Dynamic Pricing:
Using Langchain frameworks

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1.Introduction

In today's rapidly evolving marketplace, businesses face increasing pressure to adapt to dynamic economic conditions while maximizing profitability and customer satisfaction. The traditional static pricing models are quickly becoming inadequate, failing to reflect real-time market changes and customer demand. This report introduces an innovative solution: the implementation of a Dynamic Pricing Strategy using advanced AI technologies. Our focus is to demonstrate how leveraging real-time data can transform pricing strategies from reactive to proactive, significantly reducing inventory costs and enhancing profit margins.

We will explore the challenges of managing inventory and pricing, drawing on recent evidence from major corporations like Walmart, which illustrate the financial impact of inefficient pricing and stock management. Our proposed solution employs cutting-edge tools such as and Langchain frameworks to create a dynamic pricing model that adjusts in real-time to market conditions, demand, and inventory levels. Through detailed scenario analysis, comparisons of traditional and dynamic methods, and empirical data, this report aims to substantiate the efficacy of dynamic pricing, showcasing its potential to significantly improve retail efficiency and revenue growth.

The proposed strategy is particularly beneficial for professionals in the retail and e-commerce sectors, including pricing strategists, retail managers, inventory specialists, and corporate executives who are tasked with optimizing sales performance and reducing operational costs. It also holds significant relevance for data scientists and IT professionals who develop and implement pricing algorithms based on AI and machine learning technologies.

1.2 Justification of deviation from conceptual model

The deviation from the initial conceptual model centered around image generation using DALL-E to dynamic pricing analysis in the retail industry represents a significant shift in focus and application, primarily driven by differences in direct business impact, scalability, and ethical considerations.

Business Relevance and Impact:

Image Generation: The original model using DALL-E for generating images for news or journal publications primarily supports the media and publishing industry. While innovative, its direct impact on revenue generation is more tangential, serving primarily to enhance content attractiveness or engagement rather than driving core business functions.

Dynamic Pricing Analysis: In contrast, dynamic pricing directly influences the core of retail business operations—revenue management. This shift to dynamic pricing leverages data analytics to optimize pricing strategies in real-time, directly affecting sales, margins, and inventory turnover, which are critical levers for profitability in retail.

Scalability and Applicability:

Image Generation: The use of AI for creating editorial images, though valuable for visual content creation, has a limited scope of application, confined to visual media and specific content enhancement tasks within those industries.

Dynamic Pricing Analysis: This approach has a broader applicability across various segments of the retail industry, from small scale operations to multinational corporations. The scalability of dynamic pricing models is substantial, as they can be adapted for different products, markets, and competitive scenarios, making them a versatile tool in the strategic arsenal of a retail business.

Ethical and Regulatory Considerations:

Image Generation: Utilizing AI for image generation in news media can raise ethical concerns, especially around the authenticity and manipulation of visual content, which can lead to misinformation or misrepresentation. The responsibility to manage these ethical risks could limit the utility and acceptance of such technology in sensitive areas like news publishing.

Dynamic Pricing Analysis: While dynamic pricing also requires careful consideration to avoid practices such as price gouging, it is generally seen as a strategic business decision tool with clear guidelines and frameworks that can be regulated and standardized more straightforwardly than AI-generated content.

Technical Complexity and Maintenance:

Image Generation: Maintaining an AI system for generating images that continually meets the ethical standards and evolving styles or preferences in media can be technically challenging and resource-intensive.
Dynamic Pricing Analysis: Although complex, dynamic pricing algorithms can be integrated with existing ERP systems (like SAP) and updated with real-time data, allowing for more straightforward implementation and ongoing adjustment based on market conditions.

The pivot from a model focused on AI-generated images to one concentrating on dynamic pricing analysis in retail addresses more direct business needs—increasing revenue and market responsiveness—while offering greater scalability and potentially fewer ethical complications. This realignment better positions the technology to play a crucial role in the strategic and operational goals of retail businesses, making a tangible impact on their bottom lines. This shift not only aligns with the core business objectives of growth and efficiency but also mitigates the ethical risks associated with AI in media production.

