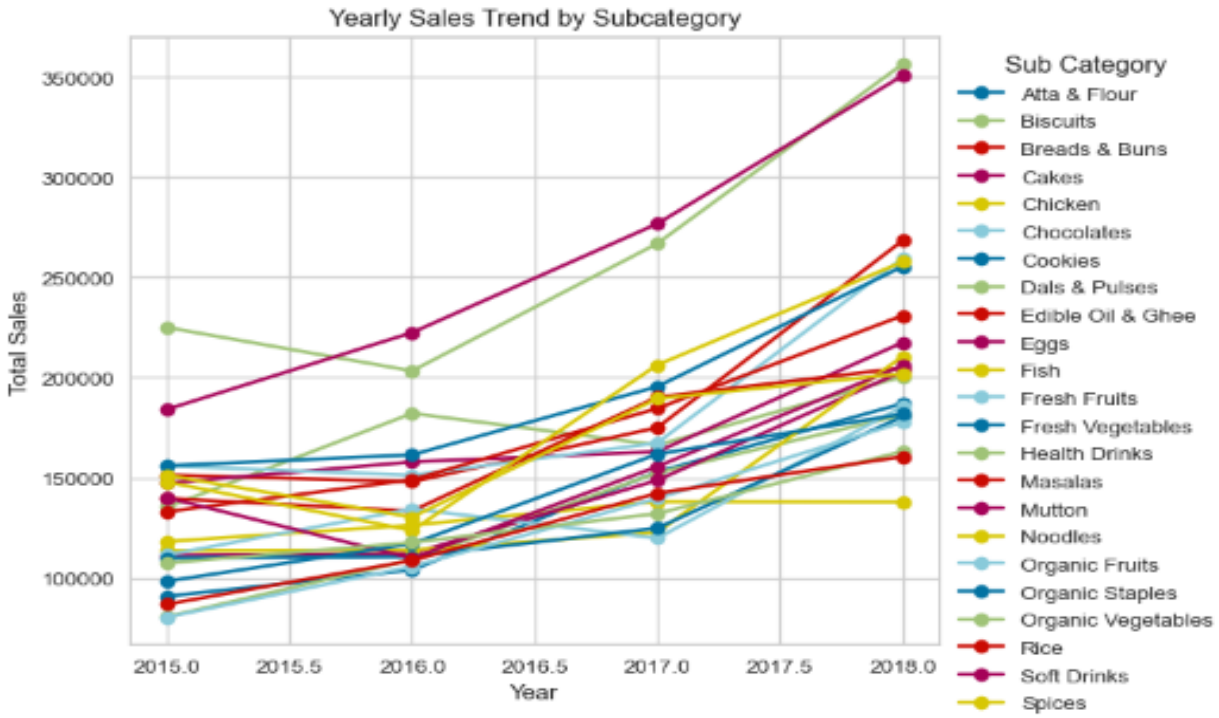
High-margin Products



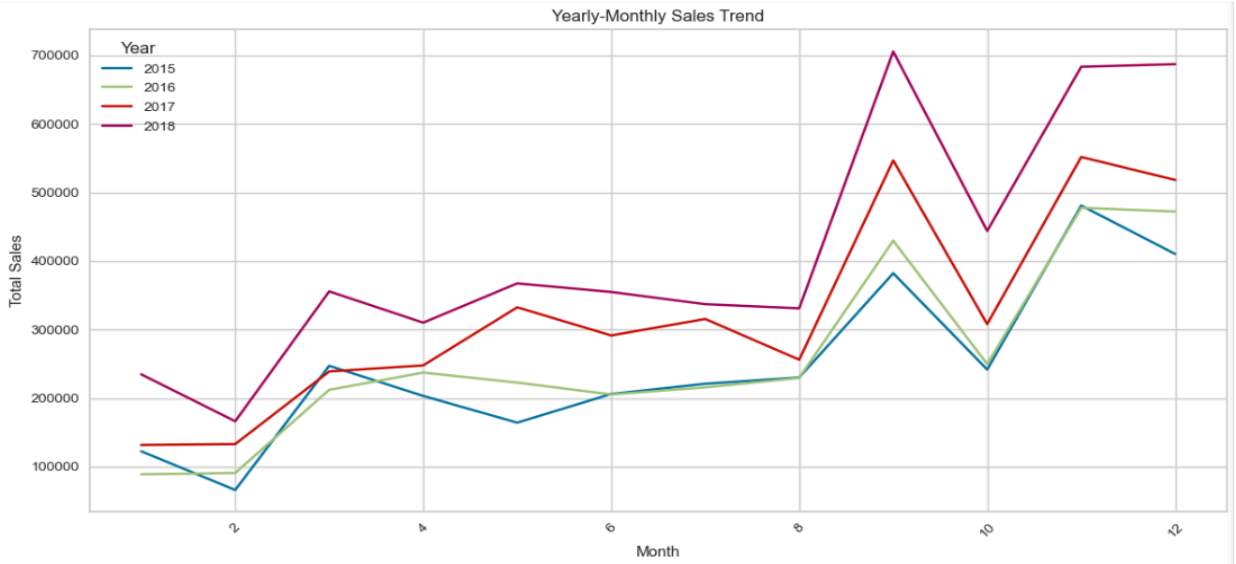


This segmentation includes segmentation on top-selling and high-margin products.

Trend Analysis



- Biscuits , Organic vegetables , Dal and Pulses the sales has increased in the year from 2015 to 2018
- Sales has always increasing but gradually decreasing in the month of december for all the years.

