SalesEye: A Fashion Retail Management System with Demand Prediction

Rumesh Siriwardhana, Isuru Kumanayake, Dilru Kumarathunga, Manuka Rashen,

E. Weerasinghe, D. I. De Silva

Department of Computer Science and Software Engineering, Sri Lanka Institute of Information Technology, Malabe, Sri Lanka

Abstract:The fashion industry is a vast, ever-evolving, and highly impactful sector within the global economy. Within this industry, fashion retail plays a pivotal role as it serves as the intermediary connecting manufacturers and consumers. Given the volatile nature of the fashion industry, forecasting demand for fashion items has grown increasingly complex. This study aims to develop a solution that gathers and analyzes retail sales data while predicting the demand for men's fashion products. This initiative is driven by the industry's need to address challenges in optimizing sales. Furthermore, the advent of sophisticated data analysis tools powered by artificial intelligence models has brought about a positive influence in the field of business analytics. Power BI, a popular data analytics tool, has been utilized in this research for data analysis and visualization to aid the prediction of customer demand for men's fashion products through a dedicated web application. This paper presents the process of analyzing sales, forecasting demand, and the outcomes of each segment.

Keywords*: demand prediction, data analytics, business intelligence, men's fashion retail, power bi.*

1. Introduction

In today's dynamic world, clothing serves a purpose beyond mere necessity. It has evolved into a medium for self-expression and a reflection of cultural significance. The fluid nature of the fashion industry perfectly echoes the ever-shifting sands of human desires and preferences. Valued at an astonishing 1.7 trillion dollars [1], the global fashion industry encapsulates the entire lifecycle of clothing, from inception in design and manufacturing to its ultimate presence in retailing and marketing [2].

Moreover, the Sri Lankan fashion eCommerce sector is poised for substantial growth, projected to reach US$441.2 million by 2023 and constituting 18.3% of the country's total eCommerce market [3]. This underscores the industry's transformative power, both on a global scale and within regional contexts.

In the ever-evolving landscape of the fashion industry, comprehending consumer behavior and precisely forecasting demand has become imperative for retailers aiming to optimize their sales strategies and stimulate business growth. However, the inherent volatility of the fashion market makes predicting product demand notably challenging. These challenges stem from a series of specific obstacles encountered by the fashion retail sector, including:

- Swift and unpredictable shifts in fashion trends.
- Seasonal variations in demand.
- Short product lifecycles in the market.
- The presence of diverse consumer preferences.

Moreover, retail industry in Sri Lanka confronts a unique set of challenges that are specific to its local context. One significant challenge is the reluctance to embrace new technologies, which hampers the industry's potential

for growth and innovation. The prevalent low levels of computer literacy among both retailers and consumers further exacerbates this issue, impeding the adoption of modern solutions.

The significance of addressing these challenges cannot be overstated. Precise demand forecasting and streamlined operations can significantly boost profitability, reduce waste, and greatly enhance customer satisfaction. The rapid fluctuations in demand within fashion retail present formidable challenges, encompassing issues such as under-stocking, overstocking, customer demand comprehension, and capital management [2]. The failure to effectively address these challenges can have real-world consequences, jeopardizing a retailer's financial health and long-term viability.

The primary objective of this research study is to develop a web application that utilizes Power BI for both sales analysis and predictive insights, specifically aiming to understand and forecast the demand for men's fashion products by analyzing historical sales data.

The proposed solution, SalesEye offers a comprehensive solution for the challenges faced by the fashion retail sector. Beyond demand prediction, it encompasses robust features including product management, customer relations, order processing, deliveries, and supplier interactions, all of which are highly relevant and beneficial for the e-commerce aspect of the fashion industry. This integrated approach is poised to revolutionize sales optimization in the industry.

In the subsequent sections, the paper is structured as follows: Section 2 conducts a literature review on the research topic, Section 3 defines the study's methodology, Section 4 discusses the obtained results, and Section 5 concludes the paper by summarizing key findings and proposing future research directions.

