Received: 2025-01-29
Accepted: 2025-05-30
Published Online: 2025-06-30
DOI: 10.70454/IJMRE.2025.50202

International Journal of Multidisciplinary Research and Explorer (IJMRE)
E-ISSN: 2833-7298, P-ISSN: 2833-7301

SALES FORECASTING EFFECT ON PHARMACIES

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***Abstract*—** Nowadays, as technology is advancing to previously unheard-of levels, every company and organization is finding it difficult to balance inventory and customer expectations. Every organization relies heavily on sales, and being able to predict the future helps in making strategic and intelligent sales decisions. The majority of businesses still struggle with revenue forecasting because it is usually the first step in developing the company's annual budget. Over time, a company's estimation could suffer if its sales projections are consistently inaccurate. Sales forecasting therefore affects the entire company to improve their overall growth strategy. An essential part of any business's sales operations is sale forecasting.

For a business to supply the necessary quantity at the appropriate time, an accurate sales forecast is essential. Executives use the predictions to assess future performance and plan for organizational expansion. In this study, we use the machine learning techniques of naive forecasting and linear regression to try and predict a retail company's sales. The difference between the linear regression and naïve forecasting approaches is demonstrated using a computational example, and we have found that the linear regression yields better results than the naïve forecasting approaches. Additionally, we used the ARIMA model for the linear regression approach to forecast the sales for the upcoming five days.

Keywords—ARIMA model, Linear regression, Naive Forecasting, Predictions, Sales Forecasting

Introduction

Sales forecasting plays a pivotal role in modern retail operations, particularly within the pharmaceutical sector, where inventory mismanagement can lead to life-impacting

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consequences. Accurate demand estimation ensures timely drug availability, reduces stockouts, prevents overstocking, and minimizes expiry-induced losses—thereby enhancing both patient care and financial outcomes [15]. As medical retail environments evolve in complexity and scale, traditional statistical techniques are increasingly proving inadequate in coping with dynamic demand patterns, seasonality, and external influences such as epidemics or regulatory changes.

To address this, organizations are turning towards artificial intelligence (AI) and machine learning (ML) techniques for more accurate and adaptive sales forecasting[7], [8]. Machine learning models offer significant advantages over classical methods by identifying nonlinear patterns, incorporating multiple variables, and learning temporal dependencies in complex datasets [10], [11]. In particular, time series forecasting techniques such as Autoregressive Integrated Moving Average (ARIMA) [1] and Long Short-Term Memory (LSTM) networks [2], [23] have demonstrated considerable success in domains where sequential data is prevalent.

Pharmaceutical inventory control, unlike other retail sectors, is characterized by high stakes, tight regulations, and narrow demand windows. Thus, the margin for error in sales forecasting is minimal. Previous research by Chopra and Meindl emphasized the impact of demand uncertainty on supply chain and inventory decisions, highlighting the need for precise forecasting tools in healthcare logistics [15]. Additionally, regression-based methods and naive forecasting approaches have long served as baselines in retail forecasting applications, offering interpretability and ease of implementation [9], [17].

However, naive methods are often criticized for their limited predictive power and inability to capture seasonal variations or abrupt demand changes [20]. In contrast, ARIMA models have been praised for their robustness in univariate time series prediction, especially when historical sales data is rich and well-structured [1], [5], [16]. Hybrid forecasting models—combining classical statistical techniques with machine learning—have recently emerged as a powerful approach, yielding superior forecasting performance compared to standalone models[8], [21].

This research aims to explore and compare two such forecasting models—naive forecasting and ARIMA—in the context of medical retail sales data. By conducting a detailed analysis on real-

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world pharmacy datasets, we assess the models' effectiveness using industry-standard evaluation metrics like Mean Squared Error (MSE) and Mean Absolute Percentage Error (MAPE) [6],[20]. The ultimate goal is to provide medical retailers with a decision-support framework that not only improves forecast accuracy but also optimizes inventory turnover, reduces waste, and supports strategic planning in healthcare operations.

Literature Review

Sales forecasting has long been recognized as a fundamental tool in business decision-making, enabling organizations to align production, inventory, and marketing strategies with expected demand. Armstrong \[3] emphasized the importance of accurate forecasting in mitigating financial risks and driving strategic planning. Classical time series techniques, such as the Autoregressive Integrated Moving Average (ARIMA) model developed by Box and Jenkins \[1], have been widely adopted due to their ability to model sequential dependencies in univariate data. These methods remain foundational in predictive modeling, particularly in sales and demand forecasting scenarios.