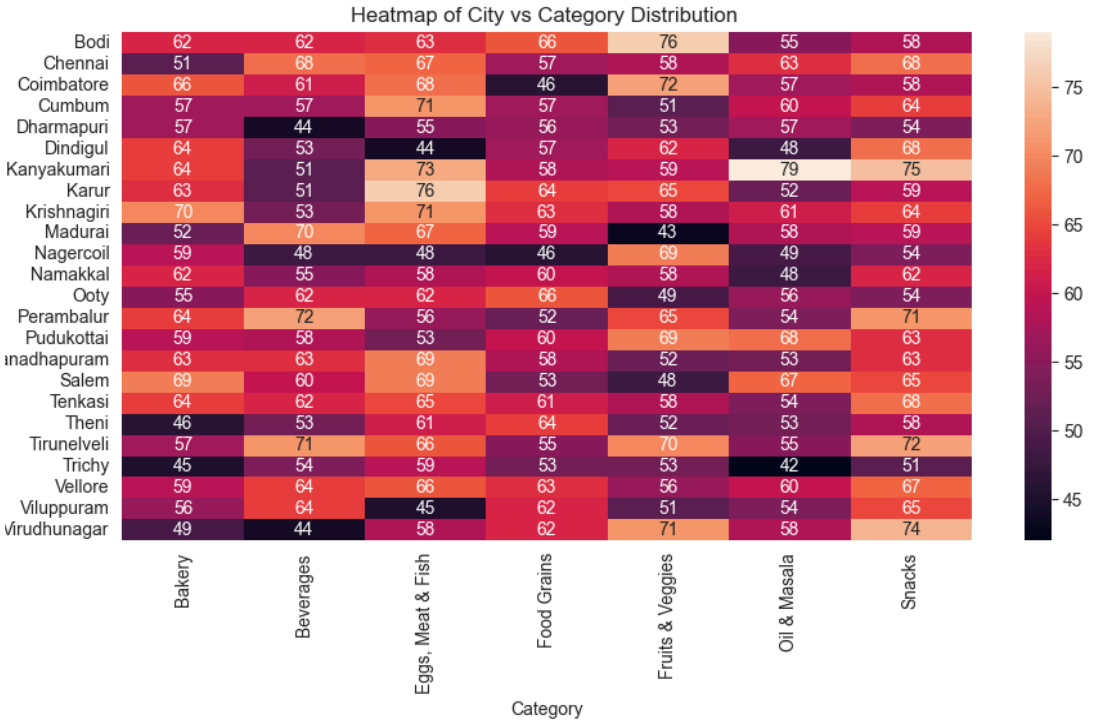


- Sales generally increase but decrease in December each year.
- Sales have shown consistent growth year over year.

- The total Sales for the year 2015 to 2018 in the March to August month is not increasing but remains constant because of summer , the consumption of food (groceries) is very low.