3.Harnessing Dynamic Pricing for Financial Resilience and Retail Revolution

Challenges and Evidence: The Imperative for Adaptive Pricing Strategies

Managing inventory efficiently and optimizing cash flow are paramount in today's competitive business environment. As businesses strive to balance customer satisfaction with cost management, the significance of dynamic pricing strategies becomes increasingly evident. Dynamic pricing can directly influence key financial metrics such as EBITDA (Earnings Before Interest, Tax, Depreciation, and Amortization) and operating cash flow. By employing dynamic pricing, companies can more effectively manage their inventory and pricing strategies, leading to improved cash flow, and reduced carrying costs, which are crucial for maintaining capital for growth initiatives. This approach underscores the vital role of dynamic pricing in enhancing overall financial health, as noted by Stice et al. (2017).

A prime example of the challenges in managing inventory and pricing can be seen in major corporations like Nestle and Walmart. Nestle's 2020 financial statement revealed that over 50% of their sales value was consumed by the cost of goods sold, illustrating the heavy financial burden

that inefficient inventory management can impose on a company (Nestle, 2022). This situation underscores the necessity for strategies that minimize the cost of goods sold by optimizing inventory levels and pricing strategies dynamically. Walmart, on the other hand, has implemented temporary price reductions as part of its rollback strategy to manage inventory. While effective in reducing carrying costs and inventory losses, this strategy risks devaluing product worth over time and can lead to a dependency on discounts, potentially affecting long-term profitability and brand image. Such scenarios illustrate the critical need for dynamic pricing models that can adapt more fluidly to market conditions and inventory demands without compromising financial stability or brand reputation.

Key Business Value: Unlocking Profitability and Competitive Edge Through AI-Driven Pricing

The dynamic pricing strategy proposed herein offers substantial business value by addressing critical aspects of retail operations. Firstly, it reduces overstock by identifying and resolving issues related to underperforming inventory, thereby decreasing the financial burden of unsold stock. Secondly, the strategy's data-led approach allows for pricing that adapts to market trends, ensuring prices are always aligned with current market conditions, enhancing the potential for sales, and minimizing the risk of stock stagnation.

In addition, the strategy enhances profitability by aligning pricing with procurement costs and market demands to ensure better margins. It also cuts losses associated with unsold inventory by minimizing financial loss through a more responsive pricing mechanism. Moreover, the dynamic pricing model boosts competitiveness by maintaining prices that are responsive to market fluctuations, thereby protecting the company’s market position despite changing economic landscapes.

Operational excellence is another cornerstone of this strategy; by enhancing operational efficiency, the approach leads to a more streamlined inventory with fewer markdowns and improved turnover rates. Furthermore, the intelligent pricing mechanism ensures products are sold at their optimal value, contributing to revenue growth without increasing inventory costs.

Collectively, these elements illustrate the transformative impact of the proposed dynamic pricing solution on retail efficiency, showing its capability to not only mitigate current financial challenges but to also drive sustainable growth and market resilience.

3.1 Dynamic Pricing: Activity System Framework

- Tools: At the apex of the framework, the 'AI-enabled query and pricing system' represents the technological means through which the activity is carried out. This system processes data and automates pricing decisions, enabling real-time responses to market changes.
- Subject: Wholesale retail owners and warehouse managers. These actors utilize the tools to manage pricing and inventory effectively.
- Rules: Retail policies – stock level management, inventory tracking. These rules provide guidelines for the operation of the dynamic pricing system and ensure that inventory management aligns with organizational objectives.
- Community: Encompasses the wider network of actors who share the same objective, including suppliers, vendors, retail wholesale sellers. This collective contributes to and is impacted by the activity of dynamic pricing and inventory management.
- Division of Labor: Warehouse employees, IT Admin, procurement, sales analysts. The division of labor delineates responsibilities and workflows within the system, ensuring that each role contributes to the operational effectiveness and the attainment of the desired outcome.
- Object: Increased revenue in a short time, efficient stocking of products. This goal is the driving force behind the application of the AI-enabled pricing system and the coordination of all actors within the system.