2. Related Work

In the realm of fashion retail forecasting, various innovative approaches have emerged. Au et al. [4] proposed an evolutionary neural network approach, which demonstrated superior performance when compared to traditional forecasting methods like the SARIMA model, particularly for products characterized by low demand uncertainty and weak seasonal trends. Sun et al. [5], on the other hand, introduced a sales forecasting method utilizing extreme learning machine (ELM), effectively analyzing the correlation between sales, and influencing factors such as size, color, and price. Their experiments, conducted with real data from a Hong Kong fashion retailer, highlighted the superiority of their approach over backpropagation neural networks in sales forecasting. Aksoy et al. [6] contributed to this field with a decision support system for demand forecasting in the clothing industry, employing adaptive-network-based fuzzy inference systems (ANFIS). Their rationale behind selecting ANFIS was its capability to handle intricate nonlinear relationships and noisy data, often encountered in clothing industry demand forecasting. Real demand data from clothing manufacturers validated the system's accuracy, indicating its ability to achieve reliable forecasts.

The research conducted by N.B. Ganhewa et al. [2] employs machine learning to optimize sales in women’s fashion retail, comprising three components: sales forecasting, customer segmentation, and customer demand analytics. The sales forecasting component uses the Extra Trees Regressor algorithm to predict future sales based on historical data and product features. Simultaneously, the customer segmentation component uses the K-means clustering algorithm to group customers with similar characteristics, while the customer demand analytics component analyzes customer purchase patterns and reviews to identify popular items and customer preferences.

The study by Ren, S et al. [7] provides a comprehensive review on demand forecasting methods for fashionable products in the big data era. It discusses the challenges of traditional forecasting methods and the opportunities brought by big data. It also examines how a fashion retailer advances its demand forecasting method and inventory planning in practice.

Shivankar et al. [8] proposed a machine learning model to predict sales of different Big Mart shopping outlets using the Global Superstore sales dataset. The model was evaluated using K-fold cross-validation, and it was found to outperform other machine learning algorithms such as decision trees and ridge regression. The authors also used Power BI to visualize the data and gain insights into the factors that influence sales.

Raje et al. [9] and Capris et al. [10] both employed Power BI to enhance sales analysis. In their respective work, Raje et al. developed a sales dashboard using Power BI, featuring visualizations of monthly sales performance metrics including total revenue, units sold, and revenue breakdown by various dimensions such as supervisor, date, employee, and product. In addition, they used linear regression to predict future sales based on investment inputs for different marketing channels. On the other hand, Capris et al. proposed a Power BI solution centered around a robust architecture, using a data mart to store sales data and employing a dimensional model to facilitate in-depth data analysis and visualization. Their solution includes a dashboard with interactive charts and tables that allow users to drill down into the data and identify trends and patterns.

While numerous research studies have explored various facets of the fashion industry, only a limited number have distinctly focused on predicting the demand for men's fashion products. Furthermore, the utilization of Power BI as a tool for data analysis and demand prediction in men's fashion retail remains relatively unexplored.

3. Methodology

In this section, the methodology for the development of the sales analysis and demand prediction system is described. The system utilizes Power BI, an interactive data visualization tool by Microsoft Corporation with a primary focus on business intelligence [11].

The system's database is connected to Power BI, and the Power BI Live Dashboard component is used to display the obtained results, enabling real-time updates. An overview of the system architecture is presented in Fig. 1, while the stages involved in this process are illustrated in Fig. 2.

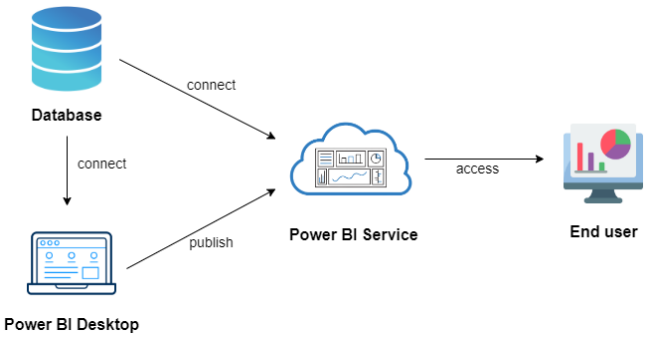

Fig. 1. System architecture

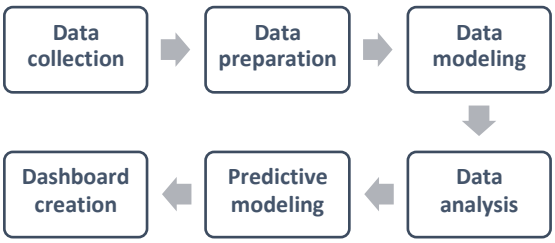

Fig. 2. The adopted process

1. Data Collection - The foundation of any data-driven analysis is the quality and relevance of the data collected. In this initial phase, a representative sample is sourced from the ecommerce application, with a focus on sales data from 2020 to present. This dataset comprises historical sales transactions, customer information, product details and other relevant data that affect sales and demand. It serves as the foundational dataset for all subsequent analyses.