Geographic Analysis

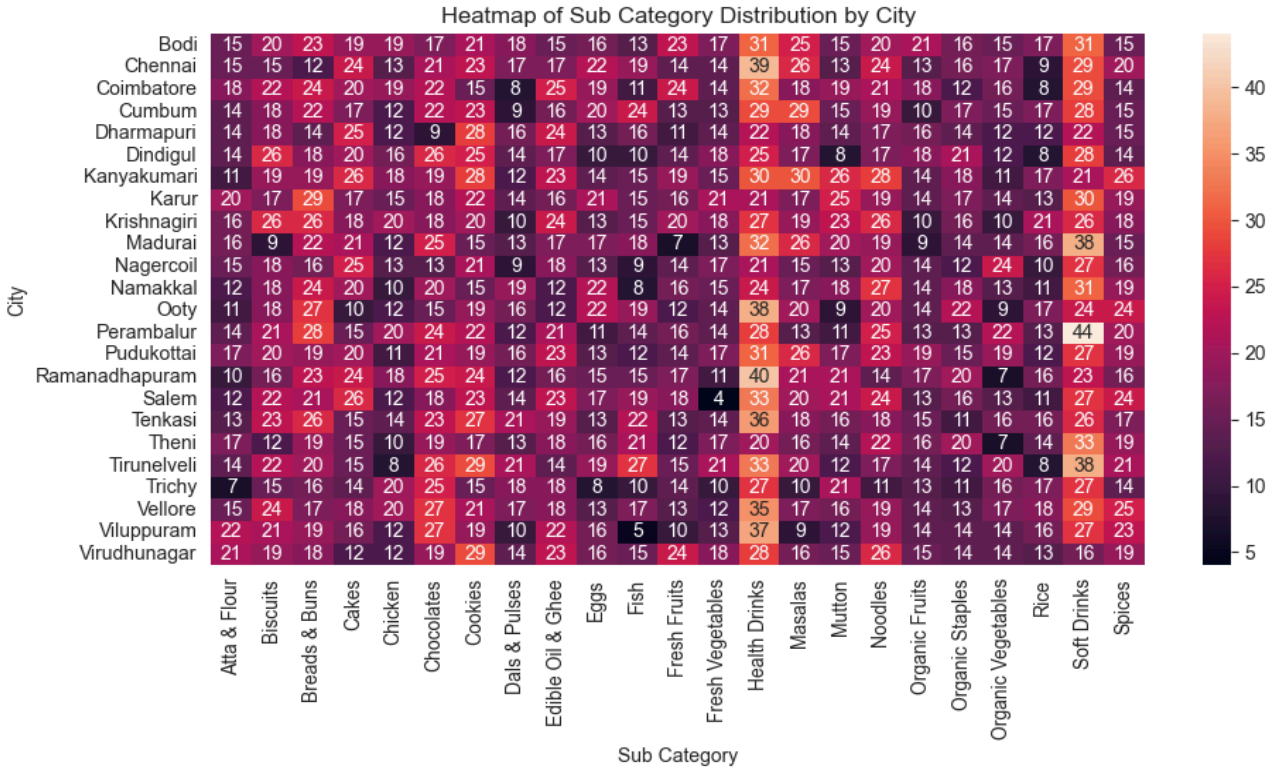
- The above graph shows the consumption of products(Category) by the cities.
- Darker squares indicate a high number of occurrences for that specific city-categories combination, while lighter squares represent fewer occurrences.



- By analyzing the color intensity patterns, you can identify potential relationships between city and category.