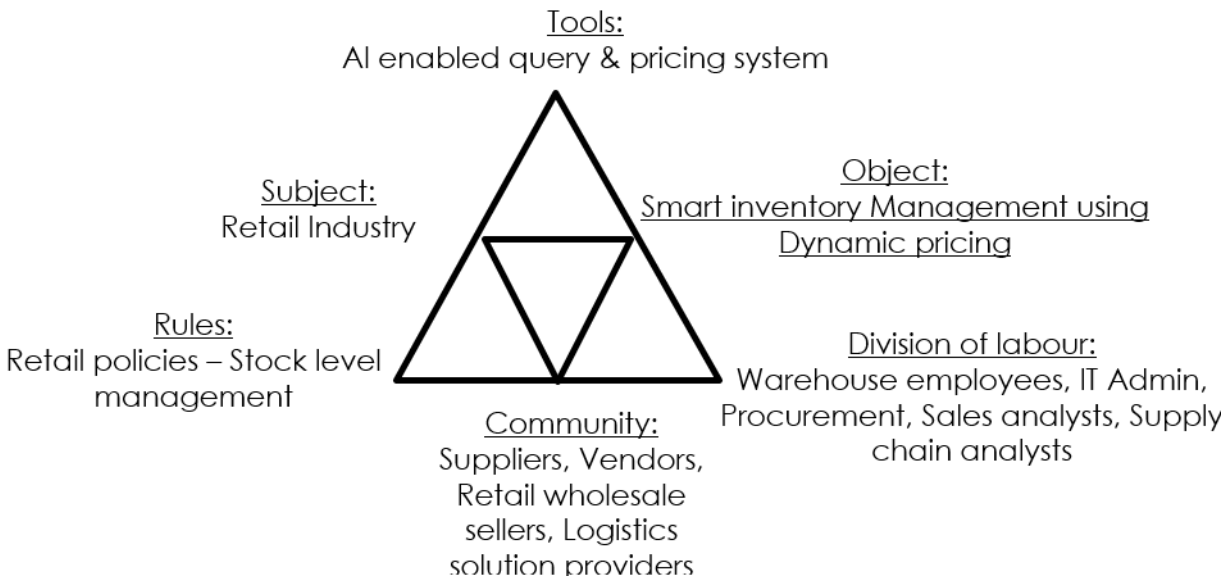

Figure 1 AI-enabled query and pricing system: Activity System Framework

3.3 Current Scenario

Limitations:

Retailers often set initial product prices based on cost-plus or competitive benchmarking strategies without the flexibility to adapt to changing market conditions. This static approach can lead to excessive inventory build-up if the product does not sell as anticipated. For example, a retailer might keep a $20 price point despite slow sales, leading to overstocked shelves and tied-up capital.

Illustrative Scenario:

From March 1 to March 30, a hypothetical product launch at $20 shows sales dwindling, inventory quadrupling, and prices slashed to $10 by mid-month as a reactionary measure. This approach not only reduces profit margins but also demonstrates a lack of responsiveness to market demands, highlighting the inefficiencies of traditional pricing.

Figure 2 Images replicating current scenario

3.4 Implementation of Dynamic Pricing Using AI

Strategy Introduction:

Using AI to implement dynamic pricing involves continuous monitoring of sales data, market trends, and inventory levels. This data-driven approach allows for agile price adjustments that better match current market conditions.

SERP API and Langchain Use Case:

In a dynamic scenario, AI models such as SERP API analyze initial sales velocities and market trends from the first days of a product launch. If sales are lower than expected, the AI system can suggest a minor price adjustment, preemptively avoiding inventory surplus and aligning price with consumer expectations more closely.

