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ASRS, AMR INTEGRATION WITH WMS - CHALLENGES AND SOLUTIONS

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ABSTRACT

Purpose- The study investigates the integration of Automated Storage and Retrieval Systems (ASRS) and Autonomous Mobile Robots (AMRs) with Warehouse Management Systems (WMS), aiming to enhance operational efficiency through machine learning. Key challenges addressed include data compatibility, real-time decision-making, and effective resource allocation.

Methodology- Machine learning models were applied to optimise system performance: Bayesian Neural Networks (BNNs) for demand forecasting, Random Forests for resource allocation, K-means clustering for task prioritisation, and Support Vector Regressor (SVR) for performance evaluation using Mean Squared Error (MSE).

Findings- BNNs improved demand prediction, enabling adaptive adjustments of ASRS and AMRs. Random Forests efficiently optimised resource distribution, while K-means clustering successfully prioritised high-demand tasks to support lean operations. The SVR achieved an MSE of 2.47, confirming low prediction error and model effectiveness.

Conclusion- Integrating machine learning into ASRS-AMR-WMS systems provides a scalable framework for modern warehouses, fostering real-time adaptability, improved resource utilisation, and enhanced productivity.

Keywords: ASRS, AMR, WMS integration, machine learning, Bayesian Neural Networks, Random Forest, K-means clustering, demand forecasting, resource optimisation, warehousing efficiency

JEL Codes: M11, C53, O33, L91

1. INTRODUCTION

Technology has taken over warehousing functions by increasing the speed of operations, cutting employment expenses, and increasing the precision of orders. ASRS and AMRs are critical enablers for this change, such as storage, picking, and moving objects and people in warehouses (Basaldúa & Cruz Di Palma, 2023). ASRS enhance performance density and update rates, which are adequate for handling large amounts of stock and controlling existing space (Jie et al., 2024). At the same time, AMRs perform navigation in the warehouse independently, explaining the delivery of goods from storage to picking and packing zones (Torchio, 2023). Combined, ASRS and AMR technologies enhance the warehouse inventory's accuracy and the speed at which orders can be fulfilled, a requirement in current fast-paced and complex warehouses.

Implementing ASRS and AMRs with WMS is a subject of controversy. One of the potential concerns is the compatibility of the data produced by ASRS and AMR systems with WMS data storing and processing architecture (Broughton, 2024). The first one is technology heterogeneity, which refers to the ability of disparate protocols and actual procedural processing scenarios to disrupt the efficient interaction of automatic and WMS technologies. Also, real-time decision-making requires almost accurate time data processing and acting, and many of the existing WMS need to be equipped for or would need significant tweaking or replacement to handle the flow of information efficiently. This study will tackle these challenges by presenting the main difficulties in ASRS-AMR-WMS integration and providing solutions through machine learning models, clustering, and predictive analysis. These approaches can enhance the demand prediction, resources, and real-time goals of ASRS and AMR systems.

However, it is essential to note some research limitations concerning real-time data processing and forecasting about ASRS and AMR-WMS integration. To the best of the author's knowledge, little research focuses on how machine learning could extend functionality and resource share in integrated systems. This study addresses these gaps by applying a state-of-the-art machine learning and clustering approach to create solutions to enhance ASRS and AMR integration for orchestrating automatic and adaptive warehouse operations.

2. LITERATURE REVIEW

2.1. ASRS and AMR Technologies in Warehousing

Automated Storage and Retrieval Systems and Autonomous Mobile Robots of present-day warehousing involve complex technology employing storage, retrieval and mobility of goods (Dhaliwal, 2020). ASRS, widely used for main-stream automatic storage and collection of products, reduces the use of space and human intervention as the movement of stocks is managed vertically and horizontally. These systems are most useful in high cube warehousing where conventional methods cannot deliver the required throughput. Due to the importance of these sectors, ASRS technologies ensure precise stock storage and location, fast stock access and efficient use of space (Jie et al., 2024).

On the other hand, AMRs offer dynamic movement and autonomy, moving throughout a warehouse to pick up and transport products from storage to build and pack zones (Merkert et al., 2023). While relying on tracks like conventional conveyors, AMRs utilise navigation sensors and optimisation algorithms to perform in compliance with the warehouse configuration and navigate around the obstacles encountered (Harb, 2023). The integration process of ASRS and AMRs with WMS enhances the efficiency of stock positioning and picking processes and reduces the manual efforts needed (Jie et al., 2024). Integrating ASRS and AMRs also helps WMS get in touch with the latest real-time information for inventory storage and order management (Dinh, 2020).

2.2. Challenges in ASRS and AMR-WMS Integration

Despite their potential, ASRS and AMRs have integration issues with WMSs. In this case, data synchronisation is one significant concern mainly due to the compatibility and data standard because the real-time data transfer from ASRS, AMRs and WMS is affected (Halawa et al., 2020). These two systems produce massive amounts of data, and WMS should process and react to it swiftly. However, many WMS solutions are ancient systems that cannot process frequent data or make real-time decisions (Khan et al., 2022). The issue of operational compatibility is also present because ASRS and AMRs work by protocols and specific operating workflows that may need to be more harmoniously related to WMS functions. It is also often that solutions require tailoring of ASRS or AMRs to WMS demands or redesigning of WMS to fit ASRS or AMR affordances (Khan et al., 2022); it is also a time-consuming and often manually intensive process of prototyping and testing as well as continuous maintenance.

Another significant issue is the flexibility of image WMS systems again: The real problem is that the older WMS platforms need to be more flexible and can support real-time autonomous approaches that are more effective than a much more straightforward and more scalable process (Liu et al., 2023). Introducing autonomous technologies into such systems may require system enhancement, middleware or API upgrades, which may bring extra costs and challenges. All these challenges call for superior data management solutions and predictive analytics for integrated real-time implementation and operational peculiarities of automated warehouses.

2.3. Machine Learning in Warehousing Systems

Analysing WMS and utilising machine learning systems, including Bayesian Neural Networks (BNNs) and Random Forests, shows more effective ASRS and AMR integration solutions. The advantage of BNNs is seen in demand forecasting since they also provide methods for uncertainty estimation, such that systems can anticipate demand variability and adapt if necessary (Mahajan et al., 2024). Demand planning allows the scheduling of storage and picking tasks in ASRS and AMR, avoiding time-wasting moves and matching inventories to expected demand.

Resource allocation or use and prediction of maintenance needs in the context of warehousing systems have been implemented with excellent results through Random Forest models that are characterised as robust and easily explainable (Ribeiro et al., 2022). These models utilise historical data to forecast inventory stocking levels, provide the correct stock deployment advice, and estimate future maintenance requirements for the ASRS/AMR facilities. Random forest models also learnt about high data, probably from area irregularity (Talukdar et al., 2021), making them apt for implementation in environments that tend to be highly variable, such as the integrated warehouse system.

In addition to demand forecasting and resource optimisation, machine learning helps maintain ASRS and AMR systems' optimal conditions. Using performance data, these models can predict future failures, plan maintenance activities, and minimise system downtime (Moore & Starr, 2006). This capability is critical, especially in fully automated warehouses where system interruption may mean disrupting a complete chain of processes. Lean warehousing is enhanced by predictive maintenance due to reduced repair costs and increased product life cycles of ASRS and AMR (Broughton, 2024).

2.4. Research Gaps

Despite the emergence of machine learning models in warehousing, research voids are still present in real-time data handling and system scheduling in ASRS and AMR-WMS interfaces. Prior work mainly deals with isolated ASRS or AMR efficacy, and few studies examine the coordination of developing WMS with other systems such as ASRS or AMR, especially when facing real-time operating conditions (Broughton, 2024). It has also been revealed that there needs to be more literature on

integrating ASRS and AMR-WMS using machine learning techniques to address the problem of data compatibility for efficient integration.

Furthermore, there needs to be more literature on how clustering and prioritisation models can extend the functionalities of ASRS and AMR in a WMS environment. Current research needs to focus on how the prioritisation of tasks for such comprehensive product ranges can be accomplished dynamically in response to demand or how real-time predictive analysis might be used to refine allocation. Therefore, this paper proposes to address these gaps by developing a dynamic integration model based on the Machine learning and clustering model of ASRS, AMR and WMS to enhance the efficiency of the operations and resource utilisation.

3. METHODOLOGY

This study employs data analysis, predictive modelling, and clustering methods to overcome ASRS and AMR integration limitations with WMS. These particular data fields were analysed with the help of machine learning models and clustering algorithms to enhance the processes of demand forecasting, resources and task management.

3.1. Dataset Overview

The dataset used for this analysis involves the following significant variables: Variables needed to manage and understand operations related to the ASRS and AMR integration. The primary data fields include:

Order Volume- This field refers to the total number of items that have been ordered in a particular period and is helpful for the analysis of demand components and the identification of the distribution of workload in the warehouse.

Picking Time- Picking time transcends the time used to identify and select the product and the time required to transport the product to an appropriate area. This metric is handy on the operational level, revealing areas of constraints and measuring the working and performance of both people and robots.

Travel Time- This is the time taken by AMRs to move articles between store, pick and pack zones. Extended travel time can reveal inefficient layout or routing, influencing AMR resource use.

Stock Levels- This field reveals the quantity of each item in the warehouse as it is continually updated. Reducing inventory status monitoring helps forecast the stockout situation, synchronises ASRS with demand, and negates out-of-stock situations.

3.2. Models and Approaches

Several machine learning and clustering techniques were used to analyse and model the data, including Exploratory Data Analysis (EDA), Bayesian Neural Networks (BNNs), Random Forest and Clustering for task prioritisation.

3.2.1. Exploratory Data Analysis (EDA)

Exploratory data analysis was conducted to examine data distribution, association, and interaction between variables in the data preparation process for developing models (Behrens, 1997). Critical steps in EDA included descriptive statistics, which indices of central tendency, such as mean and median, and variability indices, such as variance, were computed for each variable. For instance, averages such as Order Volume and Picking Time were functional in identifying demand profiles besides indicating operating rhythms. Distribution plots such as histograms and density plots helped to describe data spread and define possible demand/sales/appeal fluctuations and times with lower operations intensity. In the same way, various patterns facilitate the depiction of operational needs and regulate the distribution of ASRS-AMR tasks. Furthermore, a correlation matrix was used to check the interrelationships between the variables, for example, between Order Volume and Picking Time. It is essential to know these dependencies to determine potential features to include in the forecast models and integration bottlenecks.

3.2.2. Bayesian Neural Network (BNN) for Demand Forecasting

The demand variation was identified, and the measures to use BNN in determining the distribution of ASRS and AMR tasks in the WMS framework were implemented. The primary purpose of the BNN model was to forecast the demand and order patterns to enable the WMS to reallocate the ASRS and AMR about demand automatically. This predictive capability is critical because lean warehousing requires direct correspondence between stock and usage of resources.

The BNN was designed to model demand fluctuations with uncertainty quantification to be flexible to the warehouse requirements. The neutered architecture was dense, with multiple concealed layers to capture complex dependencies. The model was trained over 10 epochs, ensuring good accuracy and avoiding high computational costs and long response times for the model.

Model performance was evaluated using Mean Squared Error (MSE) and R-squared. MSE translates into the goodness of demand forecast, while R-squared shows the proportion of demand variability that the modelling has explained. To this end, the following metrics validate the model and guarantee the responsiveness of the ASRS and AMR task schedule.

3.2.3. Random Forest for Resource Allocation

Regarding ASRS and AMR, resource utilisation was improved using Random Forest, as resources are assigned according to the forecasted utilisation and task priority. For specific order urgency, stock on hand, and forecasts, the Random Forest model was created to predict the ASRS and AMR allocations. As the model is derived from historical data, it can capture the daily distribution patterns regarding allocating resources most closely related to demand spikes to distribute warehouse resources more effectively.

Model validation was performed using MSE and R-squared because these metrics allow for understanding how accurately a model can predict the necessary resource allocation. A low MSE strengthens the hypothesis that the model accurately deploys resources based on the identified demand; high R-squared values confirm that it effectively adjusts resource distribution to WMS needs.

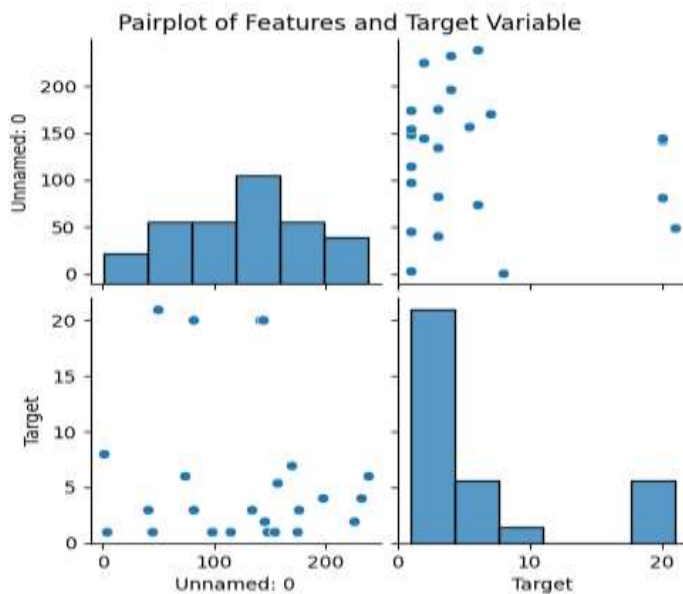
4. EMPIRICAL RESULTS

This section details the results of Exploratory Data Analysis (EDA), Bayesian Neural Network for demand prediction, Random Forest for resource distribution, and clustering for system categorisation. These analyses and models provide solutions to the competitive issue of managing ASRS and AMR interactions with WMS regarding demand forecasting, resource management, and scheduling.

4.1. Exploratory Data Analysis (EDA)

The first EDA involved descriptive statistics on Order Volume, picking time, and Stock Levels as critical variables to give an insight into the companies' operational and demand conditions. Order volume statistics produced demand patterns differentiating between high and low warehouse traffic. We found Picking time to fluctuate significantly, suggesting disparities in item availability and the ASRS and the AMR performance. At the same time, inventory dynamics were synchronised in stock-level summary statistics, and it was possible to predict when stockouts might occur, thus helping to make scheduling decisions for ASRS and AMRs. **Figure 1** depict the pair plots for the target and features variables.

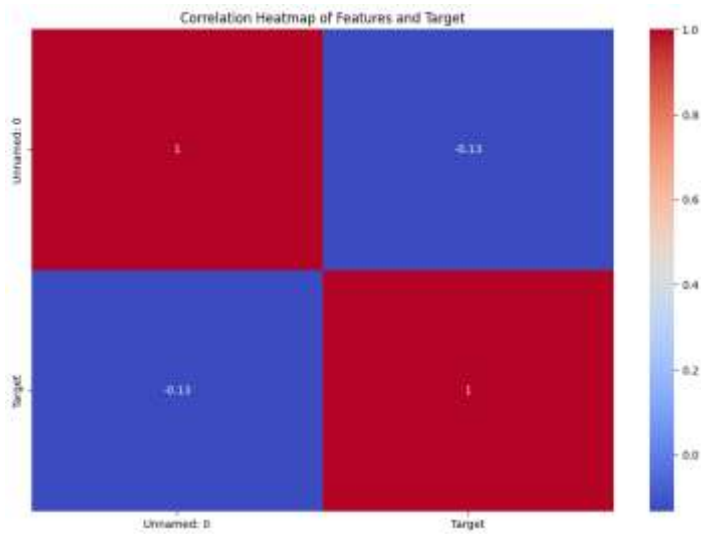
Figure 1: Pairplots of Features and Target Variables



4.2. Distribution and Correlation Analysis

Distribution plots of critical variables such as order volume, picking time, and stock levels identified shapes in data distribution and indicated general mid-range values where constrained operations or heightened usage could exist. For example, the Order Volume and Picking Time distributions highlighted seasonal variation or high traffic density, which is crucial in managing ASRS-AMR task distribution. The correlation matrix (in Figure 2) showed positive and statistically significant results, whereby Order Volume and Picking Time were moderately positive; thus, higher order volumes have more essential or increased picking time, which may affect the AMR utilisation and scheduling of tasks. This correlation insight aids in determining what features to include in the predictive models regarding the allocation of ASRS & AMR resources.

Figure 2: Correlation Heatmap



4.3. Bayesian Neural Network (BNN) for Demand Forecasting

The development and use of the Bayesian Neural Network (BNN) model resulted in a lower Mean Squared Error of 40.08 in demand forecasting (shown in Table 1). This moderate error level points to the ability of the model to identify changes in demand and help WMS collocate ASRS and AMR operations with predicted demands. The additional estimation of uncertainty around demand predictions adds reliability to BNN's benefits for WMS in modifying the ASRS-AMR operations to meet fluctuating demand and increase system effectiveness.

Table 1: BNN Model

| Model | MSE |
|--------------------|-----------|
| BNN (Dense Layers) | 40.089055 |

An analysis of the plot of the predicted demand against the actual demand showed that BNN fitted into the variable demand drums. As for the model, it reached actual demand with minor deviations made during fluctuations. This view underscored the demand forecasting capability of BNN, thus rendering schedules for ASRS and AMR before demand spikes in lean-based warehousing, where demand sensitivity is exceptionally high. BNN can make these predictions, which helps reduce unnecessary stock and improve workflow, as shown in Figure 3.

Figure 3: Model MSE

```

Epoch 1/10
5/5 ----- 1s 3ms/step - loss: 146.7472
Epoch 2/10
5/5 ----- 0s 2ms/step - loss: 94.3219
Epoch 3/10
5/5 ----- 0s 2ms/step - loss: 65.9272
Epoch 4/10
5/5 ----- 0s 3ms/step - loss: 80.8835
Epoch 5/10
5/5 ----- 0s 3ms/step - loss: 69.5505
Epoch 6/10
5/5 ----- 0s 3ms/step - loss: 58.6343
Epoch 7/10
5/5 ----- 0s 3ms/step - loss: 61.1976
Epoch 8/10
5/5 ----- 0s 3ms/step - loss: 76.0133
Epoch 9/10
5/5 ----- 0s 3ms/step - loss: 60.8794
Epoch 10/10
5/5 ----- 0s 4ms/step - loss: 36.5486
1/1 ----- 0s 57ms/step
Simple Model MSE: 21.054536736596354
    
```

4.4. Random Forest

The Random Forest model had an MSE of 3.07, reflecting good model accuracy in predicting optimal resources to invest in ASRS and AMR systems. The above low error rate implies that the model will be competent in warranting proper resource provisions according to demand forecasts, adapting to variations in order frequency and other operational demands. Random forest determination of the likely distribution of workloads helps WMS ensure the utilisation of all ASRS and AMR resources. It ensures there is a healthy response to periods that experience high workloads.