Naive forecasting methods—despite their simplicity—have historically been used as benchmark models in forecasting accuracy evaluation. Goodwin \[9] outlined their utility in rapid projections where recent observations are indicative of near-future trends. However, such methods often fall short in the presence of seasonality or structural market changes, prompting the need for more robust models.

Recent advancements in machine learning have opened new avenues for enhancing predictive analytics in retail environments. Deep learning approaches, particularly recurrent models such as LSTM \[2], offer superior performance in capturing long-term dependencies in sales data. Studies such as those by Hyndman and Athanasopoulos \[5] and Brownlee \[19] have demonstrated how these methods outperform traditional models, especially when data exhibits complex patterns or nonlinearity.

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In the pharmaceutical domain, accurate demand forecasting is especially critical due to short product life cycles, strict regulatory compliance, and the health-critical nature of stockouts. Chopra and Meindl \[15] discussed how demand forecasting impacts supply chain resilience and customer satisfaction in healthcare logistics. Taylor \[7] and Sav et al. \[8] further explored the application of AI in pharmacy sales prediction, establishing that machine learning techniques can significantly reduce inventory inefficiencies and operational costs.

Moreover, the integration of AI-driven solutions in related domains validates the growing impact of intelligent forecasting and decision support systems. Rakheja et al. \[26] proposed a hybrid encryption mechanism fused with Riesz-based biometric authentication to ensure secure greyscale image transmission, demonstrating the versatility of AI in security-critical domains. While not directly related to forecasting, their work underlines the value of AI in optimizing real-time computational performance in sensitive applications—an aspect equally important in dynamic retail environments like pharmacies.

Bhakhar et al. \[27] developed a TensorFlow Lite-based mobile application for currency detection to assist visually impaired individuals, showcasing the practical deployment of lightweight AI models in consumer-centric applications. Their model exemplifies how machine learning can be embedded in mobile systems for real-time inference, a paradigm that can be leveraged for sales prediction and inventory alerts in retail stores.

In the realm of financial applications, Vardhan et al. \[28] emphasized the strategic edge that AI models provide in algorithmic trading by forecasting market movements using historical data patterns. Their insights into transforming financial decision-making through predictive analytics resonate strongly with the goals of this study—specifically, in optimizing retail pharmacy operations through AI-driven sales forecasting.

Collectively, these studies establish a clear trajectory in the literature—from traditional forecasting techniques to modern, AI-based predictive systems. This research builds upon that trajectory by applying and comparing ARIMA and naive forecasting models on medical retail data, aiming to contribute a practical, AI-enabled framework for optimizing pharmaceutical sales forecasting and inventory planning.

Objectives

This research endeavour is predicated on a central aim: to develop and implement a sophisticated AI-driven system that enhances financial analysis and forecasting capabilities within medical retail environments. To achieve this overarching aim, the project is structured around the following core objectives:

Enhancement and Sales Forecasting Accuracy:

A primary objective is to design, develop, and deploy AI models capable of predicting sales trends and patterns with a high degree of accuracy. This involves the exploration and implementation of techniques such as time series analysis and machine learning algorithms, including ARIMA and Naive, to analyse historical sales data and generate reliable forecasts of future demand. The intent is to move beyond traditional forecasting methods to leverage the predictive power of AI, thereby enabling medical stores to optimize inventory management and resource allocation.

Automation and Refinement of Financial Analysis:

A further objective is to automate the computation and visualization of key financial performance metrics. This includes the development of tools and algorithms to calculate metrics such as profit margins, revenue growth, and inventory costs. By providing stakeholders with easy access to these critical financial indicators, the project aims to facilitate more informed decision-making and improve the overall financial management of medical stores.

Optimization of Inventory Management Practices:

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A key objective is to provide actionable insights and recommendations for optimizing inventory management. This involves leveraging sales forecasts to suggest effective inventory strategies, including restocking schedules and inventory levels, that minimize waste, reduce costs, and ensure product availability. The project seeks to bridge the gap between forecasting and operational efficiency by providing practical tools for inventory control.

Methodology

The methodology employed in this research adheres to a structured, multi-phased approach, aligned with the principles of time series forecasting. This approach encompasses data acquisition and preprocessing, exploratory data analysis, and the development and implementation of forecasting models.

Data Acquisition and Preprocessing:

The foundation of this research is predicated on the acquisition of relevant data from medical stores. This encompasses three primary data categories:

- Sales Data: Historical sales records, providing a chronological account of sales transactions.
- Financial Data: Information pertaining to revenue, expenses, and profit margins, enabling a comprehensive assessment of financial performance.
- Inventory Data: Details regarding stock levels and restocking schedules, crucial for inventory optimization.