Sub-Category

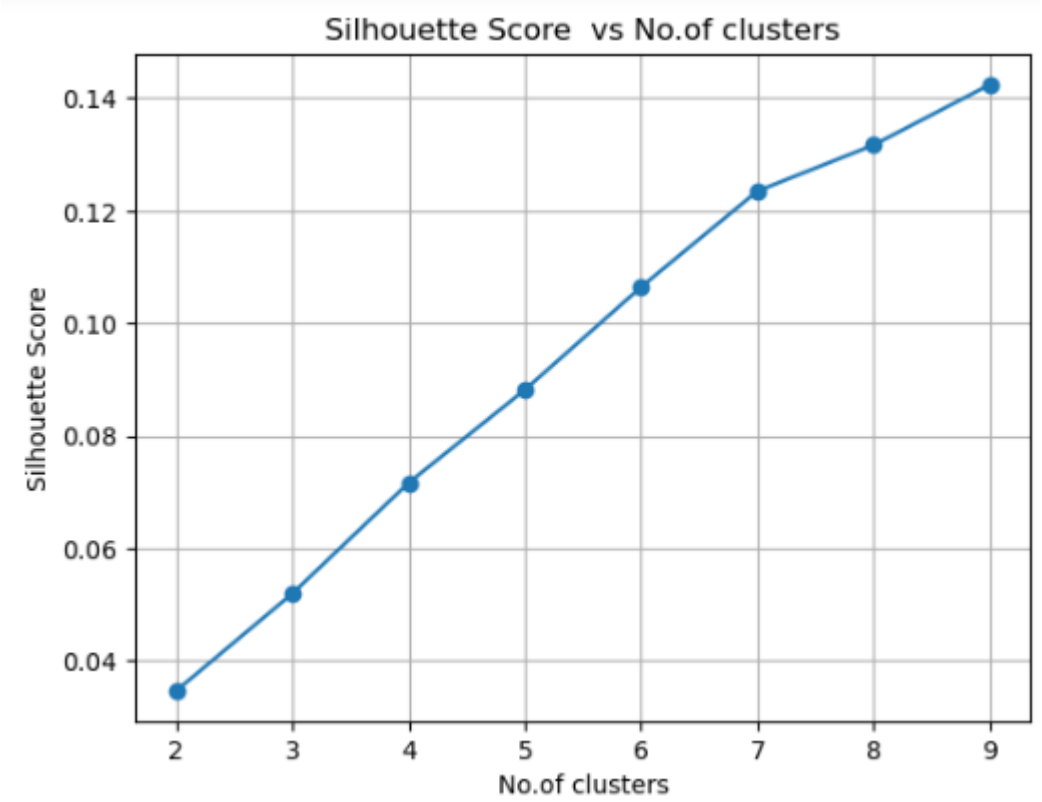
- The below graph shows the consumption of products(sub category) by the cities.
- Similar to the category heatmap, this visualization displays the co-occurrence of city and sub category.