2. Data Preparation - High-quality data is not only about quantity but also about cleanliness and consistency. Data preparation is a critical step that ensures data accuracy and reliability. The collected data is subsequently cleaned and transformed to achieve this goal. Data cleaning involves handling missing values, removing

duplicates, and dropping unnecessary columns, such as the image column, while data transformation involves standardizing data formats and encoding categorical variables.

3. Data Modeling - In this stage a well-structured data model is created for effective analysis. Relationships are established between different tables such as sales, products to connect related data. Measures and calculated columns are created, frequently using Data Analysis Expressions (DAX), to perform calculations and aggregations. This stage also involves identifying key performance indicators (KPIs) that will be used to measure and evaluate sales performance.

4. Data Analysis - Utilizing Power BI, a series of visualizations and reports are generated to perform in-depth sales analysis. This includes the generation of key performance indicators such as sales revenue, profit margins, and sales trends over time. Furthermore, customer segmentation is examined to understand purchasing patterns and customer behavior.

5. Predictive Modeling - For the prediction of future demand, Power BI's robust forecasting capabilities are employed, specifically utilizing the Time Series model [12]. This model harnesses historical sales data, incorporating factors such as seasonality, promotions, and market trends to generate precise demand forecasts. The Time Series model, seamlessly integrated within Power BI's line charts, delivers real-time demand projections, making it the primary tool for forecasting future demand in this analysis.

During this stage, the dataset is divided into training and testing subsets to evaluate the model. The training dataset allows the model to learn from historical data, uncovering hidden patterns and relationships. To ensure an effective assessment of the model's performance, the dataset is split into a training set and a testing set, maintaining a ratio of 80% to 20%.

6. Dashboard Creation - Using the analyzed data and the insights gained from the previous stages, an interactive dashboard is created in Power BI [13]. The demand prediction and sales performance are comprehensively outlined through a range of visual aids, including tables, charts, and maps. Through this dashboard, users can drill into key indicators, apply data filters, and obtain useful insights for making decisions.

Once the dashboard is created in Power BI, the next crucial step is to publish it to the Power BI service and embed it into the web application. This seamless integration ensures that stakeholders and end-users can access real-time updated sales analysis and demand predictions conveniently through the web application's interface.

4. Results and Discussion

A. Sales Analysis

The sales analysis phase yielded valuable insights into the performance of the men's fashion retail sector. Through the interactive dashboard, users can comprehensively explore sales data, uncovering key insights. Prominent summary metrics include total sales, quantity sold, orders, and products. Here are some specific highlights from the analysis:

Sales and Orders by Year and Quarter: Fig. 3 displays this chart, which utilizes a combination of line and clustered column charts to present vital insights into business performance. Along the horizontal axis, it tracks the progression of years and quarters, providing a chronological framework for analysis. On the left, clustered columns denote sales figures for each quarter, enabling a straightforward comparison of sales performance between different time frames. On the right, the chart represents the number of orders with a continuous line, offering a visual perspective on order volume fluctuations. This chart facilitates the identification of correlations and disparities between order volume and sales revenue, aiding decision-makers in optimizing strategies and seizing growth opportunities based on a clear understanding of these dynamics over time.

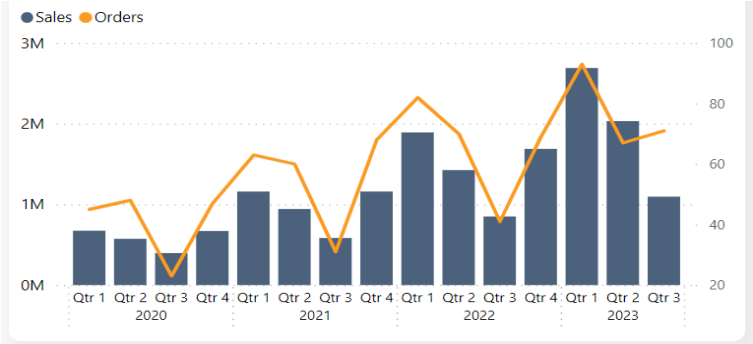

Fig. 3. Sales and orders by year and quarter chart

Sales by Category: As shown in Fig. 4, the pie chart visually represents how sales are distributed across different men's fashion retail product categories. Each category's slice size corresponds to its contribution as a percentage of total sales, making it easy to grasp the relative importance of each category.