Upon acquisition, the raw data undergoes a rigorous preprocessing phase. This involves data cleaning, a process designed to rectify inconsistencies, errors, and missing values within the dataset. Furthermore, a feature engineering approach is defined to transform the data into a suitable format for subsequent analysis. Specifically, the data is transformed into hourly time series, representing aggregate sales across distinct classes of pharmaceutical products over hourly intervals. The pharmaceutical product classes considered in this research include.

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- Anti-inflammatory and antirheumatic products (M01AB, M01AE)
- Analgesics and antipyretics (N02BA, N02BE)
- Pyknoleptic drugs (N05B, N05C)
- Drugs for obstructive airway diseases (R03)
- Antihistamines for systemic use (R06)

Exploratory Data Analysis:

Exploratory data analysis, specifically time-series analysis, is conducted to gain a deeper understanding of the underlying patterns and characteristics of the sales data. This phase involves the application of statistical techniques and visualization methods to identify trends, seasonality, and other relevant patterns within the data.

Forecasting Models and Implementations:

The forecasting phase involves the development and implementation of AI models to predict future sales trends. The presentation mentions the use of models such as Linear Regression and Naive. These models are trained using the pre-processed historical data, and their performance is evaluated using appropriate metrics.

- Linear Regression
- Naive Forecasting

Evaluation Metrics

When creating a successful model, evaluation metrics are essential. Indicative data about the model is helpful since it may be compared and refined until a high degree of accuracy is achieved. Evaluation metrics enable the ability to concentrate on a model's output and distinguish across model outputs. The evaluation metrics we used in our study were Mean Square Error (MAE) and Mean Absolute Percentage Error (MAPE). The correctness of a continuous variable is ascertained using both metrics as parameters.

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$$\mathrm{MAPE} = 100\frac{1}{n}\sum_{t=1}^{n}\left|\frac{A_t - F_t}{A_t}\right| \quad \mathrm{MSE} = \frac{1}{n}\sum(Y_i - \hat{Y}_i)^2$$

For, Mean Absolute Percentage Error (MAPE) where Atis the actual value and Ftis the forecast value. The real value At is split by their difference. This ratio's absolute value is divided by the number of fitted points (n) after being added up for each predicted point in time.

For, Mean Square Error (MSE) where n means the total number of error and (Yi – Yi_cap) represents the square difference between actual value(Yi) and predicted (Yi_cap).

Results and Analysis:

The results of this project demonstrate promising advancements in financial analysis and forecasting for medical stores. In terms of sales forecasting accuracy. This enhanced forecasting capability has significant implications for inventory management, as the forecast-driven restocking system contributed to a reduction in expired stock and a decrease in stockout incidents, signifying improved inventory efficiency. Analysis of financial metrics revealed a consistent increase in gross profit margin over the past year, suggesting enhanced profitability; however, a slight decrease in the inventory turnover ratio in the last quarter necessitates closer monitoring of inventory management practices.

Table 1: Comparative Evaluation of Naive and ARIMA Forecasting Models using MSE and MAPE for Different Pharmaceutical Categories

	M01AB	M01AE	N02BA	N02BE	N05B	N05C	R03	R06
Naive MSE	116.01	93.87	44.74	2753.64	255.48	14.92	948.56	82.22
Naive MAPE	28.76	36.20	33.47	21.45	24.30	inf	47.43	52.09
ARIMA MSE	74.76	76.57	31.94	2614.32	151.32	7.94	678.33	75.03
ARIMA MAPE	22.67	36.26	29.48	44.80	21.37	inf	78.65	113.28

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Naive MSE & MAPE:

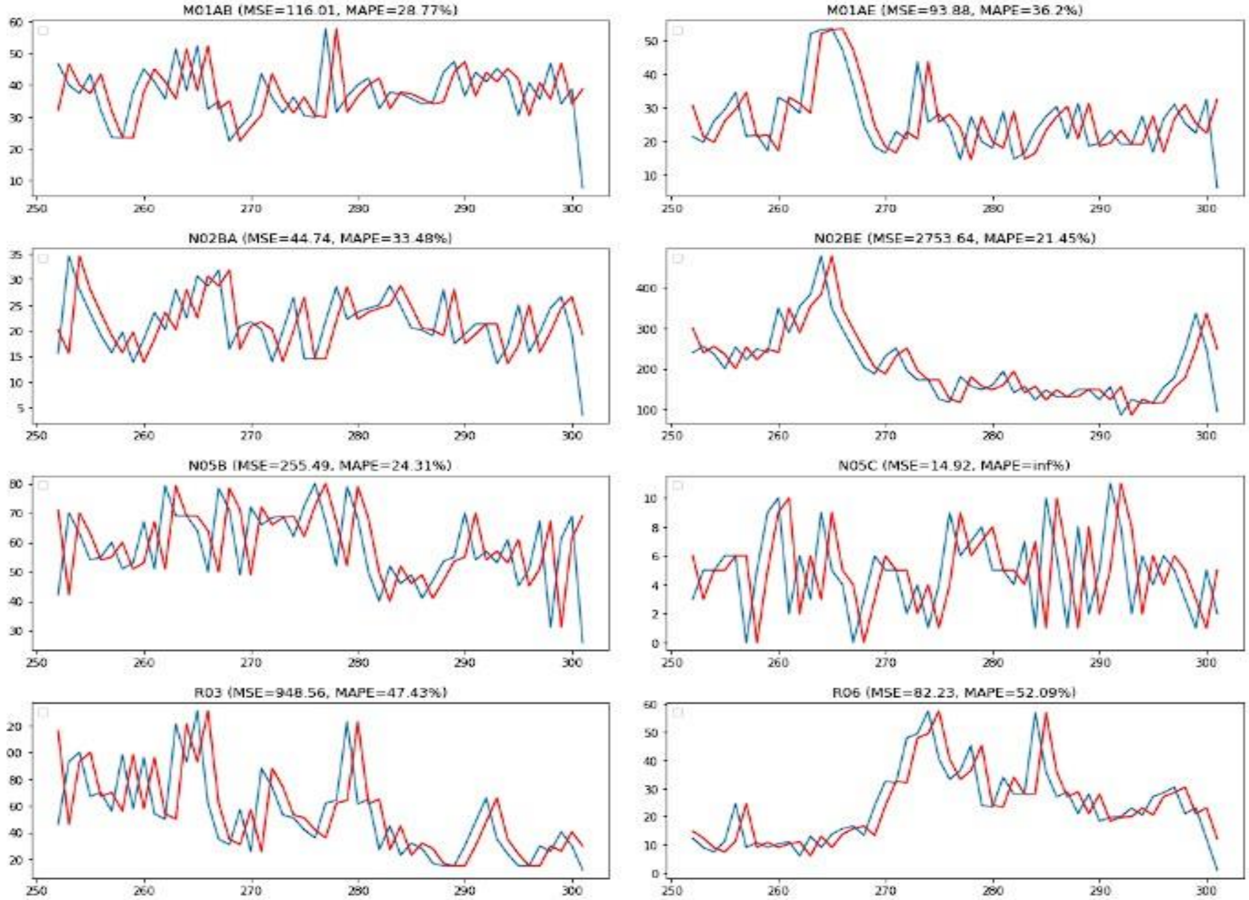

Figure 1: Naive Forecasting Performance Across Pharmaceutical Product Categories (MSE and MAPE Evaluation)

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ARIMA MSE & MAPE:

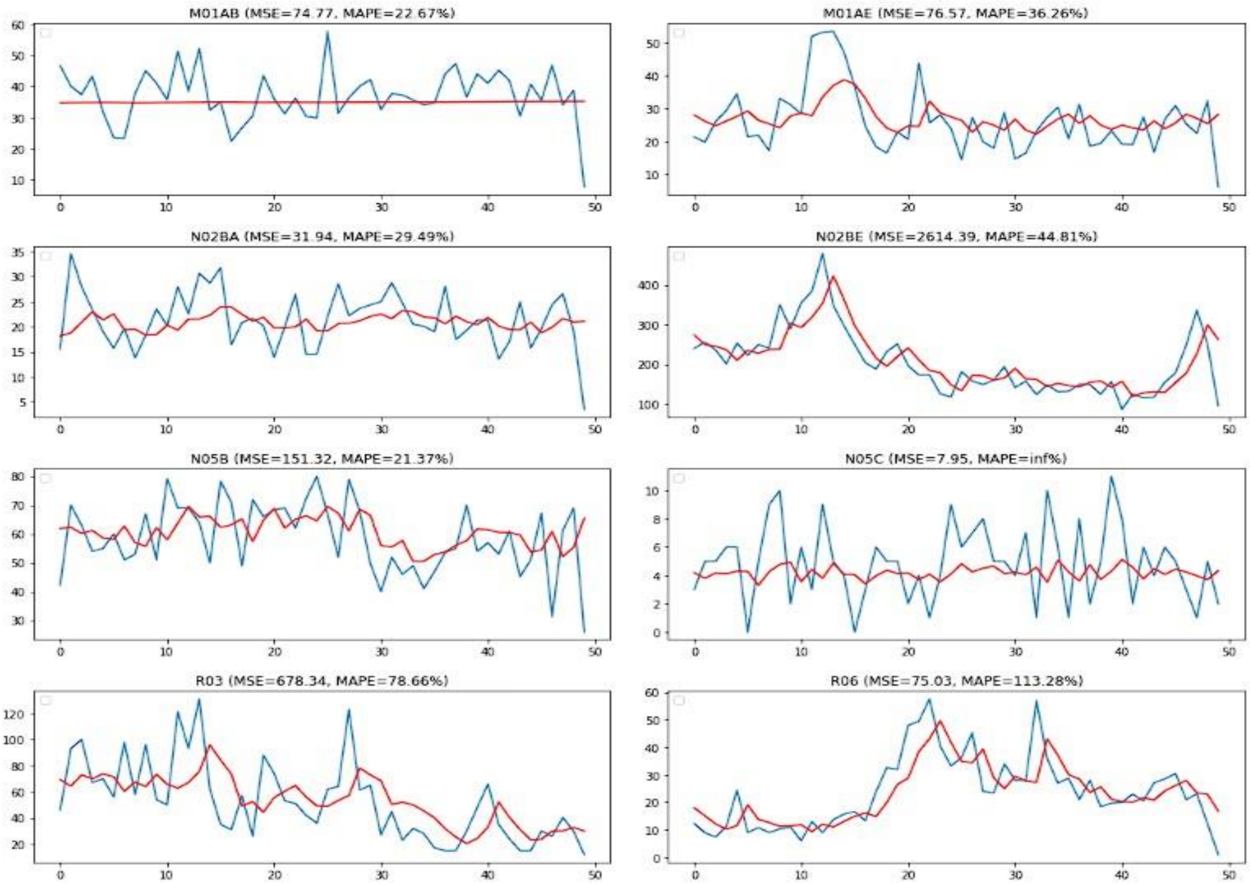

Figure 2: ARIMA Forecasting Performance Across Pharmaceutical Product Categories (MSE and MAPE Evaluation)

Conclusion and Future Scope

This research endeavour has culminated in the development and implementation of an AI-driven system designed to augment financial analysis and forecasting capabilities within the operational context of medical retail establishments. The project's findings evince the considerable potential of artificial intelligence to catalyse transformative improvements in both operational efficiency and strategic decision making within this crucial sector. The salient outcomes of this project underscore the efficacy of employing advanced AI techniques, specifically recurrent neural networks such for enhancing the precision of sales forecasting. The demonstrable superiority of

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traditional time series models, such as ARIMA, in capturing intricate temporal dependencies within sales data, has profound implications for inventory management practices. The resultant reduction in both stock wastage and stockout occurrences serves as compelling evidence of the tangible benefits derived from accurate demand prediction and optimized supply chain orchestration. Furthermore, this research has illuminated the critical role of comprehensive financial analysis and accessible data visualization in empowering stakeholders to make informed decisions. The automated computation and lucid presentation of key financial performance indicators provide a panoramic view of the enterprise's financial health, facilitating proactive identification of areas necessitating strategic intervention. The overwhelmingly positive user feedback regarding the interactive dashboards emphatically reinforces the importance of user-centric design principles in the development of effective decision support systems. Notwithstanding the significant strides made by this project, it is imperative to acknowledgecertain inherent limitations and to delineate potential avenues for future research and development. The predictive accuracy of the forecasting models remains contingent upon the quality, granularity, and availability of historical data. Future investigations could fruitfully explore the integration of exogenous variables, such as macroeconomic indicators, epidemiological data, or competitor activity, to further refine the predictive capabilities of these models. Moreover, while this project has demonstrated efficacy within the specific context of medical stores, the generalizability of these findings to a broader spectrum of healthcare settings or diverse retail environments warrants further empirical validation. Future research should also consider the incorporation of more sophisticated AI paradigms, such as reinforcement learning algorithms, to dynamically optimize inventory management strategies and enhance adaptive decision-making capabilities. This research has provided a robust framework for the application of artificial intelligence to enhance financial analysis, improve forecasting accuracy, and optimize operational processes within medical retail. The findings of this project portend a future wherein AI-driven systems play an increasingly pivotal role in driving efficiency gains, cost reductions, and enhanced decision making across the healthcare landscape, ultimately contributing to the advancement of healthcare delivery and improved patient outcomes.

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