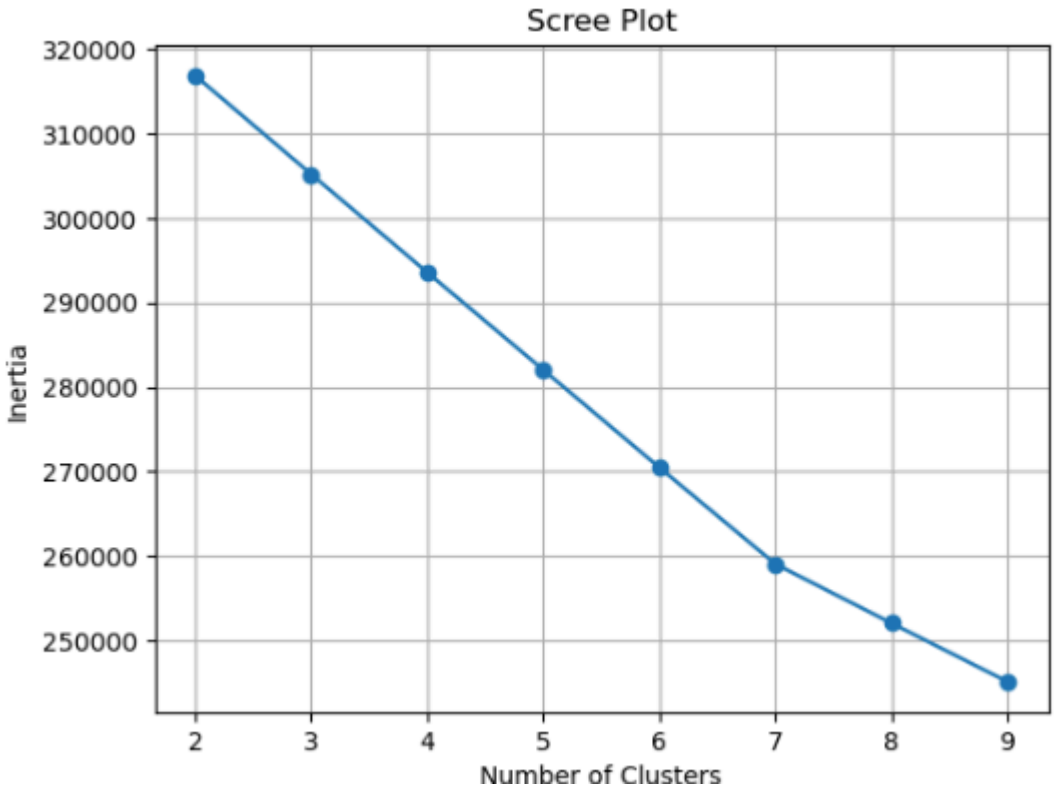


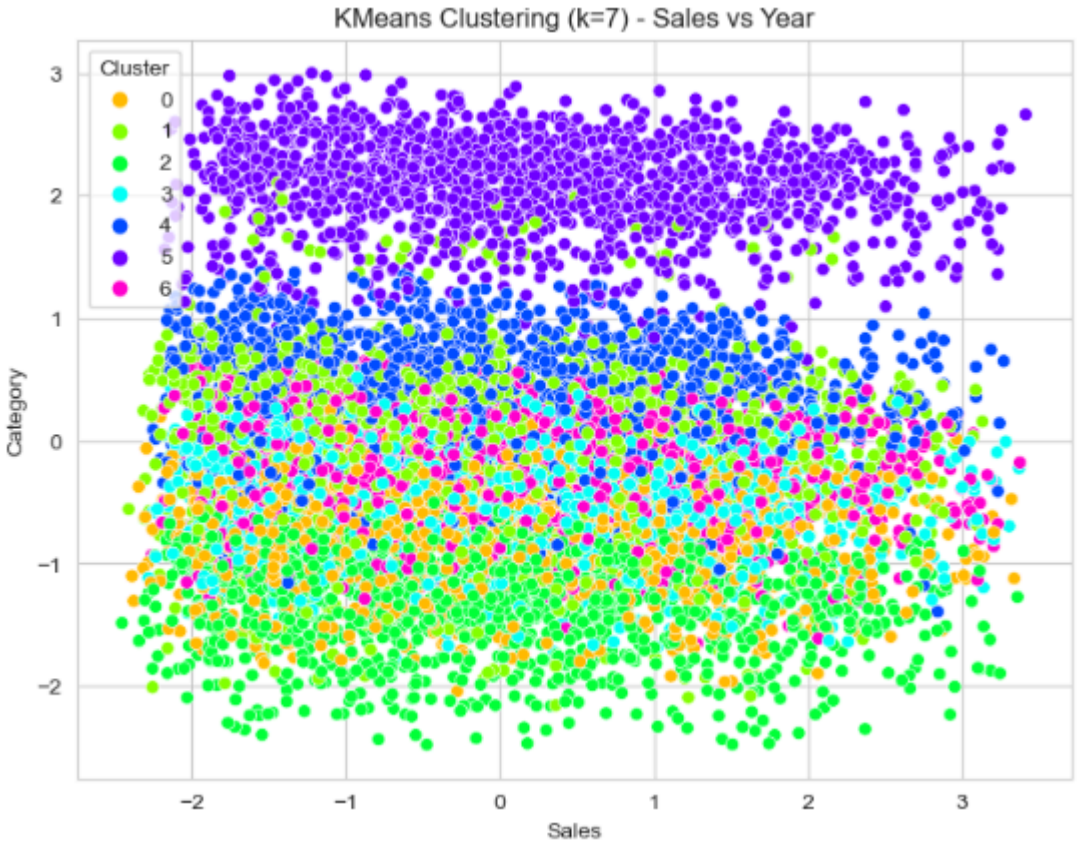
14.0 Principal Component Analysis (PCA)

- The graph shows the amount of variance captured (on the y-axis) depending on the number of components we include (the x-axis).
- A rule of thumb is to preserve around 80 % of the variance. So, in this instance, we decide to keep 6 components.

14.1 K Means Clustering







14.2 Insights from PCA:

Here's a breakdown of the insights with a simpler and more impactful structure:

Who are the top customers and what do they buy?