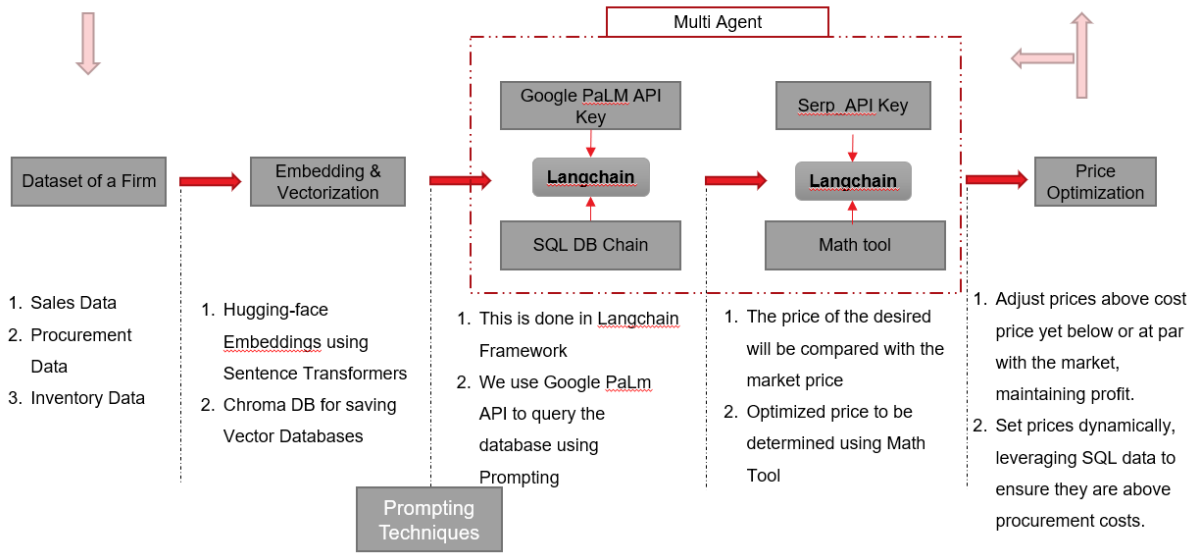

Figure 3 Technical architecture

Benefits Over Traditional Methods

This proactive pricing strategy reduces the risk of severe stock accumulation and preserves profit margins by maintaining more steady sales through small, timely adjustments rather than large, infrequent price cuts.

Data Handling:

Real-time integration with enterprise resource planning systems like SAP allows for the seamless flow of critical data points into the AI models. This integration ensures that sales, procurement, and inventory data are continuously updated, providing a robust dataset for AI analysis.

Dataset:

Data is extracted from the SAP access in the real time.

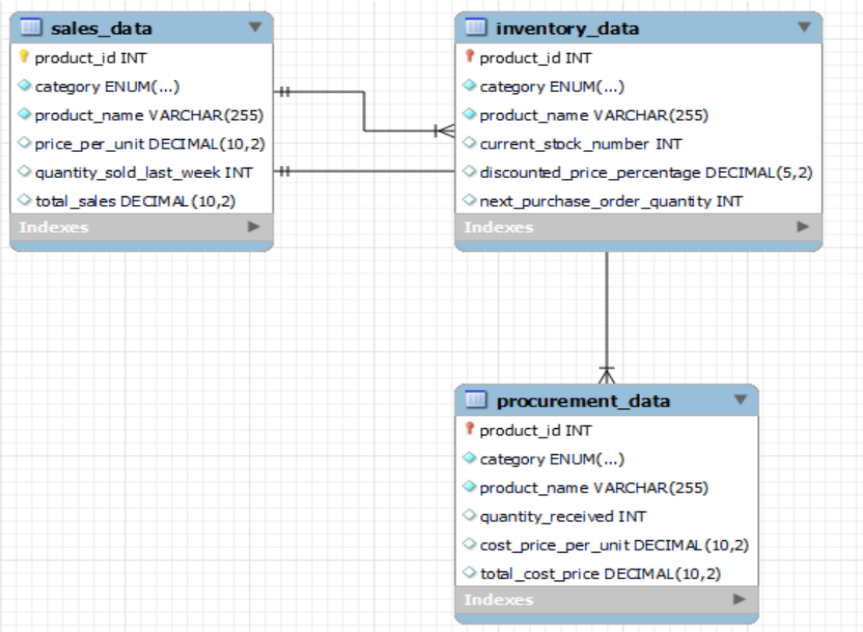

Figure 4 Linking of data for prototype

The diagram above shows how we linked data**.** The following is an explanation of process of linking data.

- Primary Key: The **'product_id'** serves as the core link across our database, connecting procurement costs, sales performance, and inventory levels.
- The **'inventory_data'** integration facilitates swift adjustments in pricing, preventing overstock and aligning with current demand patterns.
- By connecting **'procurement_data'** via **'product_id'**, we gain insights into supplier costs, crucial for setting competitive prices while safeguarding profit margin.

4.Working Prototype:

https://colab.research.google.com/drive/1LDVw8rULxuN1LQRAAvPVgDzvF80EXUWx#scrollTo=QOwS8AFsBn_R

4.1 AI Tools and Methodologies used

SerpAPIWrapper:

Purpose: This is initialized with an API key stored in userdata. SerpAPI is typically used for scraping and extracting data from search engine results. It enables the program to fetch real-time data from web pages without handling the complexities of scraping, parsing, and dealing with anti-bot measures.

