

Artificial Intelligence-based Dynamic E-Commerce Pricing System using Machine Learning

G. Boomika

Department of Computer Science and Applications,
Vivekanandha College of Arts and Sciences for Women
(Autonomous),
Elayampalayam, Tiruchengode, TamilNadu, India.
Email: boomigunasekar@gmail.com

Dr. K. Ramesh

Department of Computer Science and Applications,
Vivekanandha College of Arts and Sciences for Women
(Autonomous),
Elayampalayam, Tiruchengode, TamilNadu, India.
Email: krmca86@gmail.com

Abstract: Pricing is a key factor that directly affects sales and profit in e-commerce businesses. Many existing e-commerce platforms use fixed or manually updated prices, which do not respond quickly to changes in customer demand, competitor pricing, or market trends. This paper proposes an AI-Based Dynamic E-commerce Pricing System that automatically adjusts product prices using machine learning techniques. The system applies Random Forest Regression to analyze historical sales data, product demand, and competitor prices in order to predict the most suitable price for each product. SQL Server is used to store and manage product and sales data securely, while Power BI is integrated to provide clear and interactive visual dashboards showing pricing trends, profit, and loss. Experimental results indicate that the proposed system improves pricing accuracy, reduces manual effort, and supports better decision-making. Overall, the system offers an efficient and intelligent pricing solution for modern e-commerce platforms.

Keywords: Dynamic Pricing, Machine Learning, Random Forest, E-Commerce, Artificial Intelligence, Data Visualization, Power BI

1. INTRODUCTION

The rapid growth of e-commerce has transformed the way people buy and sell products, Online platforms such as Amazon, Flipkart, and other digital marketplace offer a wide range of products and attract millions of customers every day. In such a competitive environment, pricing plays a crucial role in influencing customer purchase decisions and business profitability. Even a small change in product price can significantly impact sales volume, customer satisfaction, and revenue. In most real-time e-commerce systems, static or fixed pricing strategies are still widely used [1].

In these systems, product prices are either set once or updated manually by administrators at regular intervals, However, real-world market conditions are highly dynamic. Factors such as customer demand, competitor pricing, seasonal trends, stock availability, and time of purchase change continuously. Static pricing models fail to adapt to these frequent changes, leading to inefficient pricing decisions. As a result, businesses may lose potential customers due to higher prices or suffer profit loss due to under-pricing[2].

A real-time example of this problem can be observed during festival sales or seasonal demand peaks. When demand for certain products increases rapidly, fixed pricing does not take advantage of the opportunity to optimize profit. Similarly, when competitors reduce prices, manual pricing systems respond slowly, causing customer loss. This delay in price adjustment highlights the need for an automated and intelligent pricing mechanism that can respond instantly to market changes[3].

Artificial Intelligence (AI) and Machine Learning (ML) provide effective solutions to address these challenges. By analyzing large volumes of historical and real-time data, machine learning models can identify patterns and relationships that are difficult to capture using traditional methods. Dynamic pricing systems powered by AI can automatically predict and update optimal prices based on

factors such as demand, sales, history, and competitor behavior. This enables businesses to remain competitive while maximizing revenue. In this paper, an AI-Based Dynamic E-commerce Pricing System is proposed to overcome the limitations of static pricing. The system uses Random Forest Regression, a powerful ensemble machine learning algorithm, to predict suitable product prices with higher accuracy. The model processes multiple pricing factors simultaneously and products reliable pricing decisions. To support efficient data storage and management, SQL Server is used as the backend database. Additionally, Power BI is integrated to provide interactive dashboards that visualize, pricing trends, profit, and loss, helping administrators make informed decisions [4].

This system aims to reduce manual intervention, improve pricing accuracy, and enhance overall business performance. By combining machine learning with real-time data visualization, the system offers a practical and intelligent solution for modern e-commerce platforms facing real-world pricing challenges.[5]

III. LITERATURE REVIEW

Dynamic Pricing has been widely studied as an effective strategy to improve revenue and competitiveness in e-commerce platforms. Early pricing models mainly relied on fixed pricing or rule-based systems, where prices were updated manually based on experience or simple market rules. Although these methods were easy to implement, they failed to respond effectively to real-time changes in demand and competition, leading to ineffective pricing decisions. Several researchers have applied statistical and regression-based models for price prediction in e-commerce systems. Linear regression and time-series forecasting methods were commonly used to analyze historical sales data and predict future prices. While these techniques provided basic insights, they were limited in handling complex, non-linear relationships between pricing factors such as demand, seasonality, and competitor pricing[6].