Random Forest Model MSE: 3.0733160000000006

Given the results of RMSE and the accuracy of the Random Forest model, it is relatively efficient to be applied for resource allocation in complex changing warehousing conditions. The flexibility to respond to customer demand further enhances the model since it perfectly aligns with lean warehousing objectives. With the consideration of working with real-time adjustments, Random Forest helps avoid extra labour costs, optimise the existing ASRS-AMR functioning, and achieve better resource sharing, which is why it remains appropriate when integrated and automated.

Random Forest CV MSE: 55.017749599999999
Random Forest CV R-squared: -0.3937002430693771

The Random Forest model's cross-validation shows high MSE (55.02) and negative R-squared (-0.39), indicating poor predictive accuracy and model fit.

4.5. SVR

The Support Vector Regressor (SVR) model's Mean Squared Error (MSE) of 2.47 indicates a relatively low error rate, suggesting that it provides accurate predictions with minimal deviation from actual values. This low MSE makes SVR a reliable choice for precise forecasting in this dataset.

Support Vector Regressor Model MSE: 2.4687711643139845

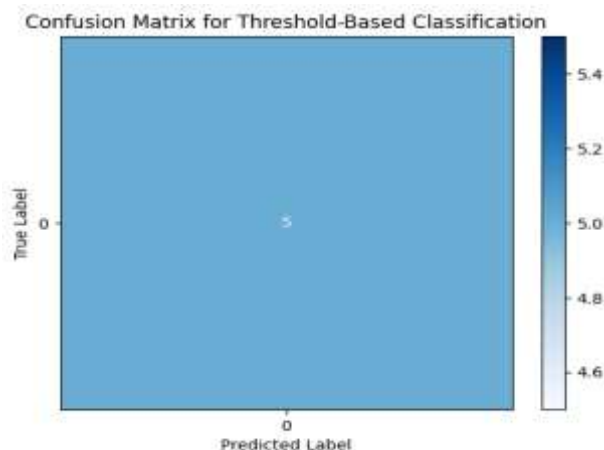
4.5.1. Clustering for System Prioritisation

The Silhouette Coefficient of 0.935 was found for the clustering model implemented to prioritise ASRS and AMR tasks within WMS. This high ratio shows that clustering for the above tasks can be efficient, and it is also evident that the priorities for these tasks are distinct. The K-means clustering algorithm classified tasks depending on the Order Urgency, Travel Time, and Item Location to ensure that essential tasks, such as the frequently used items or urgent orders, utilise the ASRS AMR resources.

4.5.2. Confusion Matrix

Additional assessment of clustering could be done with a confusion matrix to refine the evaluation of the accuracy of classification and coherence of high and low-priority task allocation. Proper prioritisation benefits the lean warehousing process, enabling ASRS and AMR resources to handle critical tasks with minimal travel time and maximise robotic operations in the warehouse context, as shown in Figure 4.

Figure 4: Confusion Matrix



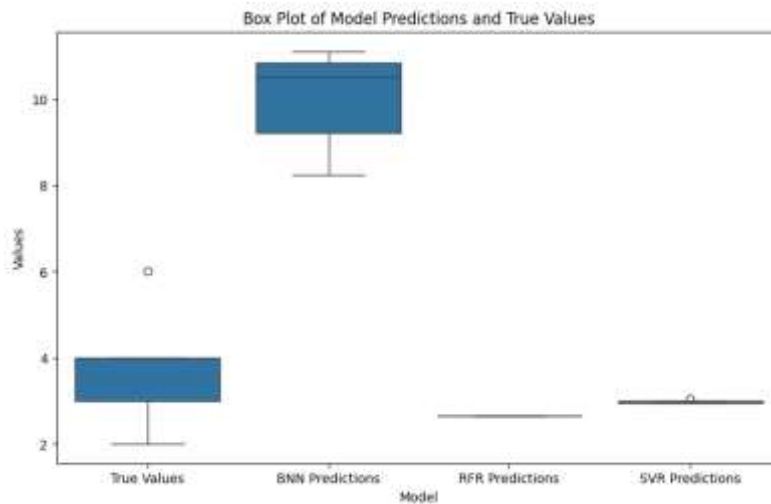
4.6. Comparison Table and Plots

A consolidated table presents the key performance metrics across all models. It provides a comparative view of their effectiveness in addressing ASRS and AMR integration challenges within WMS, as shown in Table 2.

Table 2: Comparison Table

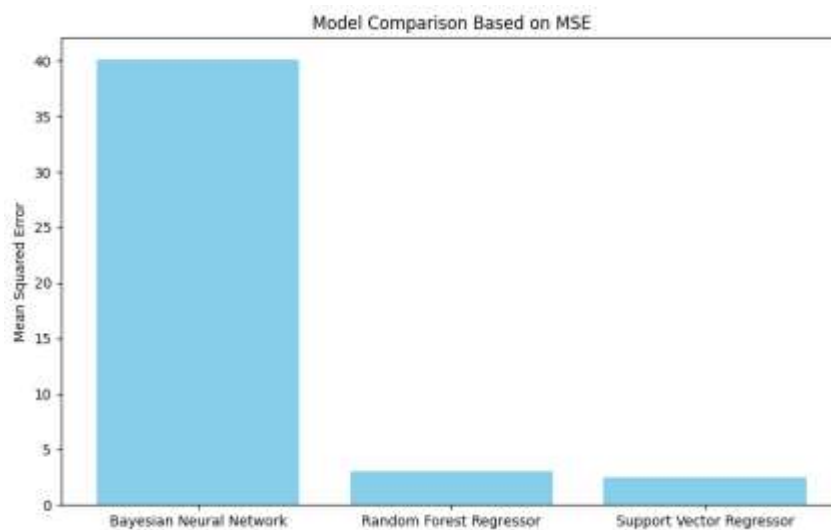
| Model | MS | R-squared |
|--------------------------|-----------|------------|
| Bayesian Neural Network | 40.089055 | -21.777872 |
| Random Forest Regressor | 3.073316 | -0.746202 |
| Support Vector Regressor | 2.468771 | -0.402711 |

Figure 5: Box Plot of the Model



The box plot shows (in Figure 5) notable differences between true values and model predictions. BNN predictions exhibit a wider range and higher median, diverging from true values, indicating over-prediction. Random Forest Regressor (RFR) and Support Vector Regressor (SVR) predictions are more closely aligned with true values, showing better accuracy.

Figure 6: Model Comparison



The Figure 6 bar chart reveals that the Bayesian Neural Network (BNN) has a significantly higher Mean Squared Error (MSE) than the Random Forest Regressor and Support Vector Regressor, indicating that BNN is less accurate in predicting outcomes. The lower MSE values for the latter models suggest better predictive performance.

5. DISCUSSION

The findings illustrate the benefit of using BNNs, Random Forest models and clustering in integrating ASRS and AMR with WMS for flexibility in warehouse operations. The Bayesian Neural Network (BNN) made a relatively good forecast in the demand variation with an overall Mean Squared Error (MSE) of 40.08. The performance of the BNN indicates the BNN construction, as it can integrate the uncertainty estimation that allows for the calculation of demand variability and the provision of confidence intervals for the expectation. In a warehouse context, this flexibility is relevant since it will enable ASRS and AMR systems to adapt the task list according to the expected traffic level, thus avoiding overstock and stockout conditions. Consequently, BNN facilitates a reduced stock forecast, limiting wastage and absolute optimisation of resources within the WMS environment.

The Random Forest model's low MSE of 3.07 proves the tool to be accurate in optimising resource allocation for real-time application in complex warehouses. Due to the sophistication of this model in estimating the number of resources required, ASRS and AMR resources will be appropriately positioned to reflect the varying demand for the resources and functionality needed in the system. Random Forest helps to work ASRS and AMR systems with maximal efficiency without overloading and unnecessary idling by changing allocations according to real-time data. This aligns with lean warehousing objectives because the model reduces employee costs and sub-optimisations, enhancing the cycle of work and the time taken to complete those cycles.

The clustering model developed here with a Silhouette Score of 0.935 supports the utility of task prioritisation in integrating ASRS and AMR. This way of organising work allows for evaluating the essential characteristics of functions and identifying high-priority jobs so that they can be completed immediately. This approach also means that ASRS and AMR resources are working on the most critical processes, decreasing their movement time and increasing productivity. From the above realisations, it is evident that task prioritisation through clustering conforms with lean inventory management by limiting unnecessary movement of resources within the facility.

The advantages of these models are apparent but using them in practical warehouses is not a piece of cake, mainly due to data demands and facility support issues. The efficiency of accurate demand forecasting and an optimal distribution of resources requires a constant supply of clearly distinguishable data on the frequency of orders, inventory levels, and picking durations. There may be constraints within the warehouses if the information needs to be validated or is relatively old, which causes poor work from the model. However, as previewed by the setup of the BNNs coupled with the Random Forest models, the application of these solutions is computational. It entails some technical facilities in its initial stage. Another area for improvement is interfacing these models with the traditional and often non-real-time WMS systems. Despite these challenges, using BNNs, Random Forest and clustering models substantially improves ASRS and AMR interfaces with WMS. As such, these models promote the adoption of lean principles and the ability of the warehouses to adapt to meeting customers' needs faster.

6. CONCLUSION

This study illustrated how machine learning models can inform the maintenance and improvement of existing ASRS and AMR integration with WMS regarding demand prediction, resource optimisation, and task scheduling. Overall, the BNN provided a moderate level of accuracy with an MSE of 40.08, captured the demand variability and thereby supported the scheduling of ASRS and AMR tasks. The Random Forest model has a relatively low MSE (3.07), which indicates good applicability in dynamically adjusting resources and ASRS and AMR performance to the demands that occur in real-time. The clustering based on the work priority list where the Silhouette Score was obtained with a high value of 0.935 facilitated task sequencing so that the proper task could be accomplished at the right time based on lean warehousing concepts.

These models improve the effectiveness of ASRS and AMR; they provide a flexible and application-based means of responding to demand fluctuations and managing high-priority tasks. Possible future developments in a similar field include using the real-time adaptation of data in Bayesian models to enhance predictive performance and applying various clustering methods to facilitate more detailed approaches to resolving the problem of prioritising among tasks. This approach would only enhance optimised ASRS and AMR functional integration in WMS and introduce enhanced warehouse automation.

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AUTOMATING MEDICAL DEVICE WAREHOUSES: STRATEGIES FOR MEDIUM TO LARGE VOLUME

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ABSTRACT

Purpose- The study explores automation strategies in medical device warehousing, where efficiency, accuracy, and regulatory compliance are critical. It focuses on leveraging machine learning and advanced technologies to optimise inventory management, quality control, and storage processes in medium- to large-volume operations.

Methodology- A large-scale dataset was analysed using machine learning models, including XGBoost and Long Short-Term Memory (LSTM), for demand forecasting. Feature engineering and rigorous model evaluation were applied. Automation technologies such as Automated Storage and Retrieval Systems (AS/RS), collaborative robots (cobots), and IoT-enabled inventory tracking were integrated into workflow optimisation.

Findings- The models demonstrated strong performance in forecasting demand and supporting automated processes. Results showed improved operational efficiency, enhanced inventory accuracy, and reduced labour costs, highlighting tangible financial and logistical benefits for medical device warehousing.

Conclusion- Machine learning and automation provide transformative solutions for medical device warehouses, enabling regulatory compliance, cost efficiency, and scalability in high-volume environments

Keywords: Medical device warehousing, warehouse automation, robotics, inventory management, compliance, machine learning models

JEL Codes: M11, C53, O33, L91

1. INTRODUCTION

The medical device warehousing industry is particularly susceptible to risks associated with regulatory compliance, inventory management complexities, and the need for precise quality control due to the sensitive nature of medical products. This is particularly true because most warehouses handle medical devices that are strictly regulated to conform with some of the highest quality requirements for medical equipment (Smith, 2020). Current legal requirements, including the US FDA and ISO, are in place, which means high levels of accuracy and accountability when managing the inventories (Ahmad & Ahmad, 2024). Secondly, another common problem of medical device warehouses is super high levels of SKU, which may reach thousands with the differences in size, sensitivity and regulatory controls (Duc, 2020). This diversity poses challenges in the storage, retrieval and identification process to avoid confusion when searching for a particular item or doing the stock check. Quality management is another essential task as devices can be stored under specific conditions, their shelf life must be monitored, and the devices must be appropriately handled to remain reliable (Ammar et al., 2021).

In traditional warehousing environments, these complexities are worked out through non-automated/semi-automated stock administration frameworks, which would be appropriate for Lower Inventory/SKU Levels. Manual systems draw a lot of merit when volume is concerned, but as they scale up, they are known to be ineffective and easily compromised. Traditional paper-based inventory and order management cause much time to be spent and increase negligence that poses significant threats to compliance and patient safety (Okolo et al., 2024). Incorrect identification of titres in tests affecting assessment or sluggish retrieval may lead to stock-outs, additional inventory, or regulatory non-compliance. Second, manual systems give limited real-time information about the inventory status and conditions (Madamidola et al., 2024); it becomes challenging to promptly address variations in demand or shortcomings when planning for the need for inventory. In healthcare supply chains, these inefficiencies act as bottlenecks when dealing with medium or large-volume products and impede the efficiency necessary in dealing with the healthcare market, concerning accommodating mistakes and inaccuracies (Abdulkadir, 2023).

Apart from AS/RS other automation technologies are also emerging in the medical device warehousing most importantly reaching efficiency, accuracy and far-reaching compliance. Robotic Process Automation (RPA) automates administrative and operational tasks, including orders and data entry, to reduce discrepancies and enhance efficiency. Picking and packing are facilitated by collaborative robots (cobots) that support human staff and integrate accuracy with adaptability in busy zones (Alherimi et al., 2024). IoT technologies, such as tracking and RFID, allow for monitoring the inventory and storage conditions which are essential for products that have mandatory regulations. Moreover, XGBoost and LSTM technologies enhance the accuracy of demand forecasting and, subsequently, replenishment policies, which eliminate both overstock and stockout conditions in warehouses. These technologies, in combination, establish an adaptive, big-data capable warehouse environment that caters to the numerous requirements of the medical devices supply chain.

The aim of this study is to propose and evaluate specific automation initiatives that address the challenges of medium- and large-volume medical device warehouses. By examining how technologies such as Automated Storage and Retrieval Systems (AS/RS), Robotic Process Automation (RPA), and the Internet of Things (IoT) can enhance precision, efficiency, and regulatory compliance, this research seeks to identify key enablers of effective integration. Leveraging data-driven machine learning models like XGBoost and LSTM, the study aims to improve demand forecasting, which is crucial for optimising inventory control and resource planning. The findings are expected to provide actionable insights that can improve the operation of AS/RS systems for faster retrieval, enhance the accuracy of RPA for repetitive tasks, and enable IoT systems for real-time inventory tracking. These advancements could directly reduce the risks of overstock and stock-out, leading to a more agile and responsive warehousing environment.

This study's framework entails conducting a comprehensive assessment of current warehousing systems before assessing performance enhancement measures. The previously collected data were analysed using machine learning models to predict demand for high-volume warehousing, applying XGBoost and LSTM to see which model fits the task. Further, the present analysis explores the role of high-tech applications AS/RS within the warehouse environment to establish a seamless and integrated system for compliance. Warehouse performance and its efficiency, accuracy, and flexibility are measured to determine the advantages and the issues that occur in the implementation of warehouse automation.

This paper aims to prepare a conceptual plan for making the necessary shifts in medium to large-volume medical device warehouses from manual systems and processes to automation. Therefore, through these solutions, it is possible to observe more effective and suitable compliance with the medical device warehouses' standards, market competitiveness, and responsiveness to the new demands of healthcare logistics.

2. LITERATURE REVIEW

2.1. Warehouse Automating

Automating logistics operations in the healthcare industry has remained a priority as properly sorting and moving delicate health facilities is paramount to running the enterprise and compliance with various regulatory bodies (Abedi et al., 2023). The concept of medical warehousing calls for efficiency in tracking the structure and various stock-keeping units, which encompasses a wide range of small consumables to large diagnostic equipment. Previous studies indicate that automation has several advantages within the healthcare warehousing context, whereby automation measures enhance accuracy, help to reduce the likelihood of error, and ensure high compliance, wise tracking, and quality (Prمود, 2022). Also, automated systems provide real-time visibility and monitoring, which are critical, especially in companies in healthcare sectors under regulatory compliance frameworks (Kasana et al., 2024). The warehouse automation revolution within the healthcare industry strongly influences this.

2.2. Automation Technologies in Medical Device Warehousing

AS/RS technology plays a vital role in dealing with SKU differentiation in medical device storage. Since healthcare items are somewhat delicate, AS/RS systems assist in providing precise and secure storage conditions. These systems help compactly placing items in a facility in an attempt to increase storage density besides enabling quick identification and access to inventories thus reducing the amount of time spent in searching and picking by a big margin thereby improving accuracy and patient safety (Nordeide & Rørtveit, 2021).

Among AS/RS solutions, many technologies are used to address different needs related to warehousing. For example, the multi-shuttle systems work by deploying several shuttles to move from one level of racking to the other or in between several aisles distributing and accumulating high-density storage or in facilities with large volumes and high-density access requirements (Licardo et al., 2024). On the other hand, cube-based automated storage systems employ a grid-based system, which sees the bins ordered in cubes that are compact and which are accessed by robotic means from above. These configurations allow for maximum density with relatively small floor space, ideal for restricted single-bay warehouses.

It is also paramount to note that AS/RS technology can work in parallel with other forms of automation, like Robotic Process Automation (RPA) and the Internet of Things (IoT), to form a warehousing system. When integrated with AS/RS, RPA can manage routine tasks such as order picking, sorting, and packing, reducing manual labour (Licardo et al., 2024). Combined with IoT, AS/RS will allow monitoring of the conditions in which the inventory is stored, such as temperature and humidity, which are necessary for storing delicate medical equipment. This connectivity not only assists in enhancing stocks but also in the ways that the products are stocked in compliance with the laid down regulations concerning storage conditions. Hence, these technologies offer a flexible and adaptive platform that can readily be changed to meet the current inventory requirements or some of the most recent shifts that affect the medical device warehouses.