Use Case: Useful for questions requiring up-to-date information on various topics, such as pricing, product availability, or recent news.

LLMMathChain:

Purpose: This tool appears to be a specialized component that utilizes a language model (model3.5Turbo) to perform mathematical calculations or logic operations. The verbose flag likely controls the output of debugging or detailed logs.

Use Case: It can handle queries that involve numerical analysis, complex calculations, or logic problems that are framed in natural language.

SQLDatabaseChain:

Purpose: This integrates the same language model with a database (db), allowing the agent to execute database queries or interact with the database using natural language.

Use Case: This is particularly useful for applications needing access to structured data like product catalogs, employee records, or customer transactions.

4.2 Use cases in Prototype

All the below cases have been fine-tuned by techniques like **Zero-Shot Prompting**

Market Adaptation Price Adjustment: To Retrieve the current price of [product] from our sales_data table, fetch the lowest market price from SERP API, and calculate the necessary percentage decrease to match the market price using the math tool.

Tools Used:

- SQL Database: To fetch internal current prices.
- SERP API:To get the lowest market price from competitors. Math Tool: To calculate the percentage decrease needed.

```
> Finished chain.
Answer: 21.570308147259247Here is the step-by-step breakdown of the calculation:

1. Current price of our product (Google Pixel 8): $699.99
2. Lowest market price for the same product: $549.00
3. Percentage decrease needed for our product's price to match the lowest market price:

\[ \text{Percentage Decrease} = \frac{699.99 - 549.00}{699.99} \times 100 \]
\[ \text{Percentage Decrease} = \frac{150.99}{699.99} \times 100 \]
\[ \text{Percentage Decrease} \approx 21.57\% \]

Therefore, a 21.57% decrease in our product's price is needed for it to match the lowest market price of $549.00.

> Finished chain.
```

Figure 5 Market adaptation & price adjustment output

Break-even Price Calculation: Identifying the product which is puchased most and sold least. And, to check, when it will be sold based on the trend

Tools Used:

- SQL Database: For retrieving the products
- SERP API: For real-time market price comparison.

```
> Entering new SQLDatabaseChain chain...
products
SQLQuery:SELECT "product_id", "product_name" FROM inventory_data
LIMIT 5;
SQLResult: [(1, 'Google Pixel 8'), (2, 'Samsung Galaxy Watch'), (3, 'Sony Wireless Headphones'), (4, 'Cashmere 24 Rolls Tissue'), (5, 'Tide Laundry
Detergent')]
Answer:Google Pixel 8, Samsung Galaxy Watch, Sony Wireless Headphones, Cashmere 24 Rolls Tissue, Tide Laundry Detergent
> Finished chain.
Google Pixel 8, Samsung Galaxy Watch, Sony Wireless Headphones, Cashmere 24 Rolls Tissue, Tide Laundry DetergentThe product that is purchased more a
sold least in the database is Google Pixel 8. Based on the trend of the data, it is likely that the Google Pixel 8 will be sold fast in the future a
it is a popular product that is in high demand.

> Finished chain.
'The product that is purchased more and sold least in the database is Google Pixel 8. Based on the trend of the data, it is likely that the Google P
el 8 will be sold fast in the future as it is a popular product that is in high demand.'
```

Figure 6 Break even price calculation output

Impact of increasing the price: Identifying the potential revenue changes for a particular percent increase in selling price of a product.

Tools Used:

- LLM Mathchain**:** For predicting the revenue for a particular product

```
> Entering new LLMMathChain chain...
1.05 * (699.99 * 150) + 1.05 * (299.99 * 120) + 1.05 * (129.99 * 180)```text
1.05 * (699.99 * 150) + 1.05 * (299.99 * 120) + 1.05 * (129.99 * 180)
```
...numexpr.evaluate("1.05 * (699.99 * 150) + 1.05 * (299.99 * 120) + 1.05 * (129.99 * 180)")...

Answer: 172615.27500000002
> Finished chain.
Answer: 172615.27500000002The total revenue from the Electronics products sales last week was $164,395.50.

If there is a 5% price increase for each product, the potential revenue with the price increase would be $172,615.28.

Based on this data, people may still buy the products even with a 5% price increase as the potential revenue is projected to increase.