2.1 Existing System

In most current e-commerce platforms, product pricing is based on static or manually controlled pricing mechanisms. Prices are usually fixed for a long period and are updated only when administrators manually review sales performance or market conditions. These pricing decisions depend heavily on human experience and basic market analysis rather than real-time data processing. The existing system does not effectively consider important pricing factors such as real-time customer demand, competitor pricing, seasonal trends, and stock availability [7].

2.1.2 Traditional Pricing Systems

In traditional e-commerce platforms, pricing is usually based on static or fixed pricing models. In these systems, product prices are set manually by administrators and remain unchanged for long periods. Price updates are done periodically based on experience, simple market analysis, or manual comparison with competitor prices. Although this approach is easy to implement, it does not adapt to real-time market changes such as fluctuating demand, seasonal variations, or sudden changes in competitor pricing. The existing system heavily depends on human intervention, which makes pricing decisions slow and inefficient. Manual pricing also increases the chances of errors and inconsistencies. As a result, businesses may lose customers due to higher prices or suffer financial loss due to under-pricing. These limitations highlight the need for an automated pricing solution. The existing pricing system is efficient, inflexible, and slow to respond to dynamic market conditions. These limitations highlight the need for an automated, AI-driven pricing solution that can adapt in real time and support better decision-making.

Table 1 : Comparative analysis of existing methods

Aspect	Existing System	Limitation
Pricing Method	Static or manual pricing	Not responsive to real-time changes
Analytical Approach	Regression & time-series models	Cannot handle complex market factors
Machine Learning Use	Basic decision tree models	Overfitting and instability
Real-Time Adaptability	Periodic price updates	Delayed market response
Manual Effort	High human involvement	Error-prone and inefficient
Decision Support	Limited reports	Low transparency

III. RESEARCH METHODOLOGY

This section describes the methodology followed to design and implement the AI-Based Dynamic E-Commerce Pricing System. The proposed approach combines data collection, machine learning-based price prediction, database management, and data visualization to achieve automated and accurate pricing decisions[8].

3.1.1 Data Collection

The dataset used in this study consists of historical e-commerce data, including product details, sales history, demand levels, and competitor pricing information. The data was collected from simulated and sample e-commerce records to represent real-time market conditions. Proper data cleaning was performed to remove missing values, inconsistencies, and duplicate records to ensure data quality[9].

3.1.2 Feature Selection

Key features influencing product pricing were identified and selected for model training. These include product demand, historical sales volume, competitor prices, time-based factors (such as seasonal demand), and stock availability. Feature selection helps improve model performance and reduces unnecessary computational complexity.

3.1.3 Machine Learning Model

The system employs Random Forest Regression for dynamic price prediction. Random Forest is an ensemble learning algorithm that builds multiple decision trees using random subsets of data and features. Each tree predicts a price, and the final output is obtained by averaging all predictions. This approach improves accuracy and reduces overfitting compared to single-model techniques.

3.1.4 Model Training and Testing

The dataset was divided into training and testing sets. The training set was used to train the Random Forest model, while the testing set was used to evaluate its performance. Evaluation metrics such as prediction accuracy and error rate were analyzed to ensure reliable pricing predictions.

3.1.5 System Architecture Implementation

The backend of the system was implemented using SQL Server, which stores product data, sales history, and pricing records securely. The trained machine learning model retrieves data from the database, predicts optimal prices, and updates them dynamically in the system.

3.1.6 Data Visualization Using Power BI

To support decision-making, Power BI was integrated into the system for data visualization. Dashboards were designed to display pricing trends, product-wise profit and loss, demand analysis, and category performance. These visual insights help administrators understand system performance and pricing behavior.

3.1.7 Dynamic Price Update Process

Once the model predicts the optimal price, the system automatically updates the product price in real time. This reduces manual intervention and ensures that pricing decisions reflect current market conditions.

3.2 Proposed System

The proposed system introduces an AI-Based Dynamic E-Commerce Pricing System that automatically adjusts product prices based on real-time and historical data. Unlike traditional static pricing methods, the proposed approach uses machine learning to analyze multiple market factors and determine the most suitable price for each product. The system aims to improve pricing accuracy, reduce manual intervention, and enhance overall

business performance. The core of the proposed system is a Random Forest Regression model, which predicts optimal product prices by analyzing key features such as product demand, historical sales data, competitor pricing, seasonal trends, and stock availability. By combining multiple decision trees, the Random Forest model provides stable and accurate price predictions even in dynamic and uncertain market conditions.