- Amrish is the store's biggest spender over the past four years.
- Snacks and Eggs, Meat & Fish are the most popular categories overall, with Health Drinks and Soft Drinks leading the sub-category pack.

Where are the most sales coming from?

- Kanyakumari and Tirunelveli districts have the highest order volume.
- West Tamil Nadu is the top-buying region, driving a significant portion of the store's sales.

What are the buying trends by region?

- Kanyakumari leans towards Oil & Masala and Snacks, while Tirunelveli prefers Beverages and Snacks. Trichy buys less Oil & Masala compared to other regions.

How are sales patterns changing?

- Chicken, Fish, Noodles, and Spices are seeing a rise in popularity across Tamil Nadu.
- Sales hold steady from March to August, likely due to lower summer food consumption.
- There's been a consistent increase in sales of Biscuits, Organic Vegetables, Dal, and Pulses from 2015 to 2018.

What are some interesting customer insights?

- Amy from Pudukkottai loves Masalas (2018 champion buyer).
- Harish from Ramanadhapuram is a loyal Health Drink customer.
- Kartick from Cumbum takes the cake for buying the most Atta and Flour.
- Karur saw a surge in Fresh Vegetable sales during 2018.

The takeaway?

These insights can be used to make smarter decisions about product offerings, promotions, inventory management, and customer engagement strategies. This, in turn, will help the smart store optimize sales and keep customers happy.

15.0 Financial Modeling Equation

This report presents a comprehensive model for evaluating the profitability of selling a specific product in a departmental store. The model incorporates both fixed and variable costs, along with the impact of machine learning (ML) on pricing recommendations.

Profit Equation

The profit earned (Profit) from selling this product can be calculated using the following equation:

Profit = 1250 * x(t) - (2 * ML_salary + FS_salary)

- **x(t):** Represents the growth of the customer base over time.
- **ML_salary:** Represents the salary of each Machine Learning engineer.
- **FS_salary:** Represents the salary of the Full Stack web developer.

Integrating Machine Learning (ML) Pricing

The model further integrates the scenario where the profit equation is expressed in terms of:

- **x:** Quantity sold
- **m:** Selling price per unit

- **c:** Variable cost per unit

This integration results in a new equation reflecting the balance between revenue and costs:

1250 * x(t) - mx = -2 * ML_salary - FS_salary - cx

Considering Team Costs

To refine the model further, we consider the specific roles of the team members involved:

- Two Machine Learning engineers
- One Full Stack web developer

Therefore, the total cost includes the combined salaries of these team members.

Final Profit Model

By solving the integrated equation for x (quantity sold), we arrive at the final model for calculating profitability:

x = (1250 - m) / (-2 * ML_salary - FS_salary - cx)

This equation provides a comprehensive tool for evaluating the profitability of selling the product. It allows for the analysis of:

- **Selling price (m):** How does adjusting the price impact the quantity sold and overall profit?
- **Variable cost (c):** How do changes in production or material costs affect profitability?
- **Customer base growth (x(t)):** How can attracting new customers contribute to increased profit?
- **Team salaries (ML_salary, FS_salary):** How do staffing costs impact the profit margin?

16.0 Benefits

This model empowers departmental stores to make data-driven decisions regarding product pricing, resource allocation, and marketing strategies. By factoring in ML-driven recommendations, the model helps optimize profitability for the product's life cycle.

The departmental store profit model with machine learning integration offers a valuable tool for maximizing product profitability. By considering both fixed and variable costs, along with the impact of customer growth and team salaries, this model allows for informed decision-making throughout the product's life cycle.

17.0 Conclusion

In a nutshell, Smart Store helps department stores win by using smarts!

- **Stocking the right stuff:** Smart Store helps stores avoid overstocking and running out of popular items.
- **Selling smarter:** With better data, stores can offer the right price and promotions to boost sales.
- **Happy customers:** By keeping shelves stocked and offering good deals, Smart Store helps stores keep customers coming back for more.

18.0 GitHub Links

Github Link for the analysis:

https://github.com/Satyam-2004/Smart-store-segmentation
https://github.com/suganyajulianna/Super_store_market_analysis

Github Link for the model:

https://github.com/Hemanth-konduru/Final-project.git