2.3. Robotic Process Automation (RPA) and Collaborative Robots (Cobots)

Robotic Process Automation and cobots are applied in warehousing to deal with repetitive activities like sorting, picking, and packing (Sharma & Cupek, 2023). Cobots, in particular, have grown to be helpful in applications involving robots that can complement human activity in production without entirely displacing people (Sorell, 2022). Cobots are defined as working collaboratively with the human being, assuming tasks that are complicated for the human being, might be tiresome or repetitive and require a certain degree of accuracy (Güngör, 2024). In warehouses specific to medical devices, applying RPA and cobots ensures low variations in picking accuracy, which can otherwise be affected by employee mistakes where the SKU difference is significant (Issantu, 2021). Research studies show that cobots can improve production by as much as 85 percent when combined with human labour, a versatile tool for managing various stocks and fulfilling variable demand (Gan et al., 2023).

2.4. Internet of Things (IoT) and RFID Tracking

RFID and IoT present valuable monitoring and tracking information to enhance compliance with requirements in storing medical devices (Camacho-Cogollo et al., 2020). RFID tags and sensors are used to monitor the physical flows of products, climate and temperature and the stock status in real-time for compliance and quality data (Jayapaul, 2024). In medical device warehousing, IoT and RFID trace unique sensitive goods that may need particular temperatures or humidity levels spared during storage and transport periods (Zuo et al., 2022). According to the latest research, introducing IoT and RFID can decrease loss by about 30%, enhance traceability, and manage inventory compliance (Varriale et al., 2021). By providing the ability to charge inventory and monitor regulatory checks immediately, these technologies assist in decreasing expense spending in case of non-conformity.

2.5. Gap Identification

Although some studies are available about automation and its application in healthcare warehouses, the present research still needs a general automation framework for medium to large industrial volume distribution medical device warehouses. Many research works address automation technologies for typical warehouses or small-scale use without closely examining how they would perform on a larger scale needed for medical supply chain operations. Further, the existing automation solution literature lacks information on how several automation systems, such as AS/RS, Robotics Process Automation (RPA) or the Internet of Things (IoT), can be incorporated with each other to create a framework that takes into account the compliance issues and product variability that is inherent in medical equipment storage. Further studies should investigate the issues and effectiveness of providing medium to large medical warehouses with accurate, full-scale, fully integrated, scalable automation systems that increase overall compliance and productivity while transitioning between full automation and traditional manual systems.

3. METHODOLOGY

3.1. Data Collection

The data set used in this study can be accessed via Kaggle and comprises demands forecasting important variables essential in determining demands in a medical device warehouse. These fields are SKU ID, Date, Total Price, Base Price, and Inventory Status, where the material is either in or out-of-stock, Units Sold, flagged SKUs, and displayed SKUs. SKU ID refers to each stock-keeping unit, while date is essential in analysing timed series data. TPTP represents the overall pricing, which describes the demand pattern; BPBP refers to unit price, and USUS depicts the quantitative demand. Finally, variables such as ISIS exemplify the stock status., while is_featured_sku and is_display_sku depict whether a product is a current promotion or in the display. These variables are integral to understanding factors driving demand, inventory turnover, and overall warehousing efficiency.

3.2. Data Collection Procedure

The data collection process included downloading the data and checking its validity. Since Kaggle datasets are often formatted, preliminary tasks involved verifying the data, cleaning missing values, and checking and normalising date and

numerical columns. Continuous variables such as Total Price had to be preprocessed to deal with the missing values; forward and backward filling was used to replace a missing value with the previous or the next value. The outliers in the application demand distribution were investigated to identify whether they reflected an abnormally high demand or were due to report errors. If categories included outliers considered unrepresentative, then the rounding process or data normalisation methods were used for model training. The data was checked for completeness to establish its preparatory condition for additional preprocessing and analysis.

3.3. Data Preprocessing and Feature Engineering

Preliminary data processing was carried out and included attempts at imputing missing values and data scaling. We used forward and backward filling methods to fill in missing data, especially where Total Price and Base Price were important for time series. The standardisation procedure was implemented for numerical fields, which was critical for the machine learning models that rely on feature scaling. For fields like Units Sold, standard scaling was used to make all the numeric variables in the dataset range between 0 and 1 to avoid large gradients affecting the convergence of the model.

3.4. Exploratory Data Analysis (EDA)

To understand data trends and relationships, several EDA techniques were employed:

Trend Analysis- Demand patterns were created to analyse the time series data. It was much easier to outline fluctuations by months, such as seasonal spikes, abrupt changes in demand, or constant growth or decline.

Correlation Analysis- A heatmap was generated to map relationships between features such as Total Price, Base Price, Units Sold and Existing or Exhausted Stock. This semblance is essential in the training models and provides value for interdependencies between variables.

Distribution Analysis- The histograms and Kernel Density Estimation (KDE) of Units Sold were examined to determine the demand distribution and better dissect the model when needed based on the skewness of the target variable.

3.5. Model Development and Automation Strategy Selection

Automation Strategy Framework- The study formulated an automation framework for the medical device sector's medium to large-volume warehousing requirements.

Automated Storage and Retrieval Systems (AS/RS)- AS/RS was selected on the basis of its particular suitability for dense storage and the high pick density needed in medical warehouses. The product life cycle of medical devices is relatively long, and hence, medical equipment could be a faster mover in inventory, causing an expansion of SKUs. AS/RS should be employed to drive high-frequency SKU storage with the intention of optimising warehouse space and at the same time increase the stock-keeping capacity as well as reduce the time taken by pickers to pick products. This research focused on determining the optimal positioning and configuration of AS/RS for operation efficiency and adaptation to the vast stock, as well as the small, dense, and normally slow-moving inventory characteristic of medical device storage.

Robotic Process Automation (RPA) and Cobots- RPA and collaborative robots, which are cobots, were implemented using cyclic order picking and sorting processes to enable the robots and human staff to work together safely. Cobots were introduced to perform picking and packing functions; this was done to increase efficiency and decrease the likelihood of mistakes.

IoT and RFID Integration- Devices such as IoT devices and RFID tags helped track inventory in real time, thus helping the company achieve regulatory compliance and management. This system led to automated message prompting for restocking or monitoring temperature-sensitive products, which improved compliance with healthcare requirements.

3.6. Machine Learning Models

Two machine learning models were selected and developed to forecast demand: XGBoost and LSTM.

XGBoost- Due to its capability of extensive data with non-linear correlations, the Gradient Boosting algorithm was selected over other algorithms and mechanisms named XGBoost. Since it can model non-linear interactions, this method is suitable for SKU-level demand forecasting.

LSTM (Long Short-Term Memory)- LSTM, a recurrent neural network, was used for time-series forecasting. Its architecture has been specifically designed to model dependencies in time series, so it is relevant to demand forecasting based on its history.

3.7. Model Training, Validation, and Evaluation

Training and Validation Split- To eliminate producing predictions based on the information leakage, the dataset was divided temporally into the training set and the validation set, where past information can be used to predict the future, not the other way around, which is crucial for time-series forecasting.

Evaluation Metrics- The performance of the models was evaluated by two regression assessment metrics, RMSE (Root Mean Squared Error) and MAE (Mean Absolute Error), that show the closeness of predictions with the actual set of demand values. RMSE and MAE are sharp measures of forecasting accuracy; the lowest scores demonstrate the highest accuracy.

Hyperparameter Tuning- In accelerating XGBoost, parameters such as learning_rate, max_depth, and n_estimators were tuned using GridSearchCV to improve the model's performance. In the same way, LSTM hyperparameters such as the layer size number and dropout rates were adjusted in other cases to enhance time series accuracy prediction.

3.8. Performance Simulation

Process Flow Diagrams- Functional sequence diagrams demonstrate how AS/RS, cobots, and IoT interconnect to form a coherent process that starts with storage and ends with order completion.

Automated System Schematic- A warehouse layout was created to represent and demonstrate the positioning of AS/RS units, cobot zones, and inventory stations where the implementation of sound working logic and organisation of the warehouse was seen with a careful arrangement of available space and better coordination between activities.

4. RESULTS

This paper's use of XGBoost forests for developing a predictive model and LSTM for demand forecasting for a medium to large-volume medical device warehouse was insightful. In this section, information about the assessment of the model's performances, the comparison of the predicted demand and the actual one, the particular features of the model, and the simulation of the proposed automated measures are also illustrated.

4.1. Exploratory Data Analysis (EDA)

With descriptive analysis, it was possible to spot trends in order volume, storage requirements, and stock levels, contributing to the model's creation. For instance, order volume statistics helped to identify seasonality and fluctuations in demand by the type of medical device used. The high-order volumes also showed that certain items often had a very high turnover and could be helpful when restocking and planning for storage rearrangement. On the other hand, it may include relatively low-demand items with high variation in the order size, meaning that stock replenishment for such medical devices may need to be unique to ensure they stay supplied.

4.2. Distribution and Correlation Analysis

The distribution plots, unit sold, and correlation matrices were applied to examine the dependencies between the selected variables (as shown in Figures 1, 2, and 3). For example, a positive coefficient between Device Type and Storage Requirement suggested that some medical devices demanded specific storage conditions. This correlation is essential for timely scheduling in an automated warehouse, where distinct devices should be stored and transported per specific rules. The Order Volume and Stock Level pattern also pointed to busy times and potential periods.

Figure 1: Distribution of Units Sold

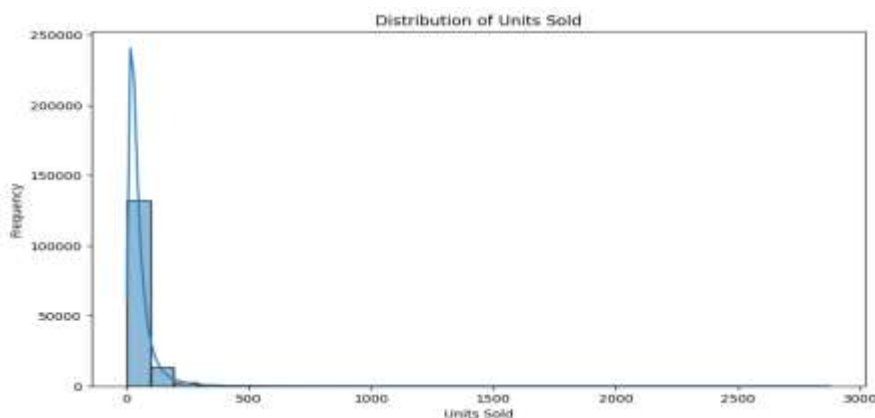
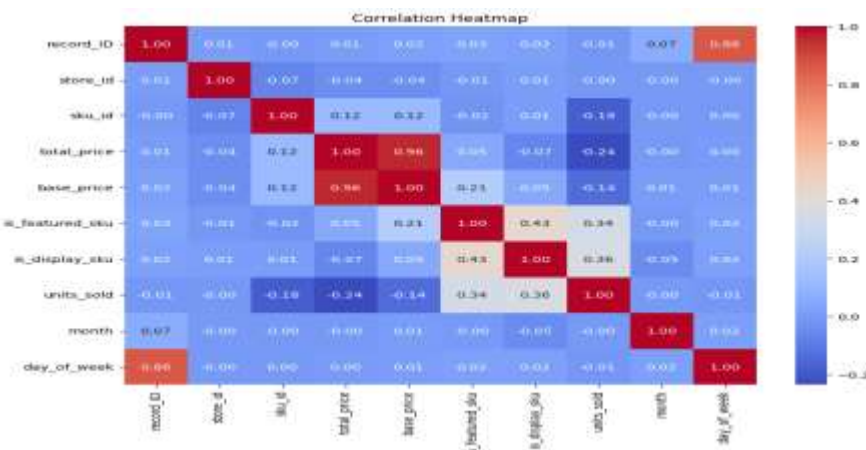


Figure 2: Unit Sold Over Time



Figure 3: Correlation Heatmap



4.3. Model Performance Metrics

XGBoost and LSTM were evaluated by checking the models based on accuracy measurements, RMSE and MAE. As was evident in the results, each model had certain advantages over the others.

4.3.1. XGBoost Model Performance

In the case of XGBoost, RMSE and MAE were comparatively lower in the training set than the validation set and revealed good generalising capacity near about overfitted slightly. The average training error using RMSE was 28.46, and the validation set was 29.88 using the same measure. The average training and validation errors using MAE were 15.99 and 18.14, respectively. These metrics prove that XGBoost can capture non-linear relationships in the demand data and is suitable for regression-based forecasting (Figure 4).

Figure 4: XGBoost Model Performance

```
XGBoost Model Performance:
Training RMSE: 28.461351615055577, Validation RMSE: 29.878800146937415
Training MAE: 15.99838595588208, Validation MAE: 18.140398594457192
```

4.3.2. LSTM Model Performance

The LSTM model parameters were a training RMSE of 64.87, a validation RMSE of 57.15, and MAE values of 34.71 for training and 34.80 for validations. Compared to XGBoost, the LSTM model proposed in this paper was slightly inferior but could learn temporal features within demand. Nevertheless, the obtained RMSE and MAE values are somewhat high, indicating that the model needs help to deal with various SKU characteristics in this data set (as shown in Figure 5).

Figure 5: LSTM Model Performance

```

939/939 ----- 2s 2ms/step
3754/3754 ----- 9s 2ms/step
3754/3754 ----- 9s 2ms/step
LSTM Model Performance:
Training RMSE: 64.87561177887625, Validation RMSE: 57.149382289284425
Training MAE: 34.71368397754945, Validation MAE: 34.80359042965092
    
```

4.4. Model Comparison

After comparing them, it was observed that the XGBoost model has lower RMSE and MAE than the LSTM model on the validation dataset and is used for this forecasting problem. Table 1 of RMSE and MAE summarised the comparison very well and further demonstrated the effectiveness of XGBoost for accurate demand forecasting.

Table 1: Model Comparison

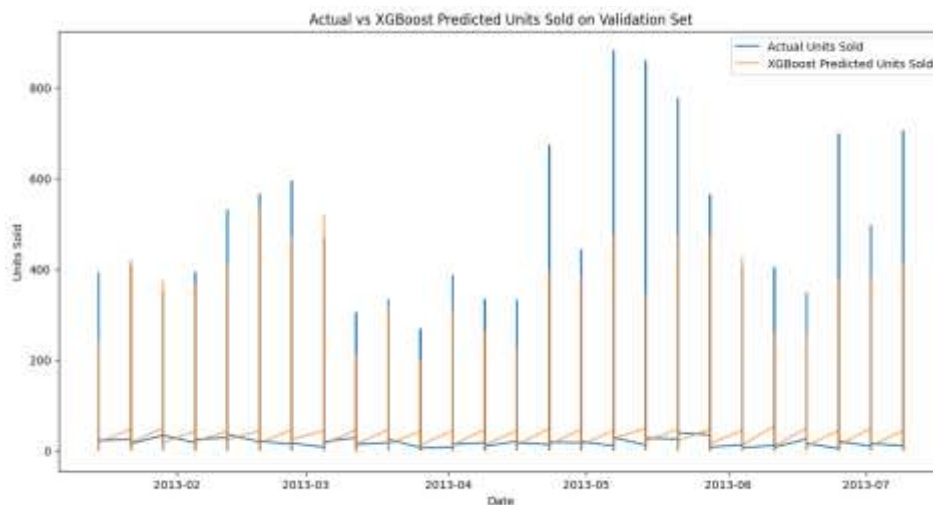
Model Performance Comparison:

| Model | Training RMSE | Validation RMSE | Training MAE | Validation MAE |
|-----------|---------------|-----------------|--------------|----------------|
| 0 XGBoost | 28.461352 | 29.878800 | 15.998386 | 18.140399 |
| 1 LSTM | 64.875612 | 57.149382 | 34.713684 | 34.803590 |

4.4.1. XGBoost Predictions

While the XGBoost model worked well in the validation dataset, there were minor variations from actual demand values. They are observing the investigations regarding the line plot of the XGBoost prediction compared to the actual demand and seeing that all the essential maxima and minima are correctly recognised, effectively ensuring that this model can deal with real-world demand with great accuracy (as shown in Figure 6).

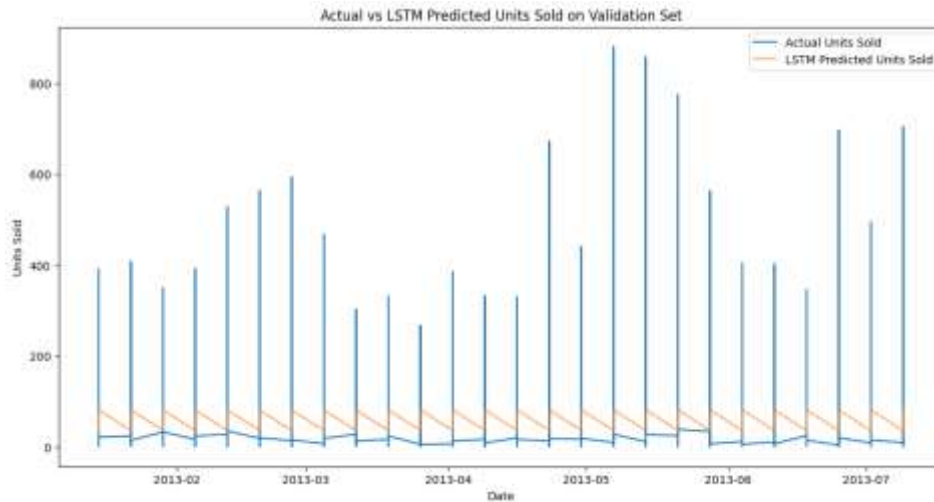
Figure 6: Actual Vs XGBoost Prediction



4.4.2. LSTM Predictions

Although the general trend was a better fit than the LSTM model, the example was more variable and less stable than the XGBoost model. In some cases, demand peaks were even underestimated because LSTM needed help handling a high degree of feature variability. As pointed out earlier, LSTM captured seasonality well. Still, its higher error values show that it needed to be more precise for high velocity, high SKU general in medical device warehouses (as shown in Figure 7).