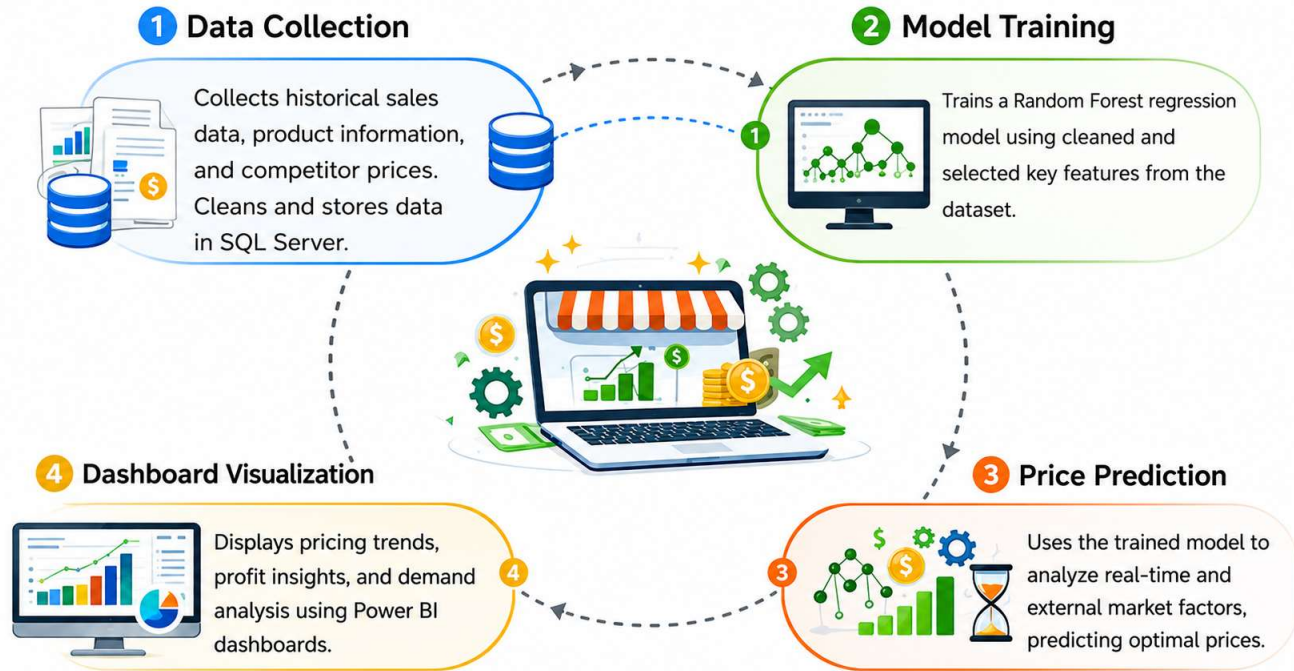


Figure 1 : Overview of Dynamic Pricing System

The system architecture consists of four main components. The data layer uses SQL Server to store product information, sales records, and pricing history securely. The machine learning layer processes this data and generates price predictions. The application layer updates product prices dynamically based on the model output. Finally, the visualization layer integrates Power BI to display pricing trends, profit and loss analysis, and product performance through interactive dashboards. The proposed system operates in a real-time environment where prices are updated automatically whenever there is a change in demand or market conditions. This eliminates the need for manual price monitoring and reduces the risk of human error. Administrators can monitor system performance and pricing behavior using Power BI dashboards, enabling informed decision-making.

Overall, the proposed system provides an intelligent, automated, and transparent pricing solution for modern e-commerce platforms. By leveraging machine learning and data visualization, the system enhances competitiveness, improves profitability, and ensures efficient price management.

IV. RESULTS AND DISCUSSION

The proposed AI-Based Dynamic E-Commerce Pricing System was implemented and evaluated using historical e-commerce data. The performance of the system was analyzed based on pricing accuracy, adaptability to demand changes, and business insight generation.