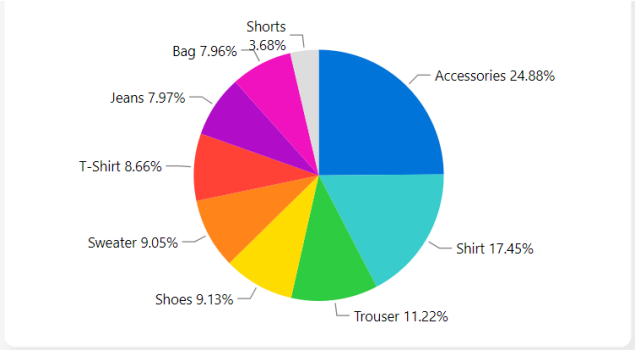

Fig. 4. Sales by category chart

Sales by Product: This bar chart enables a straightforward comparison of sales performance among different products, facilitating the swift identification of top-performing and under-performing items. It is a valuable tool for decision-makers in shaping strategies related to product management and inventory optimization.

Sales By Brand: This bar chart visually represents the sales contribution of each brand. This chart is essential for evaluating brand performance and provides decision-makers in marketing and brand management with valuable insights.

*Orders By City:*Fig. 5 displays this map showcasing the distribution of orders across different cities.It offers a visual insight into the performance of sales in various geographic areas and helps decision-makers in regional marketing and logistics planning.

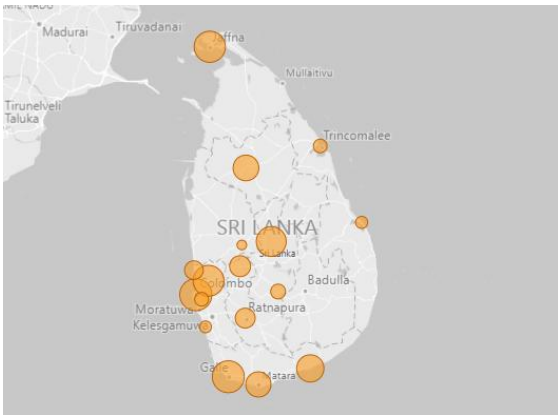

Fig. 5. Orders by city map

B. Demand Prediction

The evaluation of the prediction model yielded positive results. Initially, the model was applied to the testing dataset to predict sales quantities. The forecasted values were then compared with the actual values from the testing dataset, as shown in Table 1.

TABLE 1. Comparison of actual and predicted values

Test Sales Value	Predicted Sales Value
395930	416126
526050	462886
570260	571157

To evaluate the predictive performance of the model, Mean Absolute Error (MAE), Mean Absolute Percentage Error (MAPE), and Root Mean Square Error (RMSE) were utilized as performance metrics. The results are summarized in Table 2.

TABLE2. Performance metrics

MAE	30559
MAPE	4.866378%
RMSE	41742.43482

Fig.6 illustrates the prediction chart for a 6-month period. This chart provides valuable insights into the forecasted sales trends and allows decision-makers to plan and strategize accordingly. The positive evaluation results reinforce the model's effectiveness in predicting future demand, enabling better-informed decisions in the men's fashion retail sector.