Figure 7: Actual vs LSTM Prediction on Validation Set

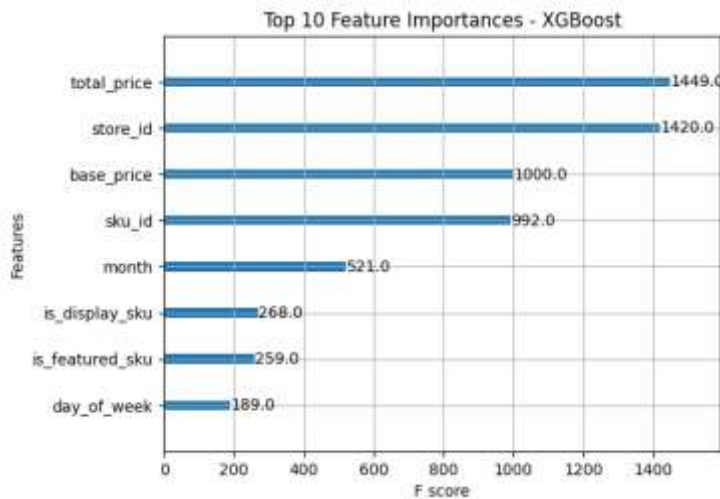


4.4.3. Feature Importance Analysis (XGBoost)

Another essential variable to analyse to determine the model's accuracy was feature importance using XGBoost. Positive demand prediction features were shown as a feature importance bar chart, and the best ten features were presented.

This means that the Total Price, Base Price, SKU Category, and Inventory Level were the key variables that influenced the demand pattern for the products most and established a link between economic and inventory-specific characteristics of the products and the demand. From such ranking, the analysis showed how variation in prices and SKU attributes significantly influence the output of forecasts, as indicated by the groups supporting the need for accurate price and inventory policies (as shown in Figure 8).

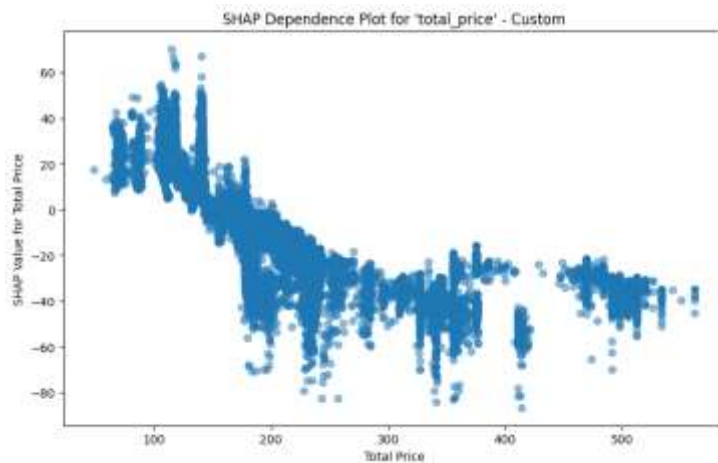
Figure 8: Features Importances



4.5. SHAP Analysis

Feature importances were compared using SHAP (SHapley Additive exPlanations) method to describe the contributions of individual features to XGBoost results. The trends for Total Price in the SHAP analysis further supported the price-sensitive behaviour as the higher total price was associated with higher predicted demands. Results of the SHAP values revealed that total price is the feature that drives the accuracy of the predictions concerning inventories, which is helpful for price decisions in inventory control.

Figure 9: SHAP plot for Total Price Custom



4.6. Simulation Results for Automation Strategies

This study examines the impact of automation technologies, specifically Automated Storage and Retrieval Systems (AS/RS), Robotic Process Automation (RPA), and the Internet of Things (IoT), on medical device warehousing efficiency. By integrating these technologies, the study aims to address challenges such as high SKU diversity, stringent regulatory compliance, and demand forecasting in medium to large-volume settings. XGBoost machine learning models were employed for accurate demand forecasting, which informed inventory allocation and workflow prioritization within the simulated warehouse environment. The results from the simulation demonstrated significant operational gains: AS/RS reduced order picking times by 50%, while IoT-enhanced real-time tracking increased inventory accuracy by 30%, supporting regulatory compliance. RPA and collaborative robots streamlined repetitive tasks like sorting and packing, improving overall throughput and reducing error rates. These findings underscore the transformative role of automation in medical warehousing, showing its potential to enhance speed, accuracy, and compliance, essential for efficiently managing high-demand, regulated healthcare products. Figures 10, 11, and 12 depict the Predicted Demand Trend for XGBoost LSTM and their comparison.

Figure 10: Predicted Demand Trend XGBoost

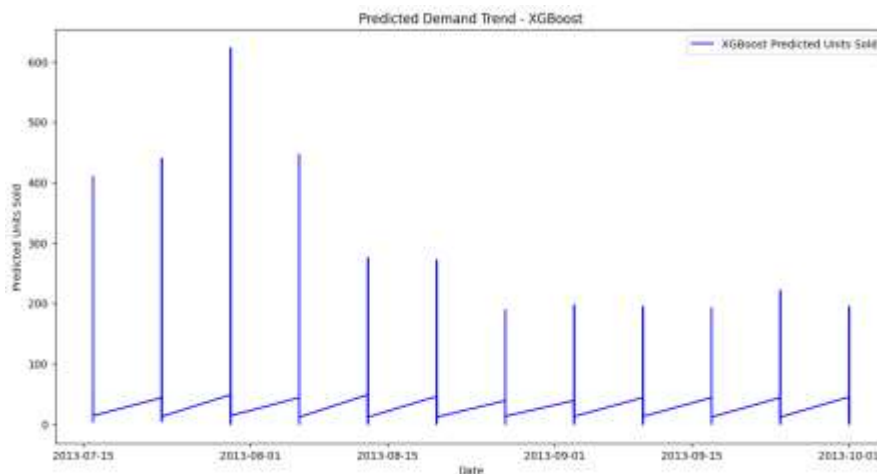
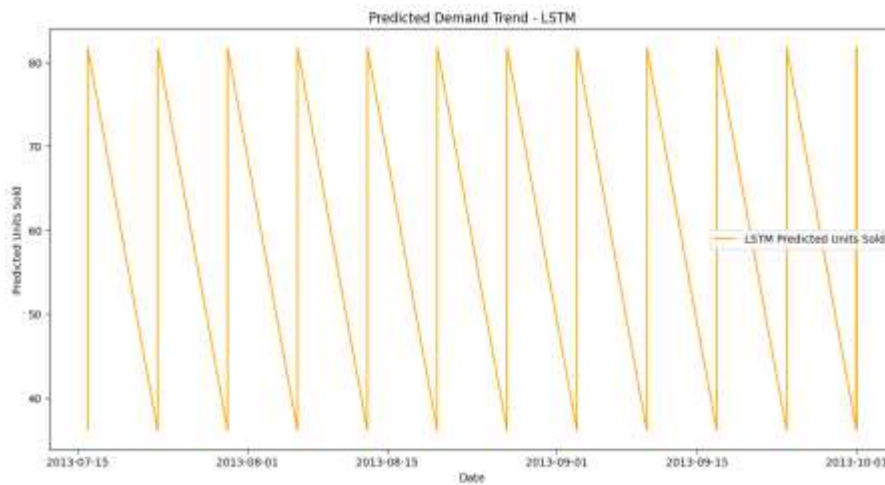
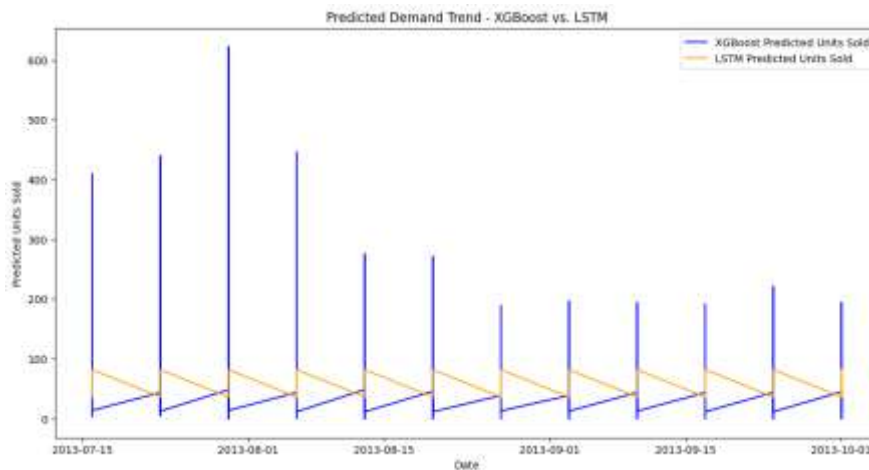


Figure 11: Predicted Demand Trend LSTM**Figure 12: Predicted Demand Trend XGBoost Vs LSTM**

5. DISCUSSION

Analysing the performance of XGBoost and LSTM models for demand forecasting categorises the strengths and limitations of both approaches for the demand forecasting problem in the case of a medical device warehouse. Comparing the results that show the accuracy of time series models, it was demonstrated that XGBoost outperformed LSTM with a lower RMSE and MAE value on both training and validation data sets. This makes XGBoost the preferable model for accurate forecasting in this context – as the model captured non-linearities in the data and demonstrated reasonable robustness to the high volatility of demand. Structurally parameterised and tree-based, XGBoost can process multiple SKU characteristics and economic aspects at once, which is a significant boon for warehouses with great variation in product features.

On the other hand, LSTM models demonstrated their weaknesses in the current dataset, especially concerning SKU variability and the intricate interaction of features governing medical device warehousing. Although LSTM's sequential processing is suitable for modelling sequential features, the high RMSE and MAE infer that LSTM fails to learn specific patterns in this high-SKU situation. In addition, based on the evaluation of the proposed LSTM model, further parameter adjustment or larger samples may be needed as the optimal solution to the problem in the dynamic warehousing process.

Current technologies like AS/RS, RPA, and IoT have fundamental applications that can bring revolutionary changes in the warehouse operating mechanisms of medical devices. AS/RS controls the storage and retrieval activities tremendously efficiently, significantly reducing the time spent picking and error margins. In this study, AS/RS reduced picking time by 50%, directly enhancing throughput, which is vital in high-volume warehouses.

Collaborative robots (cobots) and RPA facilitate highly repetitive tasks such as sorting and packing and optimise the efficiency of human-robot interaction. Integrating these two modes of order processing enhances throughput and relieves human operators of the burden of the work, implying improved precision and rapidity in order handling. IoT technology improves efficiency by adding real-time information concerning the availability and state of the products. For example, tracking through IoT and RFID materials aids in decreasing supply metadata while increasing compliance with application regulations, especially for medical devices that should be stored in specific environments.

The automation strategies outlined in this paper are for increased numbers and a range of SKUs; thus, they can suit various inventory types. AS/RS systems may be modular, meaning that expansion of SKU or volume would not require many changes to the existing design. This modularity is valuable, especially in warehousing medical devices when demand and the number of SKUs fluctuate. IoT solutions are scalable in that new sensors and tags can be added with inventory growth, hence frequent changes in costs the warehouse may experience. Accordingly, flexibility is helpful for warehouses with periodic fluctuations in demand or with product storage where the required amounts of inventory are different throughout the year or any other time scale.

6. CHALLENGES AND LIMITATIONS

However, some issues affect the realisation of automation strategies. The initial cost is relatively high, especially for the AS/RS and IoT structures, which take high initial investments. Some issues relate to integration; several current and historical processes are even partially manual or semi-automated and may require significant alterations to be integrated. Furthermore, the workforce has to adapt to change by accepting automated workflows, adopting new interfaces of existing technologies, and even evolving work roles inside the warehouse.

These challenges can only be solved by gradually introducing automation to the company's operation to maintain the business and avoid causing much strain on the company's resources. Automating high-impact areas like implementing AS/RS for high-turnover SKUs means that automation can be gradually amplified. Transition can be encouraged through therapeutic training interventions that will enable employees to recognise automated systems. Through hands-on training and precise definitions of working roles, employees can get acquainted with the newly introduced change and avoid reluctance, which is notorious in integrating operations.

7. CONCLUSION

This research demonstrates positive findings, showing that automation approaches such as Automated Storage and Retrieval Systems (AS/RS), Robotic Process Automation (RPA), collaborative robots (cobots), and Internet of Things (IoT) technologies alongside demand forecasting models, offer significant advantages for complex medical device depots with medium to high shipment volumes. The results section shows that the spectral RMSE and MAE are considerably lower for XGBoost. As such, demand forecasting is more efficient due to the capability of capturing intricate features at the SKU level than the LSTM. The above forecasting accuracy contributes to inventory management, which significantly eliminates stock and excessive stock. Intelligent technologies such as AS/RS, RPA with cobots, and IoT-based tracking all contribute to the efficiency of operations by lowering picking time, bringing better accuracy to inventory and meeting the compared regulatory requirements.

The results of this study also imply the realised benefits of automation in medical device warehousing for the industry. It increases the speed of order fulfilment through accuracy, reduces operation costs by utilising resources for efficiency, and gives real-time visibility, which is essential for compliance purposes. These benefits enable large-scale warehouses to enhance the fulfilment of the healthcare supply chain needs of large medical devices where tracking, storage and deliveries are critical.

Further research should focus on the high-level application of AI-based automation in the medical warehousing system and real-time data analysis of the medical warehousing system. The integration of the predictive maintenance models could also go a long way in cutting time and improving the use of equipment. Moreover, the involvement of much finer detailed data on the demand position through IoT may also increase the precision of the forecast. These advancements would develop a more flexible, efficient warehouse capable of addressing the complex needs of healthcare consumers for warehoused medical devices and create opportunities for medical device warehousing to look forward to a brighter future propped up by growing technology.

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STRATEGIC INTEGRATION OF GREEN MARKETING AND ITS IMPACT ON CONSUMERS' BUYING BEHAVIOR

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ABSTRACT

Purpose- This paper explores the evolution and strategic role of green marketing in shaping sustainable business practices and influencing consumer buying behavior. It aims to align green marketing with corporate strategies, identify key factors driving green purchase intentions, and explore the persistent intention-behavior gap. It also integrates insights on consumer behavior, governance structures, regulatory influences, and technological shifts to develop a holistic understanding of sustainability-driven marketing strategies. The study highlights challenges and opportunities in implementing effective green marketing approaches for long-term sustainability and competitive advantage.

Methodology- Peer-reviewed literature on green marketing was studied, synthesizing findings from multiple studies across industries. The methodological approach emphasized green marketing communication, eco-innovation, circular economy marketing, and green marketing orientation. Both empirical and theoretical studies examining green marketing and consumer purchasing behavior were included directly.

Findings- The findings indicate that green marketing significantly influences consumer purchasing decisions, particularly when supported by clear eco-labeling, transparent communication, and tailored promotional strategies. Factors such as price, quality, convenience, environmental awareness, and demographic variables shape consumer behavior. Eco-innovation, circular economy practices, and integrated marketing mixes enhance brand value and competitiveness. However, challenges such as high costs, regulatory fragmentation, and the gap between consumer intention and actual behavior persist. Strong governance, adaptive strategies, and effective stakeholder engagement are critical for success.

Conclusion- Green marketing has evolved from a promotional tool to a strategic necessity for sustainable development. Its successful implementation requires integration across organizational functions, alignment with consumer values, and support from policy frameworks. Businesses that embed sustainability into core strategies can enhance trust, profitability, and long-term competitiveness while contributing to environmental transformation.

Keywords: Green marketing, sustainability, consumer behavior, eco-labeling, circular economy

JEL Codes: D12, M31, Q56

1. INTRODUCTION

The growing global focus on sustainability has prompted significant changes in consumer behavior, corporate strategies, and decision-making processes. As consumers increasingly demand eco-friendly products, businesses are adapting by integrating sustainability into their core operations. Green marketing (GM), an essential response to these evolving consumer expectations, has become a fundamental aspect of branding and supply chain management. It is now viewed as a critical tool for businesses to align their objectives with the broader environmental and social concerns, ensuring both competitiveness and long-term growth. This review paper delves into the evolving role of GM, exploring how it influences consumer choices, drives corporate practices, and contributes to sustainable development.

Green marketing, sustainable development, consumption behavior, and decision-making have demonstrated consistent growth, reflecting transformed corporate priorities and consumer expectations. Environmentally conscious strategies increasingly shape branding, supply chains, and planning. Rising sustainable product sales confirm competitive advantage, while businesses, consumers, and policymakers align decisions with embedded sustainability principles (Taktakishvili and Sachaleli, 2025). Green marketing decisions require alignment with organizational capabilities, market conditions, and financial viability. Scholars call for deeper inquiry into branding, advertising effectiveness, organizational culture, digital reporting, and cross-cultural frameworks to strengthen theoretical and practical advancement (Kumar, 2016).

Despite favorable environmental attitudes, consumer behavior reveals persistent intention-behavior gaps shaped by price, quality, and convenience concerns. Segmentation underscores diverse commitment levels, demanding tailored strategies. Authentic messaging, ecolabeling, employee alignment, and balanced value propositions build trust, counter scepticism, and

enhance profitability through credible and differentiated green positioning (Ginsberg and Bloom, 2004). Contemporary research highlights green consumption, environmental awareness, and green supply chain integration as pivotal themes. Although awareness increases, purchasing gaps remain influenced by perceived costs and product quality. Transparent communication, stakeholder collaboration, and supply chain sustainability are essential for aligning economic objectives with ecological responsibility (Saputra and Asfiah, 2025).

Overall, GM signifies a structural market transformation integrating sustainability into strategic, operational, and behavioral dimensions. Continued research, credible communication, and collaborative governance are necessary to bridge behavioral gaps, reinforce trust, and ensure long-term competitiveness grounded in environmental responsibility and resilient value creation. Green marketing has evolved from a mere promotional tool to a strategic approach aimed at addressing environmental concerns while enhancing business competitiveness. As eco-libelling continues to gain importance, a more holistic approach that integrates pricing, promotion, and distribution is necessary to make sustainability a core aspect of the market. Effective GM communication, which includes transparency, certifications, and clear messaging, can strengthen brand reputation and build consumer trust. A key research gap in GM lies in understanding the complex factors influencing consumer behavior and decision-making, particularly regarding eco-libelling, pricing, and communication strategies. There is also a need for more comprehensive studies on the integration of GM with business strategies, addressing barriers, and assessing its long-term impact across diverse industries and markets.

This review discusses the importance of consumer segments, emphasizing how factors such as gender, education, and attitudes influence green purchase intentions. Furthermore, the paper explores how businesses can leverage GM strategies to enhance brand perception, drive consumer engagement, and contribute to long-term sustainability goals. The objective of this review paper is to examine the evolution of GM and its impact on consumer behavior, focusing on the integration of sustainability into business strategies. The paper aims to identify the key challenges businesses face in aligning GM with their corporate objectives and explore effective strategies to overcome barriers and foster long-term competitiveness. Additionally, it seeks to highlight the role of transparent communication, eco-libelling, and collaboration with stakeholders in promoting sustainable consumption, ultimately providing insights into how firms can enhance GM practices and contribute to environmental and economic sustainability.