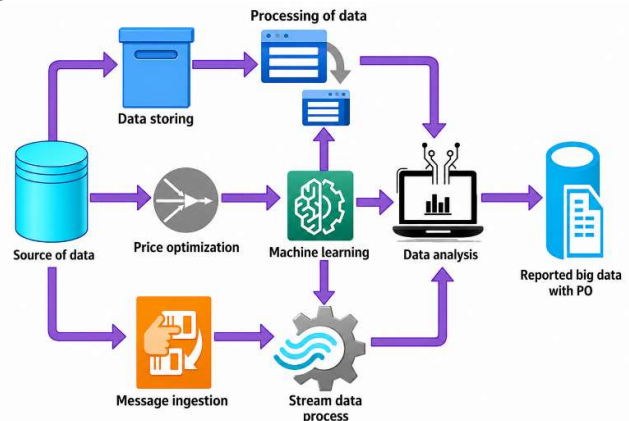


Figure 2 : Preprocessing of Data



Figure 3 : Dataset implementation in Power BI

4.1 Price Prediction Accuracy

The Random Forest Regression model demonstrated high accuracy in predicting optimal product prices. By analyzing multiple features such as demand level, historical sales, competitor prices, and seasonal trends, the model was able to generate stable and reliable pricing predictions. Compared to traditional regression-based pricing methods, the Random Forest model reduced prediction errors and handled non-linear relationships more effectively.

4.2 Dynamic Pricing Performance

The system successfully updated product prices dynamically in response to changes in demand and market conditions. When demand increased, the system adjusted prices to maximize revenue, while during low-demand periods, prices were optimized to improve sales volume. This automated pricing approach eliminated the need for manual price updates and reduced human errors.

4.3 Comparison with Existing Systems

When compared with traditional static pricing systems, the proposed system showed improved flexibility and responsiveness. Existing systems rely on manual or periodic price updates, whereas the proposed system performs real-time price optimization. The Random Forest-based model outperformed statistical and single-model machine learning approaches in terms of consistency and adaptability.

4.4 Visualization and Business Insights

The integration of Power BI dashboards enabled effective visualization of pricing trends, profit analysis, and demand patterns. Administrators were able to monitor product performance and pricing behavior easily through interactive charts

and reports. This visual support improved decision-making and system transparency.

4.5 Overall System Efficiency

The proposed system demonstrated efficient performance with reduced computational complexity and faster response time. It proved suitable for small and medium-scale e-commerce platforms by balancing accuracy and resource usage. Figure 1.4 demonstrate that the proposed AI-based dynamic pricing system provides better accuracy, automation, and business insights compared to the traditional pricing approach.

V. CONCLUSION

This paper presented an AI-Based Dynamic E-Commerce Pricing System designed to overcome the limitations of traditional static pricing approaches. The proposed system utilizes Random Forest Regression to predict optimal product prices by analyzing key factors such as historical sales data, demand variations, competitor pricing, and seasonal trends. By incorporating machine learning, the system is able to adopt prices dynamically in real time, thereby improving pricing accuracy and revenue optimization. The experimental results demonstrate that the proposed system outperforms traditional pricing methods in terms of accuracy, automation, and adaptability. The integration of Power BI dashboards further enhances the system by providing clear visual insights into pricing trends, profit and loss analysis, and overall business performance. This improves transparency and supports effective decision-making for administrators. Overall, this paper offers an efficient, scalable, and intelligent pricing mechanism suitable for modern e-commerce platforms