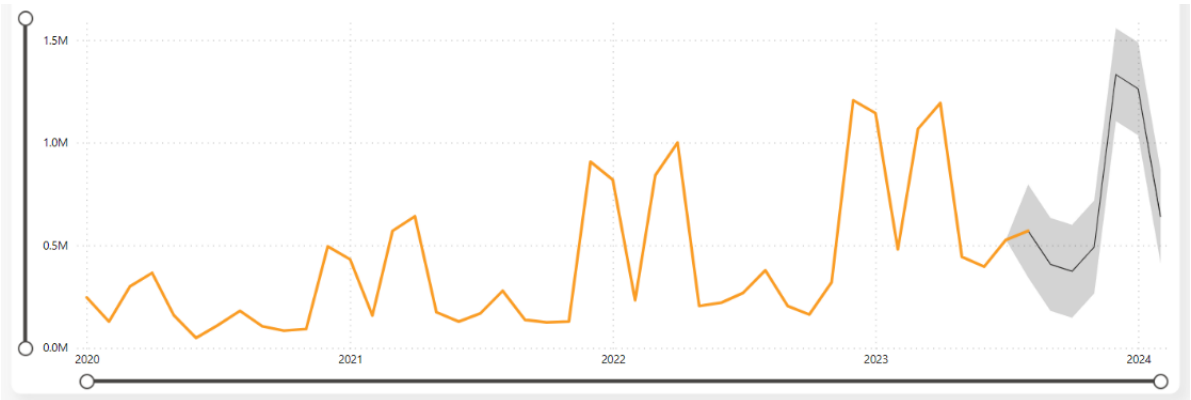

Fig.6. Sales forecast chart

5. Conclusion

This study has effectively addressed the intricate challenges associated with demand prediction and sales analysis, harnessing the power of historical sales data and robust analytical techniques. The integration of the Power BI-powered dashboard has emerged as a pivotal tool, providing comprehensive insights into sales performance and demand trends. This research highlights the transformative potential of Power BI within the

fashion retail sector, facilitating data-driven decision-making that empowers retailers and fuels growth and innovation.

Furthermore, this study paves the way for exciting avenues of future research. One promising recommendation is to delve into personalized marketing strategies as the next logical step, recognizing their potential to further revolutionize the fashion retail industry. By building upon these findings, researchers can continue to drive progress in this dynamic and evolving field, ultimately shaping the future of fashion retail through data-driven insights and strategic innovation.

References

[1] S. Ariella, "28 Dazzling Fashion Industry Statistics [2023]: How Much Is The Fashion Industry Worth," Zippia.com. Jun. 15, 2023. [Online]. Available: https://www.zippia.com/advice/fashion-industry-statistics/. [Accessed: Aug. 15, 2023].

[2] N. B. Ganhewa, S. M. L. B. Abeyratne, G. D. S. Chathurika, Dilani Lunugalage, and Dilshan De Silva, "Sales Optimization Solution for Fashion Retail," in Third IEEE International Conference on Advancements in Computing, Dec. 2021, pp. 443-448.

[3] ECDB, "Fashion market in Sri Lanka," Ecommercedb.com.[Online]. Available: https://ecommercedb.com/markets/lk/fashion. [Accessed: Aug. 20, 2023].

[4] K.-F. Au, T.-M. Choi, and Y. Yu, "Fashion retail forecasting by evolutionary neural networks," International Journal of Production Economics, vol. 114, no. 2, pp. 615-630, Aug. 2008.

[5] Z.-L. Sun, T.-M. Choi, K.-F. Au, and Y. Yu, "Sales forecasting using extreme learning machine with applications in fashion retailing," Decision Support Systems, vol. 46, no. 1, pp. 411-419, Dec. 2008.

[6] A. Aksoy, N. Ozturk, E. Sucky, "A decision support system for demand forecasting in the clothing industry," International Journal of Clothing Science and Technology, vol. 24, no. 4, pp. 221-236, Jul. 2012.

[7] S. Ren,H.-L. Chan, and T. Siqin, "Demand forecasting in retail operations for fashionable products: methods, practices, and real case study," Annals of Operations Research, vol. 291, pp. 761-777, Jan. 2019.

[8] S. Shivankar, S. Mehetar, N. Darade, S. Bhimanpalli, and D. Dafale, "Global Superstores Sales Prediction and Data Visualization Using Power BI," IJRESM, vol. 6, no. 4, pp. 90-94, Apr. 2023.

[9] M. Raje, P. Jain, V. Chole, "Sales Analysis and Prediction Dashboard Using Power BI", International Research Journal of Modernization in Engineering Technology and Science, vol. 03, no. 06, Jun. 2021.

[10] T. Capris, Y. Takagi, P. Melo, N. M. Garcia, I. M. Pires, N. J. Gonçalves, "Data Analysis for the Development of a Power BI solution for sales," in 2022 International Conference on Data Analytics for Business and Industry, Oct. 2022, pp. 531-535.

[11] Microsoft, "Data Visualization | Microsoft Power BI," Microsoft.com. [Online]. Available: https://powerbi.microsoft.com/.

[12] T. A. Dorfer, "Quick and easy Time-Series Forecasting in PowerBI: A Practical Guide," Medium.com, May 1, 2023. [Online]. Available: https://towardsdatascience.com/quick-and-easy-time-series-forecasting-in-powerbi-a-practical-guide-c31a858ee220. [Accessed: Aug. 26, 2023].

[13] G. Singh, A. Kumar, J. Singh, and J. Kaur, "Data Visualization for Developing Effective Performance Dashboard with Power BI," in 2023 International Conference on Innovative Data Communication Technologies and Application, Mar. 2023, pp. 968-973.