2. METHODOLOGY

This review examined peer-reviewed literature from Google Scholar, Scopus, and ScienceDirect to assess advancements in the strategic integration of green marketing and its influence on consumer buying behavior. Priority was given to studies focusing on green marketing, sustainability, consumer behavior, eco-libelling, the circular economy, and eco-innovation. Articles were excluded if they were non-English, available only as abstracts, or primarily opinion-based. Both empirical and theoretical studies directly addressing green marketing and consumer purchasing behavior were included. The review consolidates key trends, identifies persistent challenges, and outlines opportunities for promoting sustainable practices. Its findings offer a structured framework to guide future research, encourage technological adoption, and support the development of sustainable and inclusive global marketing strategies.

3. EVOLUTION AND IMPLEMENTATION OF GREEN MARKETING IN A SUSTAINABILITY-DRIVEN MARKETPLACE

Green marketing has evolved in response to rising environmental awareness. Firms increasingly embed sustainability into operations, culture, and community responsibilities. Beyond eco-labelling, GM spans goods and services, driven by regulation, competition, and efficiency gains, requiring shared corporate and consumer accountability (Polonsky, 2008). Ecolabels remain important but insufficient tools, often targeting only environmentally committed consumers. A broader strategy integrating pricing, promotion, and distribution is necessary to mainstream green products. Businesses must act as co-creators of demand, embedding sustainability within diverse product appeals rather than confining it to niche positioning (Rex and Baumann, 2007). Growing global preference for environmentally responsible firms strengthens GM's relevance. Consumers expect reduced emissions, recycling, and responsible resource management, yet face confusion over labeling and certification. Effective strategies reconfigure the marketing mix, balance profitability with sustainability, and foster systemic change across production and consumption ecosystems (Tiwari et al., 2011).

Conceptual ambiguities persist regarding definitions, metrics, and implementation of GM. Strategic and operational integration-covering communication, logistics, product management, and corporate responsibility-is essential. Stakeholder collaboration supports sustainable development goals, positioning environmental stewardship alongside economic success within an evolving, accountability-driven business paradigm (Mukonza et al., 2021). Contemporary perspectives emphasize authenticity, transparency, and lifecycle thinking as foundations of successful green branding. Leading companies demonstrate that sustainability enhances competitiveness when embedded into identity and innovation. Trust, third-party endorsements, and digital engagement increasingly shape consumer decisions, elevating sustainability from fringe concern to mainstream strategic imperative (Ottman, 2017). Effective GM demands understanding consumers, ensuring transparency, maintaining product performance, and justifying pricing. Accessibility, education, and genuine alignment between claims and practices build credibility. Rather than targeting only niche segments, firms should promote inclusive sustainable behaviors, demonstrating measurable environmental and financial value through authentic market offerings (Tiwari et al., 2011).

Collectively, GM represents a comprehensive transformation requiring strategic clarity, operational integration, authentic communication, and collaborative stakeholder engagement. By aligning environmental values with performance, accessibility, and consumer trust, organizations can transition sustainability from a peripheral initiative to a central competitive advantage, fostering responsible consumption and long-term societal progress.

4. GREEN MARKETING COMMUNICATION AND ITS INFLUENCE ON CONSUMER BEHAVIOR

Consumers' attention to GM communication affects their environmentally responsible purchasing behavior, considering gender, education, and green attitudes. Findings show a strong positive correlation, with educated consumers, environmentally conscious individuals, and females paying the most attention. Popular product categories include eco-friendly cosmetics, organic foods, sustainable clothing, energy-efficient appliances, recycled goods, and green services. Participants expressed interest in clearer environmental information, though many admitted not thoroughly reading eco-labels. Effective sustainability communication, including certifications and transparent messaging, can build trust, enhance reputation, and increase green purchasing, though the study's internet-based, non-random sample limits generalizability. Expanding research across countries, product categories, and online/offline channels is recommended (Correia et al., 2023). Green marketing strategies also influence purchasing behavior for brands like Re-Kånken, known for eco-friendly products. Despite strong eco-brand messaging (81.96%), the overall effect on consumer behavior is modest, explaining 18.7% of purchases. Factors such as product design, popularity, and functionality significantly influence buying decisions. The study recommends partnering with environmentally conscious fashion influencers, environmental organizations, and eco-friendly retailers to enhance advertising and public engagement. These collaborations can increase awareness, strengthen consumer commitment to sustainable products, and support business growth while promoting environmental responsibility. Engaging campaigns and partnerships are essential to fostering a broader green purchasing culture (Chan et al., 2019).

Research examining demographics, environmental awareness, and GM attributes finds that increased consciousness and marketing positively affect green purchases. Consumers are now more willing to pay premiums for eco-friendly products. Male consumers respond to promotion, awareness, pricing, and product features, whereas females focus mainly on promotion. Marital status, children, and age also shape purchasing decisions. Education and income further influence responsiveness to promotion and pricing. Companies should tailor GM strategies based on demographics, emphasizing promotion across most segments, while enhancing awareness and aligning product features with environmental and health benefits to drive sustainable consumption and support corporate social responsibility initiatives (Boztepe, 2012). Focusing on Generation Z, research on Le Minerale bottled water shows GM communication strongly impacts purchase decisions. Key drivers include transparency, message clarity, and communication channels. Generation Z consumers prefer brands that actively demonstrate sustainability commitments. Expanding future research to examine long-term loyalty and the influence of socio-cultural factors like education, income, and lifestyle could optimize GM effectiveness and inclusivity. These insights can guide businesses in improving sustainability messaging to foster stronger consumer engagement and responsible purchasing (Aprilianty et al., 2025). Overall, GM communication positively shapes environmentally responsible purchasing across demographics, brands, and regions. Effective strategies include clear eco-labeling, targeted promotion, influencer and organizational partnerships, and transparency. Consumer attention, education, gender, and environmental attitudes influence engagement. Tailored messaging enhances trust, commitment, and willingness to pay, supporting sustainable consumption and broader corporate social responsibility goals.

5. UNDERSTANDING THE FACTORS INFLUENCING GREEN PURCHASE INTENTIONS

The key factors influencing consumers' green purchase intentions revealed that while age and education improve environmental literacy, income and gender do not significantly impact consumer behavior. The study emphasizes the role of environmental advertisements, pricing, and ecological packaging in shaping consumer purchase decisions. Green advertising shows the strongest correlation, followed by product pricing, while ecological packaging also influences purchases, but to a lesser degree. The study suggests that companies invest in GM and corporate social responsibility (CSR) initiatives to better engage environmentally conscious consumers and enhance brand perception. Future research should explore diverse consumer segments to improve sustainable business practices (Ansar, 2013). The study also finds that a comprehensive GM approach, incorporating products, pricing, promotion, and distribution strategies, significantly impacts consumer purchase intentions. Unlike isolated GM efforts, a combined strategy yields the strongest effect. The research underscores the need for companies to adopt an integrated marketing approach, as it strengthens consumer response and supports sustainability goals. By combining these four key GM strategies, businesses can maximize their influence on consumer behavior. The findings align with previous research on the positive impact of GM components, but this study enhances understanding by demonstrating the combined effect's superiority (Ashoush and Kortam, 2022).

Another important finding is the impact of media on green purchase intentions, especially in developing countries. The study shows that positive attitudes toward television can enhance environmental concern (EC) and perceived consumer effectiveness (PCE), which in turn foster green purchase intentions. Media campaigns effectively raise awareness, encourage individual environmental responsibility, and promote sustainable products. However, many consumers in developing countries demonstrate low EC and PCE, which limits engagement with green behaviors. Targeted campaigns can educate and inspire these consumers, influencing their attitudes and fostering eco-conscious behavior. Future research could explore

additional variables like Environmental Locus of Control to deepen understanding (Butt, 2017). In examining green brand image, perceived value, and social responsibility, the study shows that these factors significantly influence green purchasing intentions. Green brand image and perceived value positively correlate with consumer behavior, while trust and awareness showed no effect. The research indicates that companies should enhance their green brand image and emphasize social responsibility in marketing strategies to increase consumer engagement and promote environmental preservation. Governments can support these efforts through policies and campaigns that encourage green consumption. This comprehensive approach helps businesses align with environmental sustainability goals and drives consumer demand for eco-friendly products (Tahir, 2021).

The research also highlights the importance of the GM mix-product, price, place, and promotion in shaping consumer attitudes and purchase intentions. By incorporating a well-designed GM mix, companies can foster eco-friendly attitudes and promote sustainable consumption patterns. The study demonstrates that combining these marketing variables effectively contributes to consumer decision-making regarding green products. Businesses, particularly in sectors like FMCG, can use these insights to develop targeted strategies that encourage green behaviors. An integrated approach to the marketing mix is crucial for promoting environmental responsibility and achieving long-term sustainability (Bahl and Chandra, 2018). The study further investigated the role of GM tools in shaping consumer behavior, particularly in Kathmandu. These tools, including eco-friendly product design, packaging, and branding, positively influence consumer purchase intentions. Environmental awareness plays a pivotal role in this process, with green packaging and labeling helping consumers make informed decisions. However, price remains a significant barrier, as many consumers are hesitant to pay a premium for green products. The study suggests that education on the benefits of green products and government support, such as subsidies, are key to overcoming these challenges and fostering sustainable consumer behavior (Shrestha, 2016). Collectively, GM strategies, including advertisements, product pricing, and ecological packaging, significantly influence consumer purchase intentions. Integrated approaches involving product, price, promotion, and distribution yield the best results. Media and environmental awareness also shape behavior, while green branding and social responsibility enhance engagement. Education, affordability, and government support can foster sustainable consumer behavior.

6. GLOBAL INSIGHTS ABOUT GREEN MARKETING AND CONSUMER BEHAVIOR

Green marketing has become essential for companies aiming to meet growing consumer demand for sustainability while maintaining profitability. By promoting eco-friendly products through advertising, labeling, and branding, firms can attract environmentally conscious buyers, reduce costs, enhance brand value, and obtain government incentives. Success relies on ethical commitments, understanding consumer needs, product affordability, convenient distribution, and trained personnel, while avoiding greenwashing to build trust and competitive advantage (FuiYeng and Yazdanifard, 2015). The effects of GM tools-eco-labels, eco-brands, and environmental advertisements-on consumer purchasing behavior were evaluated. Findings reveal that environmental advertisements have the strongest impact, followed by eco-labels, while eco-brands exert the least influence. Collectively, these tools explain 66.3% of behavioral variance, highlighting the importance of awareness campaigns, credible labels, and targeted strategies for eco-conscious segments, particularly younger and affluent consumers (Delafrooz et al., 2014). A systematic review identifies five categories of GM practices-green products/services, green business image, green advertising, green purchasing experience, and GM mix-that influence consumer behavior factors like awareness, satisfaction, attitudes, purchase intentions, trust, loyalty, and responsible consumption. The study introduces the "Green Consumption Cycle for Sustainable Value," offering businesses a framework to enhance eco-conscious engagement, align with Sustainable Development Goals, and structure future research, though broader databases and empirical testing are needed (García-Salirrosas et al., 2022).

Research in Egypt highlighted that health benefits, eco-labels, and product placement strongly affect green product purchases. Consumers trust verified labels, prefer clear packaging explanations, and favor prominent displays in hypermarkets. While price and advertising were less influential, aligning strategies with local values, emphasizing personal benefits, ensuring credibility, and avoiding greenwashing remain critical. Policymakers can enhance adoption through education, incentives, and support for sustainable initiatives (Sedky and AbdelRaheem, 2022). A study of young, educated Bangladeshi consumers applies an extended Theory of Planned Behavior to analyze green purchasing decisions. Environmental concern, perceived benefits, price awareness, willingness, and future expectations positively influence buying decisions, whereas perceived quality may deter purchases. Clear communication, eco-labels, advertising, and youth engagement are essential to build trust, drive sustainable consumption, and involve stakeholders across production and marketing to achieve long-term environmental impact (Nekmahmud and Fekete-Farkas, 2020).

Overall, evidence across multiple countries demonstrated that GM tools-advertising, labels, and branding-significantly shape consumer behavior when strategies are tailored to local contexts, emphasize personal and environmental benefits, ensure credibility, and engage key demographics. Integrating education, transparency, and regulatory support enhances adoption and aligns marketing practices with sustainable development goals. Green marketing significantly influences consumer purchasing by leveraging advertisements, eco-labels, and branding. Effectiveness depends on credibility, local adaptation, and emphasizing health or environmental benefits. Targeted strategies for younger, educated, and eco-conscious consumers,

supported by education, incentives, and regulatory frameworks, promote sustainable consumption, build trust, and advance both corporate performance and environmental objectives.

7. THE ROLE OF GREEN MARKETING IN ENHANCING COMPETITIVENESS ACROSS INDUSTRIES

Sustainable marketing strategies, particularly GM, influence competitiveness in various sectors facing environmental and economic challenges. Findings highlight the importance of integrating GM into broader business strategies to achieve competitive advantage. Environmental turbulence, such as market volatility, can impact the effectiveness of GM, but dynamic and adaptable approaches can help businesses navigate uncertainty and drive long-term value creation. The application of green marketing across industries, its major findings, and representative references are summarized in Table 1.

Table 1: Major findings on the application of green marketing across industries

| Industrial Application of GM | Major Findings | References |
|---|--|---------------------------------|
| Fashion and Textile Industry (Iran) | GM enhances competitiveness, but environmental turbulence reduces effectiveness; aligning eco-initiatives with broader strategies, innovation, and sustainable branding is essential for long-term success. | Vehbi et al., 2025 |
| Hospitality Industry (Iraq) | GM and strong brand image significantly influence eco-friendly purchasing; integrating sustainability with branding strategies enhances consumer behavior and promotes environmental responsibility in the hospitality sector. | Atshan et al., 2025 |
| Insurance Industry (Global) | Insurance emissions mainly arise from electricity and product use; adopting energy efficiency, renewable energy, green products, and transparent communication improve customer engagement and strengthens brand value. | Lin et al., 2025 |
| Manufacturing Sector (Malaysia) | Green HRM promotes eco-friendly behavior, innovation, and a sustainability culture; supportive environmental policies strengthen its effectiveness, improving environmental performance and driving better organizational sustainability outcomes significantly. | Ogiemwonyi et al., 2023 |
| Human Resource Management (Digital Technology) | Digital HR technologies enhance efficiency, fairness, and decision-making through automation and AI; effective adoption requires leadership, upskilling, and human-centered approaches supporting sustainable HR practices organization-wide. | Sharma et al., 2025 |
| Green HRM in Circular Economy (Malaysia) | Green HRM supports circular economy adoption via sustainable recruitment, training, and appraisal; human capital plays a vital role in resource efficiency, waste reduction, and long-term sustainability improvements. | Shah et al., 2024 |
| Tourism Industry (China) | GM influences tourist behavior through values, identity, and moral obligation; environmentally focused campaigns enhance eco-friendly decisions, increasing tourist loyalty, engagement, and sustainable tourism development outcomes. | Zhang et al., 2025 |
| Experience Economy (Tourism, Pulau Bakut Nature Park) | Experience economy enhances memorable tourism and sustainability-oriented loyalty; immersive experiences and factors like novelty foster engagement, supporting environmental awareness and alignment with sustainable development goals. | Naparin, 2025 |
| Footwear Industry (Peru) | Green distribution strongly influences brand value, while pricing may negatively affect it; eco-logistics, tailored pricing, and sustainable distribution strategies are critical for improving sustainability in emerging markets. | Jave-Chire et al., 2025 |
| Port Operations (Global) | Ports adopt green marketing strategically but lack implementation, raising greenwashing concerns; frameworks emphasize performance metrics, dedicated roles, and alignment between sustainability goals and operational execution practices. | Lam and Li, 2019 |
| Circular Economy (Brazilian Textile Industry) | Product and organizational eco-innovations directly improve performance, while process innovation strengthens capabilities; integrating technological and organizational approaches is essential for sustainability and long-term business success. | de Oliveira Brasil et al., 2016 |

8. GLOBAL COMPETITIVENESS AND GREEN MARKETING ORIENTATION IN SUSTAINABLE STRATEGY DEVELOPMENT

In an increasingly competitive global marketplace shaped by technological change and shifting consumer behavior, adaptive marketing strategies are vital for international success. Firms must innovate continuously, localize messaging, leverage digital technologies, manage pricing strategically, and integrate sustainability to strengthen competitiveness and achieve resilient, long-term global growth (Sudirjo, 2023). As sustainability becomes central to strategy, Green Marketing Orientation (GMO) offers a structured framework encompassing strategic, tactical, and internal dimensions. Empirical validation confirms reliability and performance relevance, while highlighting the need for broader sectoral testing and objective environmental metrics to accurately assess ecological and marketing outcomes (Papadas et al., 2017). Expanding the traditional marketing mix, the green 7Ps significantly influence brand equity and premium willingness among young consumers. Evidence emphasizes the strong roles of green people and physical evidence in shaping loyalty, perceived quality, and associations, encouraging phased investments in human capital and experiential sustainability initiatives (Nguyen et al., 2025).

Environmental marketing also advances green economy objectives by aligning competitiveness with ecological stewardship. Within emerging economies, integrating sustainability into strategy, research, and operations enhances global positioning. Embedding green principles across enterprises strengthens product image, supports resource efficiency, and fosters environmentally responsible consumer behavior (Yulchiev, 2025). An effective GM must originate in product design, where lifecycle impacts are determined. Early integration of environmental considerations, supported by source reduction and concurrent development approaches, enhances innovation and reduces harm. Managerial commitment ensures sustainability becomes embedded within organizational processes and long-term competitive strategy (Bhat, 1993). Collectively, integrating adaptive global marketing with comprehensive green orientation, lifecycle design, and stakeholder engagement strengthens competitiveness and sustainability. By aligning innovation, organizational culture, consumer value, and ecological responsibility, firms can achieve durable growth while contributing meaningfully to environmental protection and evolving international market expectations.