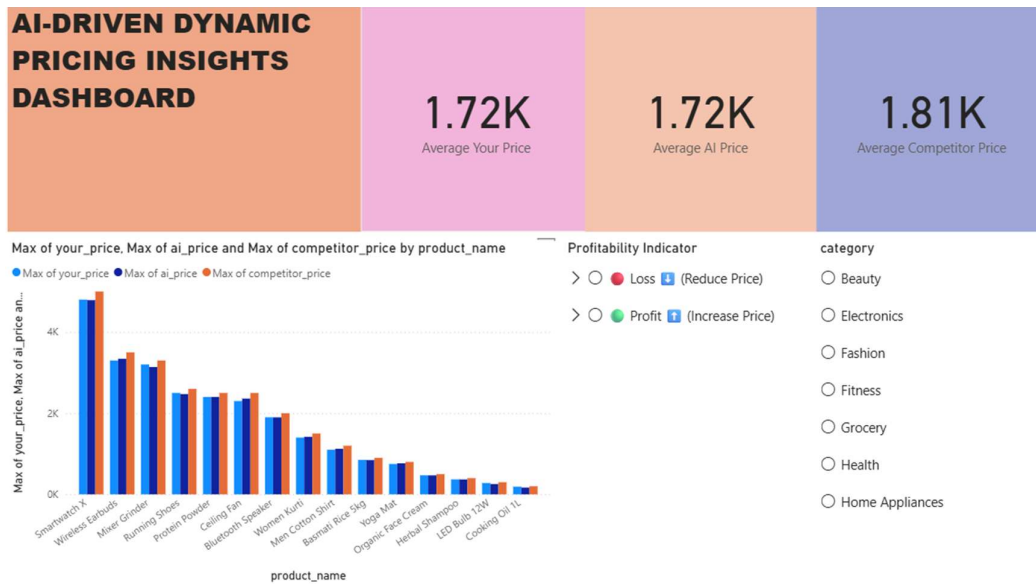


Figure 4 : Visualization of Data

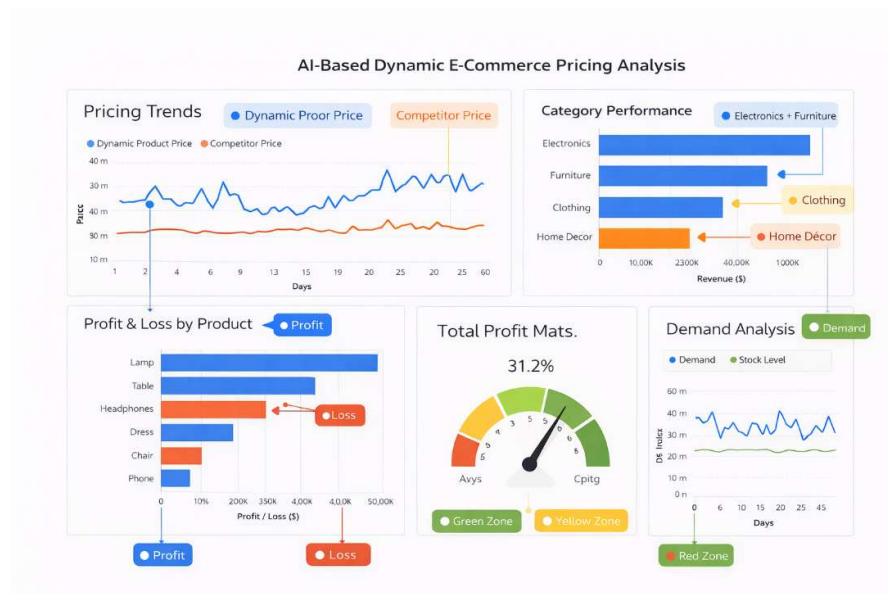


Figure 5 : Power BI Dashboard

VI. REFERENCES

[1] I. H. Witten and E. Frank, "Data mining: practical machine learning tools and techniques with Java implementations," *Acm Sigmod Record*, vol. 31, no. 1, pp. 76-77, 2002.

[2] K. Velusamy and R. Amalraj, "Performance of the cascade correlation neural network for predicting the stock price," in *2017 Second International Conference on Electrical, Computer and Communication Technologies (ICECCT)*, 2017: IEEE, pp. 1-6.

[3] K. Kalaiselvi, K. Velusamy, and C. Gomathi, "Financial prediction using back propagation neural networks with opposition based learning," in *Journal of Physics: Conference Series*, 2018, vol. 1142, no. 1: IOP Publishing, p. 012008.

[4] F. A. Shah et al., "Enhancing Weather Forecasting Accuracy: A Machine Learning Approach Using Genetic Algorithm and Random Forest," *Global Research Journal of Natural Science and Technology*, 2026.

[5] A. Agrawal, J. Gans, and A. Goldfarb, *Prediction machines, updated and expanded: The simple economics of artificial intelligence*. Harvard Business Press, 2022.

[6] D. R. Heath, "Prediction machines: the simple economics of artificial intelligence: by Ajay Agrawal, Joshua Gans

and Avi Goldfarb, Published in 2018 by Harvard Business Review Press, 272 pp., 30.00(hardcover), Kindle Edition: 16.19, ISBN: 978-1-633695672," ed: Taylor & Francis, 2019.

- [7] C. Shi, "From econometrics to machine learning: Transforming empirical asset pricing," *Journal of Economic Surveys*, vol. 40, no. 1, pp. 528-548, 2026.
- [8] S. R. Sethi and D. A. Mahadik, "Machine learning methods for financial distress prediction: an analytical overview and implications for sustainability goals," *Journal of Chinese Economic and Business Studies*, vol. 24, no. 1, pp. 1-52, 2026.
- [9] M. B. Bagherabad, E. Rivandi, and M. J. Mehr, "Machine learning for analyzing effects of various factors on business economic," *Applied Decision Analytics*, vol. 2, no. 1, pp. 41-54, 2026.