> Finished chain.
```

*Figure 7 Revenue prediction output*

## 4.3 Use case in actual environment

In real time, the company aims to be competitive in e-commerce by dynamically adjusting prices based on market conditions, inventory levels and so **user will be provided with a reward model and can be further fine-tuned.**

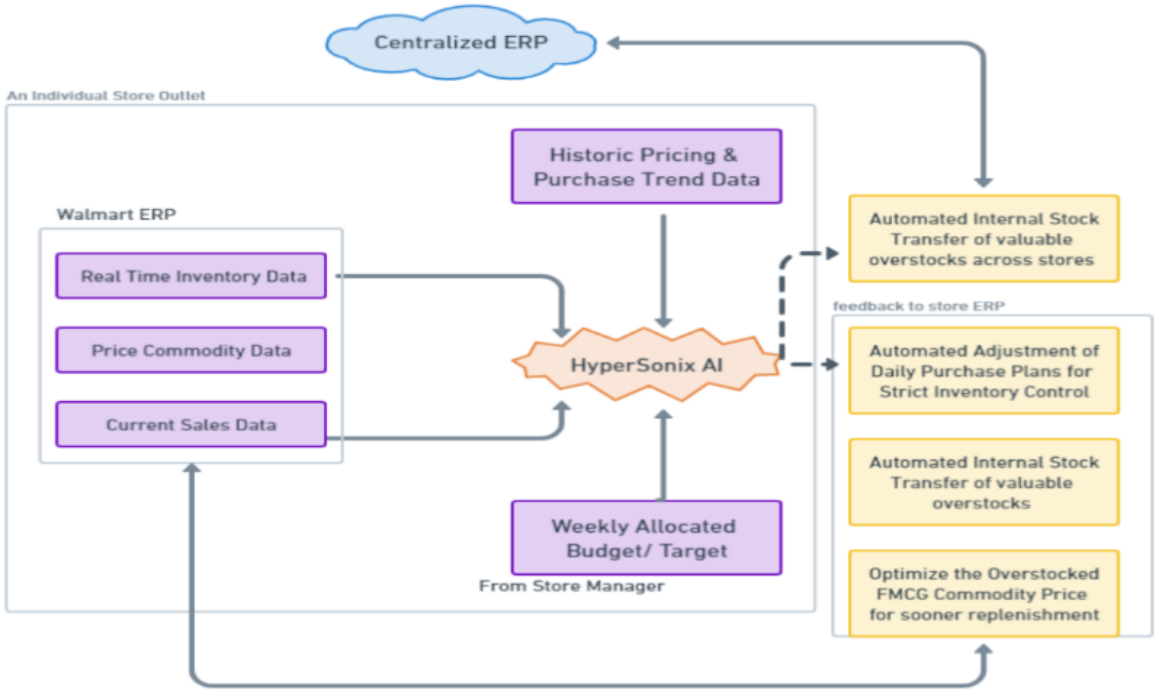


*Figure 8 Architecture of SAP ERP integrated with Dynamic Pricing Tool*
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- For instance, if the SERP API indicates that a major competitor has reduced the price of a popular smartphone model, the system automatically **suggests a new price**, which, after approval, is updated across all platforms integrated with SAP ERP.
- The break-even analysis helps in determining if promotional activities or discounts are needed for **stock clearance**, potentially feeding into an automated marketing module within SAP.
- The impact prediction technique in a peak shopping season like Black Friday, can simulate the impact of price increases on various products, helping set prices that **maximize revenue** without hurting sales volume.

5. Conclusion

Implementing dynamic pricing through AI in the retail sector not only enhances operational efficiency but also improves customer satisfaction by offering more competitive and fair pricing. Continuous adaptation and integration of new technologies and methodologies are vital for maintaining a competitive edge in the evolving market landscape. Integrating sophisticated tools such as Market Adaptation Price Adjustment, Break-even Price Calculation, and Impact of Increasing the Price into an SAP ERP system empowers a retail company to dynamically manage its pricing and inventory with precision and agility. These capabilities allow the business to adapt quickly to market conditions, optimize inventory levels, and adjust pricing strategies in real-time, thereby maximizing profitability and competitiveness. By employing these advanced analytical tools, the company not only responds more effectively to consumer demand and competitive pressures but also enhances operational efficiencies and decision-making processes. This strategic integration ensures that the business remains resilient, responsive, and forward-thinking in a highly competitive retail environment, leading to sustained growth and improved customer satisfaction.