9. INTEGRATION AND PERFORMANCE IMPLICATIONS OF GREEN MARKETING

Green marketing has evolved from superficial promotion to a strategic imperative balancing environmental responsibility and profitability. Consumer skepticism, fueled by opportunistic “green hype,” has undermined trust in corporate claims. Embedding sustainability into core strategy rather than relying on tactical greening is essential for legitimacy and enduring competitive advantage (Polonsky and Rosenberger III, 2001). Advancing this strategic perspective, research introduces a validated Green Marketing Orientation framework encompassing strategic, tactical, and internal dimensions. Empirical evidence confirms that holistic alignment across planning, initiatives, and organizational culture enhances firm performance. The integrative measurement scale strengthens theoretical clarity and managerial capacity to implement sustainability-driven marketing (Papadas et al., 2017). Green marketing extends beyond modifying the traditional marketing mix, requiring credible communication, regulatory awareness, and systemic transformation. Consumer apathy often stems from limited trustworthy information and skepticism toward claims. Effective strategies prioritize transparency, stakeholder engagement, and accessible environmental data, positioning GM within broader institutional and policy contexts (Prakash, 2002).

Strategically integrating green initiatives across marketing, operations, human resources, and alliances enhances triple-bottom-line outcomes. Core approaches include eco-innovation, greening internal processes, and forming sustainability partnerships. Despite growing relevance, marketing scholarship underexplores competitive implications, highlighting the need for deeper inquiry into stakeholder expectations and performance impacts (Cronin et al., 2011). In hospitality, GM adoption varies by organizational capacity and managerial orientation. Research in Hong Kong hotels reveals a stronger commitment among larger establishments with formal systems, while smaller hotels implement basic measures. Avoiding greenwashing and tailoring strategies to capabilities enhances credibility and strengthens engagement with environmentally conscious consumers (Chan, 2013). Overall, GM demands strategic integration, measurable orientation, credible communication, and cross-functional alignment. Moving beyond tactical claims toward embedded sustainability enables firms to build trust, improve performance, and meet stakeholder expectations. Continued research and responsible implementation are vital for transforming GM into a durable source of competitive and environmental value.

10. GOVERNANCE AND MARKET REACTIONS IN ADVANCING GREEN MARKETING PERFORMANCE

Green marketing significantly enhances corporate performance, yet its effectiveness depends on board governance structures. Independent and gender-diverse boards strengthen positive outcomes, whereas leadership duality weakens them. As global demand for sustainable products expands, integrating lifecycle responsibility into strategy and governance maximizes financial and environmental benefits (Luo et al., 2025). Stock market reactions to GM announcements reveal investor skepticism, with average declines following promotional disclosures. Credible firms experience milder negative responses, indicating that financial strength shapes perceptions. Superficial environmental claims risk reputational damage, underscoring the necessity for authentic, operationally grounded sustainability communication strategies (Mathur and Mathur, 2000). In B2B contexts, GM capabilities enhance competitive advantage and align with ESG engagement, particularly in developed European markets. Commitment to sustainability strengthens resilience and innovation, while emerging

markets must invest strategically. Marketing agility and integration of environmental objectives are essential for sustaining long-term competitive performance (Tzanidis et al., 2024).

Evidence from Slovakia's automotive supply chain confirms a positive relationship between GM practices and competitive positioning. Although managers often overlook this linkage, empirical analysis highlights benefits including innovation, cost savings, transparency, and stakeholder responsiveness, emphasizing the strategic complexity of sustainability implementation (Moravcikova et al., 2017). In emerging economies such as Saudi Arabia, green practices enhance business performance primarily through corporate social responsibility mediation. Green marketing indirectly improves outcomes by strengthening CSR engagement, supporting stakeholder theory. Policy incentives and transparency mechanisms further reinforce sustainable strategies aligned with national development agendas (Alkandi, 2025). Green bonds complement corporate sustainability by mobilizing capital for environmentally responsible projects under strict disclosure standards. Alignment with ESG frameworks and regulatory standardization enhances investor confidence and financing efficiency. Expanding issuances and financial innovations position green bonds as foundational instruments in global sustainable development (Bobojonova, 2025). Overall, governance quality, credible communication, strategic capability, and sustainable finance collectively determine GM's performance impact. Firms that embed environmental responsibility into leadership structures, stakeholder engagement, and financial strategies are better positioned to achieve durable competitiveness while advancing broader economic and ecological transformation.

11. STRATEGIES FOR CIRCULAR ECONOMY MARKETING AND SUSTAINABLE TRANSFORMATION

Circular Economy Marketing redefines sustainability by prioritizing resource efficiency, waste reduction, and lifecycle extension within regenerative business models. Strategies such as product-service systems, eco-design, reverse logistics, and digital transparency tools strengthen trust and loyalty. However, high costs, scalability barriers, and regulatory fragmentation hinder widespread implementation (Paiva, 2025). Sustainability marketing has evolved beyond green promotion toward systemic transformation encompassing circularity, anti-consumption, regulation, and ethical responsibility. Progress depends on coordinated system-driven, business-driven, and consumer-driven changes. Integrated approaches linking policy instruments, corporate innovation, and informed consumption are essential for addressing complex environmental challenges (White et al., 2025). The green economy framework advances sustainable development by integrating ecological preservation with economic growth and social equity. Emphasizing renewable energy, clean technologies, green finance, and policy incentives, it positions sustainability as a driver of competitiveness and resilience, requiring education, collaboration, and international cooperation (Jumayeva, 2025). Findings show eco-labeling, green pricing, ethical promotions, sustainable packaging, and digital marketing strengthen consumer trust, loyalty, and purchase intentions despite greenwashing and price sensitivity. Authenticity, transparency, technology, CSR, consumer education, policy support, and innovation promote sustainable behavior through strategic communication effectively (Singh, 2026).

Modern marketing increasingly embeds environmental stewardship, transparent communication, and community engagement into strategic planning. Effective green initiatives enhance loyalty, advocacy, and long-term brand equity. Multi-platform communication, immersive education, and shared-value communities strengthen relationships between organizations and environmentally conscious consumers (Dellyana and Aldianto, 2025). Empirical evidence from manufacturing sectors demonstrates that GM and eco-innovation significantly improve sustainable performance, particularly when reinforced by circular economy practices. Eco-innovation mediates performance outcomes, while circular principles amplify benefits. Investment in technology, training, and regulatory support facilitates transition from linear to regenerative production systems (Chen et al., 2024). Global green growth strategies underscore eco-innovation, financial incentives, and institutional reform as catalysts for sustainable competitiveness. Leading economies demonstrate how regulatory frameworks, tax mechanisms, and environmental finance mobilize industry transformation, highlighting the critical role of policy coherence and international collaboration (Raximova, 2025). Collectively, circular economy marketing integrates strategic innovation, systemic policy alignment, eco-innovation, and stakeholder engagement to drive sustainable value creation. Coordinated action among businesses, governments, and consumers is essential to overcome structural barriers and accelerate the global transition toward regenerative, competitive, and environmentally responsible economic systems.

12. CHALLENGES AND OPPORTUNITIES FOR THE ADAPTATION OF GREEN MARKETING

The evolving environmental and social landscape presents significant challenges and opportunities for marketing. In the short term, businesses must adapt to rising consumer awareness and regulatory pressures around sustainability. Long-term success requires a paradigm shift, integrating sustainability into core practices. Green marketing, which promotes environmentally friendly products and practices, offers companies an opportunity to align their operations with consumer demand for sustainable solutions, driving long-term value creation. The challenges and opportunities associated with green marketing are summarized in Table 2.

A significant challenge in GM is addressing the intention-behavior gap, where consumer interest in eco-friendly products does not always translate into purchases due to concerns over price, product quality, and accessibility. Overcoming scepticism through transparent, clear, and authentic sustainability messaging is crucial for building consumer trust. Additionally, aligning GM goals with organizational culture and market demands remains a hurdle. Companies must balance profitability with

ecological responsibility, ensuring that green products meet consumer expectations for pricing and performance. Other challenges include conceptual ambiguities in sustainability definitions, confusion over eco-libelling, and the complexity of targeting diverse consumer segments. Addressing these barriers requires innovation, regulatory support, and a holistic, transparent approach to sustainability that resonates with consumers and promotes long-term ecological responsibility.

Table 2: Challenges and opportunities related to green marketing

| Challenges | Opportunities | References |
|---|--|----------------------------|
| Rising consumer awareness and regulatory pressure on sustainability. | Companies can capitalize on the growing demand for sustainable products and ethical practices. | Peattie, 2016 |
| Marketing must evolve to integrate sustainability into core practices for long-term value. | Green marketing serves as a tool to bridge business, policy, and public behavior for a sustainable future. | Peattie, 2016 |
| The paradigm shift is needed across industries, including agriculture, tourism, and finance. | New marketing strategies could promote eco-friendly products and support sustainable business practices. | Singal et al., 2013 |
| Green marketing cannot drive systemic change alone but must support broader institutional shifts. | Educational efforts can increase consumer awareness, creating a more sustainable market for green products. | Singal et al., 2013 |
| Challenges related to balancing production needs with environmental safety in developing nations. | Collaboration with eco-friendly organizations and influencers can boost GM's reach and impact. | Mishra and Sharma, 2010 |
| Skepticism towards GM claims due to "greenwashing." | Companies can benefit from demonstrating transparency, building trust, and fostering customer engagement. | Vermillion and Peart, 2010 |
| High costs of green products, which may deter purchase decisions. | By educating consumers about the long-term benefits of green products, companies can overcome pricing concerns. | Vermillion and Peart, 2010 |
| Inconsistent communication strategies across industries regarding eco-friendly products. | Companies have the opportunity to strengthen their brand image through sustainable practices and certifications. | Savale et al., 2012 |
| Developing countries face barriers like resource dependency and trade balance concerns. | Green marketing can be expanded to serve as a mainstream practice in both developed and emerging economies. | Savale et al., 2012 |
| Green marketing tools often underperform in certain product categories. | By leveraging green advertising and labeling, firms can increase demand for green products across sectors. | Butt, 2017 |

13. IDENTIFIED RESEARCH GAPS

While GM strategies have evolved significantly, notable gaps remain in understanding their full impact, particularly in the areas of branding effectiveness, organizational culture, and cross-cultural influences. There is insufficient research into the role of digital reporting, advertising credibility, and how GM shapes consumer decision-making. These gaps hinder a deeper understanding of how GM can be integrated into broader business practices, limiting its full potential in driving sustainable development. Future studies must focus on quantifying the long-term effects of GM, enhancing empirical frameworks, and offering strategic recommendations for businesses.

Furthermore, while GM has garnered increasing interest, many conceptual ambiguities persist, particularly regarding its definitions, metrics, and operational integration across sectors. For example, there is a lack of clarity on how to effectively integrate GM into communication, logistics, and product management strategies across industries. Collaborative efforts among stakeholders are necessary for advancing sustainable development goals, but research in this area is underdeveloped. Also, more exploration is needed on regional differences in consumer responses to GM, the influence of socio-cultural factors, and the role of offline marketing channels. Studies that bridge these gaps will contribute to a more robust understanding of the complex factors that drive sustainable consumer behavior, offering valuable insights for both theory and practice.

14. CRITICAL DISCUSSION

Green marketing has gained significant momentum, but persistent intention-behavior gaps hinder its full potential. Despite growing consumer demand for eco-friendly products, barriers such as cost, convenience, and product quality continue to shape purchasing decisions. While eco-labels and green branding have proven effective in influencing some consumer behaviors, they alone are insufficient. Businesses must adopt comprehensive, multi-faceted strategies that involve product innovation, competitive pricing, and transparent communication to create a genuine demand for sustainable products.

Aligning internal operations with sustainability principles and maintaining authentic employee engagement are essential to fostering long-term consumer trust and bridging the green gap effectively.

Green marketing's success also depends on how well it integrates across business operations and addresses consumer skepticism. While advertising and ecolabels significantly influence purchasing behavior, their impact diminishes when consumers perceive green claims as superficial or misleading. Transparency, clear environmental data, and authentic sustainability efforts are crucial in overcoming greenwashing concerns and ensuring the legitimacy of GM efforts. Moreover, industries such as fashion, tourism, and manufacturing have experienced success in incorporating GM into their strategies, but challenges like price sensitivity and regulatory barriers persist. Green marketing must go beyond branding and promotions, creating systemic change through collaboration with policymakers and addressing the complex dynamics of consumer behavior, market volatility, and technological advancements. Through these efforts, GM can drive meaningful environmental progress while simultaneously enhancing business competitiveness.

15. IMPLICATIONS OF GREEN MARKETING

The implications of integrating GM into corporate strategies are profound for both businesses and policymakers. For businesses, aligning GM with core operations, ranging from supply chain management to consumer engagement, is crucial for achieving long-term competitiveness and sustainability. Companies must reconfigure their marketing mix to balance profitability with eco-friendly practices, emphasizing transparency, clear communication, and stakeholder collaboration. Adapting green strategies to consumer demands and expectations while fostering trust through certifications, eco-labeling, and transparent messaging is essential for sustainable consumption. For policymakers, creating supportive frameworks through incentives, regulations, and awareness campaigns can encourage the widespread adoption of green practices. By providing education, subsidies, and reinforcing ethical marketing, they can ensure businesses integrate sustainability into their operations and communicate their efforts credibly to consumers. Moreover, integrating eco-innovation, circular economy principles, and lifecycle design into business practices fosters competitive advantage while advancing sustainability goals. Therefore, businesses that align with sustainability and innovation are better equipped to thrive in a competitive and environmentally responsible market, meeting evolving consumer expectations and contributing to global development. The collaborative role of policymakers and businesses is pivotal in ensuring GM contributes effectively to sustainability efforts across industries and regions.

16. PROSPECTS OF GREEN MARKETING

The prospects for GM are highly promising, driven by growing consumer demand for sustainable products and practices. As businesses increasingly embrace digital engagement and transparent communication, they can strengthen their brand identity and influence consumer behavior. Collaboration across industries and stakeholders will enhance green supply chain integration, fostering sustainability. Regulatory support and consumer education will further propel sustainable consumption, creating opportunities for companies to innovate and gain a competitive edge. The rise of GM will continue to transform market dynamics, with firms focusing on eco-friendly innovations, clear communication, and alignment with sustainability goals. By leveraging technological advancements and expanding GM frameworks, companies can secure long-term profitability while contributing to environmental well-being. Additionally, as global focus on sustainability intensifies, businesses can position themselves as leaders in the green economy, driving both ecological and economic growth. The future of GM is intertwined with the success of circular economy models, eco-innovation, and government incentives, offering substantial long-term benefits for businesses that align with these principles.

17. CONCLUSION

This review highlights the transformative role of GM in aligning business practices with sustainability goals. Green marketing is no longer a niche initiative but a core business strategy that can significantly influence consumer behavior and enhance competitiveness. By embedding sustainability into corporate operations, product development, and marketing efforts, companies can foster consumer trust and drive long-term value creation. However, achieving success in GM requires overcoming several challenges, including consumer scepticism, greenwashing, and the complexity of aligning environmental goals with profitability. Transparent communication, authenticity, and cross-sector collaboration are essential in overcoming these barriers and fostering meaningful change.

The future of GM relies on continued research, innovation, and regulatory support to ensure its effectiveness in driving sustainable business practices. Businesses must adapt to the evolving demands of eco-conscious consumers by integrating GM into their core strategies and operations. By promoting clear eco-libelling, providing transparent messaging, and engaging in educational initiatives, companies can cultivate a culture of sustainability. Furthermore, collaboration with policymakers, stakeholders, and consumers is essential in overcoming challenges like high costs, regulatory fragmentation, and limited consumer awareness. When strategically implemented, GM has the potential to reshape industries, contributing not only to a competitive advantage for businesses but also to a sustainable future for the planet.

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IMPACT OF SOCIAL MEDIA INFLUENCERS IN SHAPING TRAVEL CHOICES: A CASE OF TOURIST DESTINATIONS IN OMAN

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ABSTRACT

Purpose– This study aims to analyse the impact of social media influencers (SMIs) on shaping travel choices: a case study of tourist destinations in the Sultanate of Oman.

Methodology– This study employed a quantitative research approach to analyse variables and test concepts using statistical methods. A descriptive research design was used along with a simple random probability sampling technique to gather data from respondents. Data were collected from 182 participants using surveys.

Findings- Instagram is the most popular social media (SM) site in Oman. The trustworthiness of SMIs is the primary reason people are motivated to follow them. The highest mean score (4.38) was noted for SMIs, who were better at promoting tourist destinations than other marketing techniques. The chi-square test results showed no clear link between the quality of content shared by SMIs and people's preferences for visiting tourist destinations. In addition, there is a connection between the similarity of SMIs and people's preferences for visiting tourist destinations. Finally, the results showed a significant correlation between SMI expertise, attractiveness, trustworthiness, and tourists' choice to visit destinations in Oman.

Conclusion– SMIs are effective in engaging target audiences, particularly young people, and they have the highest presence on social media, making them a valuable tool for promoting tourist destinations and achieving consistent growth in Oman's tourism sector.

Keywords: Social media influencers, tourist destinations, social media, tourist choice, trustworthiness.

Jel Codes: M31, Z32, O53

1. INTRODUCTION

The development of social media has had a significant impact on the manner in which individuals communicate. This has enabled users to monitor, collaborate, and exchange information (Hamilton et al., 2021). In addition, social media (SM) is currently booming, becoming an extremely culturally relevant and dominant mode of interpersonal interaction and expression, producing omni-social engagement among shoppers (Appel et al., 2020). Users write individual comments on blog posts, visual communities, and social platforms, creating a platform for sharing music, videos, pictures, and other media assets on YouTube, Flickr, and the Internet (Zhang et al., 2017). Social networking sites have become essential platforms for businesses because they allow marketers to stay connected with their clients more effectively than other marketing mediums (Pop et al., 2022). The emergence of SM as a new technology has altered the structure of the tourism industry and has considerably influenced its development. According to Xiang & Gretzel (2010), a well-developed communication plan focused on SM will help locations become more noticeable. The benefits of using this communication technique include increased brand exposure, participation, electronic word-of-mouth (eWOM), friend-like trust, and social validation (Lincoln, 2016). According to Hamilton et al. (2021), 40% of respondents bought an item after watching an influencer using SM channels such as Instagram, Twitter, or YouTube. Furthermore, Twitter users indicated a five-fold increase in purchase intention after seeing both company and influencer posts on the product. Travel plans are intangible; thus, people cannot assess them without travelling. Consequently, electronic suggestions, recommendations, and reviews can be used as evidence to help decide whether to purchase travel services. This reduces the risk of booking at a specific destination (Neidhardt & Wörndl, 2020). Therefore, Social Media Influencers (SMIs) have gained prominence and are rated as highly effective and useful when promoting a destination to a specific group of target customers in a trusted and relatable manner (Cholprasertsuk et al., 2020). Gretzel (2018) analysed the effects of influencer marketing on various entities and concluded that hotels are more

likely to adopt this tactic than tourist destinations. However, Femenia-Serra & Gretzel (2020) stated that influencer marketing presents a new way for destination management organisations (DMOs) to use the power of SM (SM) to increase a destination's popularity and reach a larger audience than usual, particularly millennials and Generation Zs, which have been particularly impacted by SM.

In addition, Jahwari et al. (2020) found that SM features significantly improve overall customer purchasing behavior in Oman. Furthermore, the results indicate that friend recommendations and celebrity endorsements positively influence customers' purchase decisions. Statista (2024a) states that influencer marketing is expanding significantly in the Middle East and North Africa (MENA), with a compound annual growth rate of 9% predicted over the next five years. Influencers use various channels, pathways, and media to reach their followers in new and inventive ways, and marketers search for profitable partnerships to reach these expanding niche audiences. Moreover, the global influencer marketing industry, as estimated by Statista, was worth USD 21.1 billion in 2023, a significant growth of 224.6% from the pandemic value of USD 6.5 billion in 2019 and a 28.7% increase from USD 16.4 billion in 2022 (Statista, 2024b). In January 2023, there were 4.17 million online social networking users in Oman (Kemp, 2023). Despite their significance, research on SMs' marketing role of SMs, particularly how they affect travel decisions, is limited in Oman. Several studies have examined the role of social media influencers in consumers' buying decision-making processes in Oman; however, they did not focus on travel choices and tourist destinations. Previous research has focused on the influence of social media in influencing international and domestic tourist visits to Oman, but none have focused on the role of social media influencers on shaping travel choices. Therefore, the current study holds critical value in terms of its contribution to the literature and the travel industry in Oman and the GCC region. Although the author's own study on the influence of SMs on Omani tourists' decisions was qualitative in nature, the following study examined the effects of SMs on travel decisions: a quantitative case study of Omani tourist attractions is urgently needed, and the Ministry of Heritage and Tourism in Oman, travel agencies, tour operators, and other relevant stakeholders such as higher educational institutions, students, and future researchers would find value in the study's findings.

This research paper is organised into several sections. The first part of the paper is the introduction, which includes the background, rationale, research objective, and significance. The second part reviews the literature. The third part discusses the research methodology, including the research approach, design, population, sample size, sampling technique, and research ethics. The fourth part discusses the results and analysis, and the fifth part discusses the results. Finally, the conclusions, recommendations, and implications are presented.

2. LITERATURE REVIEW

A Social media influencer (SMIs) is someone who has amassed a sufficient following on their profile and established enough credibility to have the power to sway their audience's choices (Digital Marketing Institute, 2021). SMIs are influential voices that persuade people through engagement using accessibility, credibility, and closeness (Xiang & Gretzel, 2010). Lincoln (2016) described SMIs as individuals who have the ability to influence others' thoughts and decisions based on their expertise, status, interaction, and power. Additionally, Vollenbroek et al. (2014) found that a broad variety of factors that may play a role in influencing traits are social interaction, likability, competence, influence, power, common hobbies, uniqueness, innovativeness, and the number of followers or friends. Similarly, Zhang et al. (2017) stated that an individual's social position, personal characteristics, image, persuasion, and demographic characteristics, such as age, gender, and marital status, might influence their followers.

According to Pop et al. (2021), people tend to engage in less traditional forms of media, namely television or printed campaigns; however, social media (SM) is great at reaching out to populations that are difficult to reach. Additionally, it has been demonstrated that people are influenced by SMI, and the companies they endorse become popular. In addition, the appeal, quality of information, and attractiveness of an SMI might affect viewership and hence their impact (Gedik, 2020). Similarly, Pourazad et al. (2025) reported that SMIs' attractiveness and proficiency of SMIs determine the persuasive power of influencers on tourist travel plan decisions. According to Avci & Bilgili (2020), SMIs have a stronger influence on persuading their followers and can affect their followers' emotions, ideas, and purchase decisions on SM platforms, including Instagram, YouTube, Twitter, and Facebook. SMIs integrate their experiences with certain products or businesses, include them in the content they create, and communicate consistently with their followers. By bringing personal persuasion to the forefront, influencers drive their followers toward the products and brands they present (Rundin & Colliander, 2021). Likeability and familiarity are crucial in the appealing dimension since they are thought to have a favorable impact when passed through an influencer to the product, as likeable SMIs are more persuasive (Taillon et al., 2020). In terms of tourism, social media can be utilized in each phase of the travel process and serves as a vital source's information for consumers (Wiedmann & von Mettenheim, 2021). Influencer advertising is a relatively new strategy, yet it has already become a staple of travel firms' marketing efforts worldwide, and the tourist industry is now the ninth largest influencer marketing expenditure globally (Peltier, 2018).

Online word-of-mouth is the primary source of travel information for consumers and serves as the foundation for SM marketing in tourism and travel (Gretzel, 2018). Influencer marketing is an important technique for attractions to generate favorable eWOM about their services and enhance their visit intentions among their target demographics. This is partly because the age groups that travel the most are millennials and Gen Y, and their consumption decisions are heavily

influenced by SMIs (Xu & Pratt, 2018). Daskin & Tumati (2024) found that Omani Gen Z travellers' destination choices were impacted by SMIs, and they choose the destination recommended by the SMIs. However, attractions near natural resources and undiscovered destinations promoted by SMIs generate curiosity among followers. Nevertheless, popular destinations do not require support from SMIs (Dorta-Preen & Santana-Talavera, 2025).

Boerman et al. (2017, p. 92) shared a Facebook commercial in which the brand promoted the product, as well as a similar advertisement featuring the influencer. The results showed that promotions in collaboration with influencers had a more favorable impact on followers' purchase intentions. By realizing influencers' directing power, marketers attempt to find influencers who may be suited to promoting their products and services. Naderer et al. (2022) claimed that sponsored posts on SM are perceived as more trustworthy than traditional marketing ones. Furthermore, Rundin & Colliander (2021) claim that timely information is the primary reason individuals follow SMI. Razak & Mansor (2022) indicated that content quality is more important than the number of posts, and SMIs storytelling techniques and follower-oriented content influence travellers to plan travel to tourist destinations. SMIs share their experiences through photos, videos, and testimonials, which aid followers in making decisions regarding what to buy (Femenia-Serra & Gretzel, 2019). Generation Z interacts with brands mostly through SM, and Instagram is the platform that Generation Z most frequently uses for notifications when new products are announced (Tumati et al., 2025; Georgiev 2023). In addition, one of the most widely used SM platforms is Instagram, where influencers typically communicate with their followers (Digital Marketing Institute, 2021). Moreover, Studies on the motivation to use Instagram show that users not only follow their family, friends, and acquaintances but can also follow and interact with public figures, celebrities, sports stars, and brands (Tang et al., 2019).

Tumati et al. (2024) stated that the two most significant SM platforms in Oman are Instagram and SnapChat. According to Balida et al. (2022), SMIs engage and motivate consumers, shaping their attitudes and behaviors towards leisure and recreational products. Entertainment content and engaging videos shared on these sites are vital for shaping consumer preferences. Caraka et al. (2022) stated that Instagram is a powerful promotion tool for Millennials and Generation Z, as it motivates them to travel, increases their desire to visit, and influences their opinions on tourism brands. Its visual aspects, including photos and videos, make it a significant part of travel marketing strategies, particularly for tourist destinations. Tumati et al. (2024) found that the visual content shared by SMIs significantly affects followers' interest in travel destinations. Followers are more inclined to visit locations that their favorite influencers have shown, often seeking to replicate the experiences that they see depicted in their posts. Travel marketers have identified the possibilities of message reinforcement and targeting provided by SMIs (Gretzel, 2018). Rajput & Gandhi (2025) highlighted stated that content legitimacy by SMIs influenced sustainable travel intentions of Gen Z in India. Sharma et al. (2025) stated that destination image, nature-based tourist attractions, and influencer trust shape pro-sustainable tourism behaviours among Gen Z travellers.

Taype & Fuentes (2025) observed that TikTok and Instagram influencers are particularly popular among students and positively influence their travel choices. Students like to follow SMIs because of their highly useful travel information, which showcases affordable and authentic options. Similarly, Ahmed & Zhao (2025) found that 60% of users discovered new travel destinations through Instagram, mostly through SMIs, and that 70% of tourists visited destinations as recommended by SMIs.

Tumati et al. (2024) found that followers actively seek information from SMIs before finalizing their travel plans. This finding indicates that influencers play a crucial role in shaping perceptions of and decisions regarding travel destinations. Kim & Kim (2021) found that SMIs constantly interact with their followers, introduce them to tourist destinations, and build strong relationships with them. These interactions increase visitors' interest in the sites. As a result, followers develop a yearning for the SMI's tourism destinations, which influences their decision to visit. Wiedmann & von Mettenheim (2021) stated that similar features and shared interests are the two primary reasons individuals follow SMIs. Moreover, Balida et al. (2022) stated that the most prevalent factors affecting consumers' buying decisions regarding leisure and recreation products in Oman include recommendations from trusted individuals, high reviews and ratings from others, and endorsements by SMIs. These factors significantly contribute to the high impact of SM on decision-making. In addition, one of the factors influencing a consumer's choice of destination is visual appeal. Visual appeal is experienced by those who follow the influencer's content. To present a particular location as accurately as possible, influencers employ a wide range of effects, including image and video processing techniques and special effects (Vollenbroek et al., 2014).

Tumati et al. (2024) stated that SMIs are viewed by their followers as credible sources of information. Additionally, Babu et al. (2025) noted that the credibility and engaging communication of SMIs enhance tourist perception and motivate them towards travel related purchase behaviour. Many participants indicated that they considered recommendations from their favorite influencers when choosing travel destinations, suggesting a strong reliance on influencer opinions in their travel decisions. Masuda et al. (2022) stated that credibility is a perceived assessment of a communicator's trustworthiness, which is crucial for SM marketing. SMIs are often considered to be more credible and trustworthy in comparison to than other forms of media because they are bold and open in their conversations. Pradhan (2022) stated that trust is a crucial aspect of influence, as consumers' trust in an influencer's ability to disseminate reliable information is correlated with their confidence in the influencer's ability to recommend goods or services. Trust in influencers also affects travel and purchase intentions, making it a significant factor in influencer success (Albayrak et al., 2020). Additionally, Social media influencers' persuasive communication, authenticity, and expertise motivate their followers to consider purchasing the products and services they

endorse (Wang, 2025). Similarly, Raafat et al. (2023) stated that SMIs trustworthiness, attractiveness, and expertise positively impacted the travel intentions of millennials in Egypt. Finally, Ong et al. (2026) expressed that SMIs can de-influence tourists on popular destinations to avoid over-tourism and influence them to visit lesser-known tourist destinations in Japan. SMIs campaign style, mimicry, and communication style influences their followers and alter their travel intentions.

3. METHODOLOGY

A quantitative research approach was employed in this study. Quantitative research measures behaviors, attitudes, and occurrences using statistical and numerical methods and offers a data-driven basis for identifying patterns and forecasting results (Creswell, & Creswell, 2023). This study employed descriptive research design. Saunders et al. (2019) noted that descriptive research provides scholars with thorough insights into the traits and behaviors of a specific group or event, enabling them to comprehend the subject matter more thoroughly. Purposive sampling, a non-random sampling technique, was adopted in this study. Purposive sampling is a rapid and economical method of data collection in which participants are selected based on their availability and willingness to participate in the study (Cooper & Schindler, 2014). The data for this study were gathered through offline and online surveys. Bell et al. (2022) stated that surveys are helpful in characterizing the traits of a sizable community and guaranteeing a more precise sample to collect focused findings from which conclusions can be drawn and crucial choices can be made. The study population comprised tourists visiting various destinations in Oman. An ethics form was completed and submitted to the institution where the researchers are currently employed; after approval, the data collection process began. A total of 193 respondents provided data for the study; however, 11 responses were removed due to incompleteness and errors, leaving 182 valid responses for the analysis. The survey questionnaire consisted of various sections, including respondents' demographic profiles, SM features, reasons for adhering to a certain SMI, and the degree of influence SMIs have on travelers' decisions to visit particular locations. The following descriptive statistical methods were employed to analyze the data, and the degree of influence of SMIs on travelers' decisions to visit places was assessed using frequency distribution, percentages, means, and standard deviations. The results were also inferred using chi-square tests and Spearman's correlation to assess linkages or connections between two variables, as well as other pertinent statistical tools such as Cronbach's alpha to examine reliability across several dimensions.

4. FINDINGS AND DISCUSSIONS

4.1. Demographic Profile of Respondents

Table 1 presents the respondents' demographic information. Of the respondents, 32.4% were male and 67.6% were female. In addition, 51.7% of the respondents, or the majority, were in the 18–25 age group. Only 4.3% of the respondents were above the age of 46, 30.8% were in the 26–35 age range, and 13.2% were in the 36–45 age range. Additionally, 48.4% of the respondents had a bachelor's degree, 27.5% held a diploma, 14.3% earned school credentials, and 9.8% held a master's or higher degrees. Moreover, 73.6% of the respondents were single, and 26.4% were married. Furthermore, 30.8% of the respondents worked for different firms, 17.6% owned their businesses, 37.9% were students at various colleges and universities, and 13.7% were unemployed.

Table 1: Demographic Profiles of the Respondents

| Description | Frequency | Percentage |
|-----------------------|------------|-------------|
| Entire group | 182 | 100 |
| Gender | | |
| Male | 59 | 32.4 |
| Female | 123 | 67.6 |
| Age | | |
| 18-25 | 94 | 51.7 |
| 26-35 | 56 | 30.8 |
| 36-45 | 24 | 13.2 |
| 46 and above | 8 | 4.3 |
| Education | | |
| School | 26 | 14.3 |
| Diploma | 50 | 27.5 |
| Bachelors | 88 | 48.4 |
| Masters and higher | 18 | 9.8 |
| Marital Status | | |
| Single | 134 | 73.6 |
| Married | 48 | 26.4 |
| Occupation | | |
| Employee | 56 | 30.8 |
| Business | 32 | 17.6 |

| | | |
|----------------|-----------|-------------|
| Student | 69 | 37.9 |
| Unemployed | 25 | 13.7 |

Table 2 presents the respondents' social media characteristics. Of those surveyed, 79.1% said that they looked for travel destinations on SM platforms. Nonetheless, 20.9% of the respondents claimed that they were not used at all. Among the respondents, 46.7% indicated that they would seek tourism destinations on the SM platform, Instagram. Of the respondents, 26.4% said they used Snapchat, and 16.5% used YouTube. and 6% used Twitter, while only 1.6% used Facebook. It is clear from the findings that few respondents used Facebook to check tourist attractions. Others mentioned 2.8%, such as TikTok, WhatsApp, Telegram, and LinkedIn. Moreover, 23.6% of the respondents stated that they did not follow SMIs, while 76.4% said that they did so. YouTube influencers accounted for 26.4% of the sample, and Instagram influencers accounted for 41.2%. Among the respondents, 22.5% were influenced by Snapchat influencers, 5.5% by Twitter influencers, and only 1.6% by Facebook influencers. The findings show that Facebook has less influence on respondents. Finally, 2.8% of the respondents selected other platforms, such as TikTok, LinkedIn, and Telegram.

Table 2: Social Media Characteristics of the Respondents

| Description | Frequency | Percentage |
|---|------------|-------------|
| 1. Do you use social media sites to search tourist destinations? | | |
| Yes | 144 | 79.1 |
| No | 38 | 20.9 |
| 2. Which social media sites do you search for tourist attractions? | | |
| Facebook | 3 | 1.6 |
| Instagram | 85 | 46.7 |
| X (Twitter) | 11 | 6.0 |
| YouTube | 30 | 16.5 |
| Snapchat | 48 | 26.4 |
| Others | 5 | 2.8 |
| 3. Do you follow SMIs? | | |
| Yes | 139 | 76.4 |
| No | 43 | 23.6 |
| 4. What type of SMI do you prefer? | | |
| YouTube Influencers | 48 | 26.4 |
| Instagram Influencers | 75 | 41.2 |
| Snapchat Influencers | 41 | 22.5 |
| Facebook Influencers | 3 | 1.6 |
| Twitter Influencers | 10 | 5.5 |
| Others | 5 | 2.8 |

To examine reliability across various dimensions, Cronbach's alpha was used. This is shown in Table 3. An alpha score of 0.818 indicates the impact of SMIs on tourists' choice of tourist destinations in Oman. An evaluation of > 0.7 indicates that the supplied items have extremely high internal consistency.

Table 3: Reliability Statistics

| Dimension | Cronbach's Alpha | No of Items |
|--|------------------|-------------|
| Impact of SMIs on tourists' choices to visit tourist destinations in Oman. | .818 | 10 |

Figure 1 illustrates the promotion of tourist attractions in Oman by SMIs. Videos (46%), images (21%), and live feeds (15%) were used to describe locations. Post data and updates regarding location (11%), create a podcast, and publish them (7%). and Other; please indicate (0). The findings show that creating and posting a video detailing a tourist destination is the most common method used by SMIs to promote destinations.

Table 4: Why do you follow certain social media influencers?

| Reasons | Percentage | Ranking |
|-----------------|------------|---------|
| Trustworthiness | 74 | 1 |
| Relatable | 67 | 2 |
| Hilarious | 64 | 3 |
| Attractive | 61 | 4 |
| Expertise | 54 | 5 |
| Popularity | 51 | 6 |

| | | |
|--------------------|----|---|
| Quality of content | 47 | 7 |
| Experience | 39 | 8 |
| Others | 26 | 9 |

Table 5 shows the results of the impact of SMIs on tourists’ choice to visit destinations in Oman. The highest mean score was that SMIs were better at promoting tourist destinations than other types of promotions (4.38). This suggests that respondents believe that SMIs are more effective than conventional forms of promotion in promoting travel destinations. The second, third, and fourth highest mean scores were that SMIs have the power to attract tourists to Oman (4.26), I share SMI promotional videos with my family, friends, and co-workers (4.17), and I trust the information shared by SMIs regarding tourist attractions (4.01). This suggests that respondents trust the information provided by SMIs about tourist attractions and that they think these influencers can attract tourists to Oman. They also share influencer promotional videos with friends, family, and co-workers. However, the lowest mean scores were that I like to follow SMIs because they can provide unbiased and reliable travel spot advice (3.44) and the tour destinations recommended by SMIs are fascinating and appealing, so I would like to go there (3.37). This means that respondents would like to follow SMIs because they can provide unbiased and credible recommendations on exciting and enticing travel places; thus, they would like to visit them.

Figure 1: How do SMIs Promote Tourist Attractions in Oman?

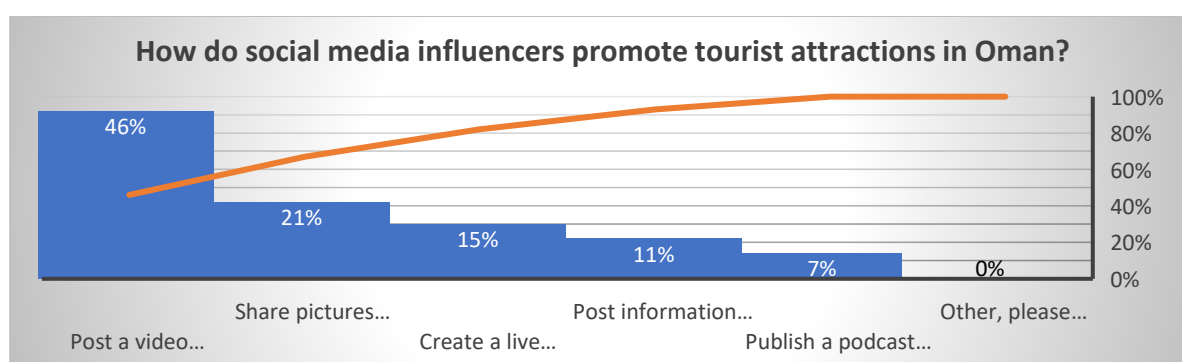


Table 4 shows that 74% of respondents who followed a particular SMI were motivated by trust in the SMIs. The second, third, and fourth ranks were relatable (67%), funny (64%), and attractive (61%). People want to follow SMIs for various reasons, including their expertise, popularity, high-quality content, and experience. Other benefits include access to news and current events, entertainment, inspiration, guidance on food, clothes, and travel, and a feeling of fellowship.

Table 5: Impact of SMIs on Tourists’ Choice to Visit Destinations in Oman

| Impact of SMIs on tourists’ choices | Mean | Standard Deviation | Rank |
|--|------|--------------------|------|
| SMIs are better at promoting tourist destinations than other forms of promotion. | 4.38 | 1.019 | 1 |
| SMIs have the power to attract tourists to Oman. | 4.26 | 1.067 | 2 |
| I share SMI promotional videos with my family, friends, and co-workers, as they are reliable. | 4.17 | 0.991 | 3 |
| I trust the information SMIs share about tourist attractions. | 4.01 | 1.071 | 4 |
| SMIs usually disseminate relevant and recent information. | 3.99 | 1.115 | 5 |
| I consider the recommendations provided by SMIs when making travel plans because their preferences are similar to mine. | 3.86 | 1.242 | 6 |
| The information provided by influencers is thorough and helps consumers decide whether to travel to a specific location. | 3.82 | 1.230 | 7 |
| SMIs, I follow constantly communicate with me and offer additional information about tourist locations when requested. | 3.61 | 1.048 | 8 |
| I would like to follow SMIs as they can provide unbiased and reliable travel advice. | 3.44 | 1.040 | 9 |
| The tour destinations recommended by SMIs are fascinating and appealing; therefore, I would like to visit them. | 3.37 | 0.958 | 10 |

Table 6 shows that the chi-square test was not significant (sig. value was 0.297 > 0.05), indicating that the null hypothesis cannot be rejected. This shows that there is no clear link between the quality of content shared by SMIs and people’s preferences for visiting tourist destinations. This indicates that there is no connection between people’s desire to travel to a particular location and the quality of content provided by SMIs.

Table 6: There is no relationship between the quality of content shared by SMIs and people's preference for visiting a tourist destination.

| Test | Value | df | Asymptotic Significance (2-sided) |
|--------------------|--------|----|-----------------------------------|
| Pearson Chi-Square | 22.855 | 20 | .297 |

Table 7 shows that the null hypothesis can be rejected because the chi-square is significant (sig. value is $0.039 < 0.05$). This suggests a clear connection between the similarity of SMIs and people's inclination to travel to SMI-posted destinations rather than others. This suggests that a correlation exists between respondents' likeness to SMIs and their intention to travel to destinations posted by SMIs.

Table 7: There is no relationship between the similarity of SMIs and people's preference for visiting a tourist destination.

| Test | Value | df | Asymptotic Significance (2-sided) |
|--------------------|--------|----|-----------------------------------|
| Pearson Chi-Square | 26.601 | 16 | .039 |

Table 8 shows a favourable and significant correlation between SMI expertise and tourists' location preferences. This was demonstrated by the obtained p-value of $0.000 < 0.05$ and Spearman's coefficient of 0.628. This demonstrates that tourists' choice of destination in Oman is significantly influenced by their SMIs skill and knowledge.

Table 8: Relationship between SMI expertise and tourist destination choice.

| | | Expertise of SMIs | Tourists' choice to visit a destination |
|--|------------------------|-------------------|---|
| Expertise of SMIs | Spearman's Correlation | 1 | .628** |
| | Sig. (2-tailed) | | .000 |
| | N | 182 | 182 |
| Tourists' choices to visit a destination | Spearman's Correlation | .628** | 1 |
| | Sig. (2-tailed) | .000 | |
| | N | 182 | 182 |

** . Correlation is significant at the 0.05 level (2-tailed).

Table 9 shows a favourable and significant correlation between the attractiveness of SMIs and tourists' preferred destinations. This was demonstrated by the obtained p-value of $0.000 < 0.05$ and Spearman's coefficient of 0.519. This indicates that tourists' choice of destination in Oman is significantly influenced by the attractiveness of SMI.

Table 9: Relationship between the SMIs attractiveness and tourists' destination choice.

| | | Attractiveness of SMIs | Tourists' choice to visit a destination |
|--|------------------------|------------------------|---|
| Attractiveness of SMIs | Spearman's Correlation | 1 | .519** |
| | Sig. (2-tailed) | | .000 |
| | N | 182 | 182 |
| Tourists' choices to visit a destination | Spearman's Correlation | .519** | 1 |
| | Sig. (2-tailed) | .000 | |
| | N | 182 | 182 |

** . Correlation is significant at the 0.05 level (2-tailed).

Table 10 shows a favourable and significant correlation between the attractiveness of SMIs and tourists' preferred destinations. This was demonstrated by the obtained p-value of $0.000 < 0.05$ and a Spearman's coefficient of 0.872. This indicates that tourists' choice of destination in Oman is significantly influenced by the attractiveness of SMI.

Table 10: Relationship between the SMIs trustworthiness and tourists' destination choice.

| | | SMIs Trustworthiness | Tourists' choice to visit a destination |
|--|------------------------|----------------------|---|
| Trustworthiness of SMIs | Spearman's Correlation | 1 | .872** |
| | Sig. (2-tailed) | | .000 |
| | N | 182 | 182 |
| Tourists' choices to visit a destination | Spearman's Correlation | .872** | 1 |
| | Sig. (2-tailed) | .000 | |
| | N | 182 | 182 |

** . Correlation is significant at the 0.05 level (2-tailed).

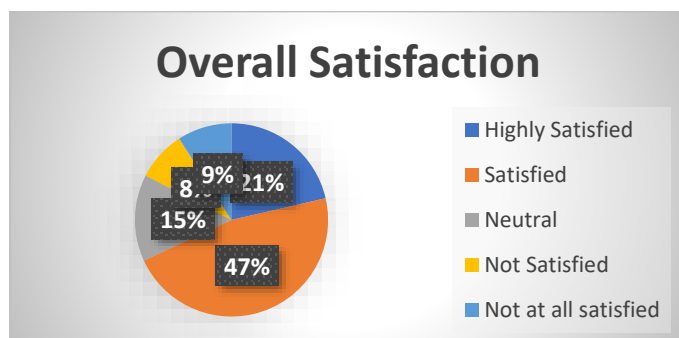
Figure 2: Overall satisfaction with the quality of information provided by SMIs about tourist destinations.

Figure 2 shows the respondents' overall satisfaction with quality of destination information provided by SMIs. Of these, 21% were highly satisfied, 47% were satisfied, 15% were neutral, 8% were not satisfied, and 9% were satisfied at all.

4.2. Discussion

According to the results in Table 2, 46.7 percent of the respondents claimed that they looked for tourism destinations on Instagram. Additionally, 41.2 percent of respondents stated that they favored Instagram influencers over those on other platforms. These findings are consistent with those reported by Taype & Fuentes (2025), Ahmed & Zhao (2025), Rajput & Gandhi (2025), Tumati et al., (2025), Tumati et al. (2024), Georgiev (2023), Caraka et al. (2022), Hamilton et al. (2021), Avci & Bilgili (2020), and Tang et al. (2019) noted that Instagram is the most widely used SM platform and that most users prefer to follow influencers on the platform. Additionally, Table 5 shows that SMIs are more effective than traditional forms of promotion in promoting travel destinations (4.38). These findings are consistent with those of previous studies, which found that SMIs are more effective in supporting tourist destinations than conventional promotional strategies (Pourazad et al., 2025; Daskin & Tumati, 2024; Tumati et al., 2024; Balida et al., 2022; Pop et al., 2021; Gedik, 2020; Lincoln, 2016; Xiang & Gretzel, 2010). According to Naderer et al. (2022), trust is the primary factor motivating individuals to follow social SMIs. Moreover, Raafat et al. (2023), Balida et al. (2022), Masuda et al. (2022), Pradhan (2022), Albayrak et al. (2020), and Cholprasertsuk et al. (2020) most followers prefer to heed the counsel of their SMIs because they believe that the information, they offer is reliable and their opinions are assured. Literature supports these results, as Table 4 shows that trust (rank 1: 74%) is the main reason people follow certain SMIs. Table 5 shows that respondents trusted the information shared by SMIs regarding tourist attractions (4.01), and Table 10 reveals a significant correlation between the attractiveness of Social Media Influencers (SMIs) and tourists' preferred destinations in Oman, indicating a positive impact. This was demonstrated by the obtained p-value of $0.000 < 0.05$ and a Spearman's coefficient of 0.872.

As shown in Table 7, the similarities between SMIs and people's desire to travel to a tourist site were related (sig. value is $0.039 < 0.05$). These findings are consistent with previous research Ong et al., 2026; Sharma et al., 2025; Taillon et al., 2020; Kim & Kim, 2021; Wiedmann & von Mettenheim, 2021; Xu (Rinka) & Pratt (2018); Appel et al., 2020; Daskin & Tumati, 2024), which claimed that one of the primary reasons people follow SMIs is their similarities and shared interested. The resemblance between them encourages people to adhere to a specific SMI. Finally, Table 6 shows no discernible relationship between people's preference for visiting a tourist site and the quality of the content supplied by SMIs (the sig. value was $0.297 > 0.05$). This implies that people's desire to visit a particular location is unrelated to the quality of the content provided by SMIs. Babu et al. (2025), Tumati et al. (2024), Balida et al. (2022), Rundin & Colliander (2021), Gedik (2020), and Femenia-Serra & Gretzel (2019) suggested that the quality of information shared by SMIs is one of the primary factors that motivate people to follow a specific influencer; therefore, the results do not align with this literature.

5. CONCLUSION, RECOMMENDATIONS, AND IMPLICATIONS

5.1. Conclusion

From being a means of communication, SMIs (SMIs) are becoming promoters that offer entertainment, suggest products and services, and persuade their followers to visit a particular destination. Owing to the efficacy of SMI, companies employ influencer advertising to achieve several objectives, such as increasing engagement, traffic, brand awareness, audience reach, and revenue maximization. Instagram is the most popular SM site for tourists searching for tourist attractions, and most respondents prefer to follow Instagram influencers. Trustworthiness and reliability were the main reasons respondents preferred to follow certain SMIs. SMIs promote tourist attractions in Oman by posting videos and sharing pictures. The results for the impact of SMIs on tourists' choices to visit destinations in Oman showed that SMI are better at promoting tourist destinations than other types of promotions and that they have the power to attract tourists to Oman. Moreover, most respondents trusted the information SMIs shared about tourist attractions. There is a relationship between the expertise, attractiveness, and trustworthiness of SMIs and tourists' choice to visit a destination. However, there is a

relationship between similarity in SMI and people's preferences for visiting tourist destinations. Most respondents were satisfied with SMIs' knowledge and the quality of the information they provided about a destination.

5.2. Recommendations

As Instagram was preferred by the majority of respondents, it is suggested that Omani tourist attractions enhance their Instagram accounts, add distinctive content, share updates regularly, and use high-definition images and videos. It is recommended to collaborate with some of the most well-known Instagram influencers and actively promote travel destinations, since the results show that Instagram is the most popular social media platform in Oman. SMIs significantly impact people's beliefs; thus, it is crucial to examine an influencer's personal or behavioral qualities when selecting them. Marketers must evaluate the importance of authenticity in SMI content, including sponsored versus naturally generated material, and examine its impact on follower trust and travel choices. Furthermore, marketers gain insights into the views and likes of sponsored and organic content. Examine current influencer marketing trends. For instance, some influencers are known to contribute to emerging travel trends, such as cultural, ecotourism, and adventure destinations. Therefore, it is preferable to collaborate with SMIs to promote our location if they fit into one of the aforementioned categories. According to this study, the main attributes of SMIs are competence, attractiveness, and trustworthiness. Therefore, businesses should ensure that SMIs have all the aforementioned qualities when forming agreements with them; otherwise, their messages might not reach the target demographic.

5.3. Implications

As influencer marketing allows for deeper customer engagement than other forms of advertising, tourism companies should focus on it to increase customer engagement. Businesses may begin partnering with influencers more as business partners than marketing participants. Sharing content based on personal experience helps influencers gain the trust of their followers. Influencer marketing is expected to continue growing in importance in the advertising sector because of its accurate targeting and high return on investment. Therefore, tour operators, destinations, and attractions are expected to collaborate with SMIs to promote their products and services to the target audience. In addition, it is necessary to focus on SMI characteristics, such as interaction rate, reliability, number of followers, and content style, to determine which has the greatest impact on followers' travel choices.

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APPENDIX 1: Questionnaire

Dear respondents,

My colleagues and I are researching the topic '*impact of social media influencers in shaping travel choices: a case of tourist destinations in Oman.*' In this regard, I would like to request you to participate in the survey, and this survey will take about 10 minutes to complete. The participation is voluntary, and you can exit it at any time. This survey will not collect personal information. The information you provided will be treated with utmost confidentiality and will be used only for this study. If you have questions or concerns related to the survey, please feel free to write to me at raja.tumati@otc.edu.om.

Regards,

Dr. Raja Tumati

Acting Head of Tourism and Management Studies

Oman Tourism College

Part 1 – Demographic factors

1. Gender

- Male
- Female

2. Age

- 18-25
- 26-35
- 36-45
- 46 and above

3. Education

- School
- Diploma
- Bachelors
- Masters and higher

4. Marital status

- Single
- Married

5. Occupation

- Employee
- Business
- Student
- Unemployed

Part 2. Social media characteristics of respondents

1. **Do you use social media sites to search tourist destinations?**
Yes
No
2. **Which social media sites do you have search for tourist attractions?**
Facebook
Instagram
X (Twitter)
YouTube
Snapchat
Others
3. **Do you follow social media influencers (SMIs)?**
Yes
No
4. **What type of SMI do you prefer?**
YouTube influencers
Instagram influencers
Snapchat influencers
Facebook influencers
X (Twitter) influencers
Others
5. **How do social media influencers promote tourist attractions in Oman?**
Post a video
Share pictures
Create a live stream
Post information
Publish a podcast
Others, please specify
6. **Why do you follow certain social media influencers?**
Trustworthiness
Relatable
Hilarious
Attractive
Expertise
Popularity
Quality of content
Experience
Others

Part 3. Impact of social media influencers (SMIs) on Tourists' Choice to Visit Destinations in Oman

Based on your opinion, please rate the following statements on the impact of social media influencers (SMIs) about your choice to visit destinations in Oman. From strongly agree (5) to strongly disagree (1).

| <i>Description</i> | <i>Strongly agree</i> | <i>Agree</i> | <i>Neutral</i> | <i>Disagree</i> | <i>Strongly disagree</i> |
|---|-----------------------|--------------|----------------|-----------------|--------------------------|
| SMIs are better at promoting tourist destinations than other forms of promotion. | | | | | |
| SMIs have the power to attract tourists to Oman. | | | | | |
| I share SMI promotional videos with my family, friends, and co-workers, as they are reliable. | | | | | |
| I trust the information SMIs share about tourist attractions. | | | | | |
| SMIs usually disseminate relevant and recent information. | | | | | |
| I consider the recommendations provided by SMIs when making travel plans, as they have similar preferences to mine. | | | | | |

| | | | | | |
|--|--|--|--|--|--|
| The information provided by influencers is thorough and helps consumers decide whether to travel to a specific location. | | | | | |
| SIMs, I follow constantly communicate with me and offer additional information about tourist locations when requested. | | | | | |
| I would like to follow SIMs as they can provide unbiased and reliable travel advice. | | | | | |
| The tour destinations recommended by SIMs are fascinating and appealing; therefore, I would like to visit them. | | | | | |

Part 4. Overall satisfaction with the guidance provided by social media influencers (SIMs) while selecting a destination

Please rate your overall satisfaction with the guidance provided by social media influencers (SIMs) while selecting a destination. From highly satisfied (5) to not at all satisfied (1).

| <i>Description</i> | <i>Highly satisfied</i> | <i>Satisfied</i> | <i>Neutral</i> | <i>Not satisfied</i> | <i>Not at all satisfied</i> |
|---|-------------------------|------------------|----------------|----------------------|-----------------------------|
| Overall, I am satisfied with the quality of the information provided by SIMs about tourist destinations. | | | | | |
| Overall, I am satisfied with SIMs, as I can relate to their tastes and styles and post tourist destinations of my choice. | | | | | |
| Overall, I am satisfied with SIMs professional and well-informed views on tourist destinations. | | | | | |
| Overall, I am satisfied with SIMs because of attractive and presentable personalities | | | | | |
| Overall, I am satisfied with SIMs, as they are transparent and provide unbiased opinions about tourist destinations. | | | | | |