Shrutika Giri, 2026, 14:3
ISSN (Online): 2348-4098
ISSN (Print): 2395-4752

International Journal of Science, Engineering and Technology
An Open Access Journal

Adaptive BNPL with AI: A Comprehensive Study

Shrutika Giri[1], Gayatri Badgujar[2], Anvi Kore[3], Ravindra Apare[4]

[1,2,3]Artificial Intelligence and Data Science PVG's College of Engineering Technology and Management,SPPU Pune, India
[4]Professor, Artificial Intelligence and Data Science PVG's College of Engineering, Technology and Management,SPPU Pune, India

Abstract- Traditional Buy Now, Pay Later (BNPL) services are held back by their rigid, outdated systems, making them easy targets for fraud and unable to offer personalized experiences. This new Adaptive BNPL with AI is designed to overcome these limitations. Solution is a smart, multi-layered system that uses artificial intelligence to boost security and improve the user experience. At its core, it relies on AI models like Logistic Regression and Random Forest to create dynamic credit scores and accurately predict potential late payments. We're also using Isolation Forest for proactive fraud detection, stopping fraudulent activity before it even happens.To make the service even more user-friendly, we're integrating a conversational AI assistant powered by Natural Language Processing (NLP). The system will also feature flexible payment options, including the ability to split payments for a single transaction across multiple items or even multiple people.

Keywords: Credit Risk Prediction, Dynamic Credit Scoring, Fraud Detection, FinTech ,Buy Now Pay Later.

I. INTRODUCTION

The Buy Now, Pay Later model has fundamentally reshaped consumer finance in recent years, emerging as a compelling alternative to traditional credit instruments. By allowing consumers to split purchases into manageable installments, BNPL has gained remarkable traction worldwide. The market reflects this growth, rising from $5.01 billion in 2021 and projected to reach $90.51 billion by 2029, driven by the expansion of e-commerce and sustained consumer demand for flexible payment options.

But fast growth comes with real risks. BNPL platforms are designed to be quick and frictionless, which means deep credit checks are often skipped. That convenience is exactly what makes them attractive — and exactly what makes them vulnerable. Fraud and credit risk are serious concerns, and the old rule-based detection systems financial institutions have relied on for years are struggling to keep pace.

AI and machine learning offer a better path forward. Instead of waiting for a known pattern to trigger a preset flag, these models learn and adapt in real time, catching subtle fraud signals that traditional systems miss entirely.

This paper examines how these AI techniques apply to BNPL platforms — how they're built, how they perform, and what ethical and regulatory guardrails need to surround them. We contribute three things: a breakdown of the AI methods explored, a real-world comparison of model performance, and a discussion of what responsible development here actually requires.

The paper moves through this in order — Section 2 reviews existing research, Section 3 covers the techniques and results, Section 4 evaluates the algorithms, and Section 5 lists all referenced sources.

II. LITERATURE SURVEY

This project, "Advanced BNPL with AI," aims to improve existing BNPL platforms like Simpl and LazyPay by using AI and machine learning to overcome their reliance on limited data and static rules. The proposed system will analyze user behavior to predict late payments and detect fraud in real-time. It will use models such as Logistic Regression and XGBoost for dynamic credit scoring, Isolation Forest for fraud detection, and Random Forest for forecasting payment delays. This approach will provide a more secure, personalized financial experience, reduce losses, and enhance financial inclusivity by offering tailored EMI plans and continuous risk assessment.

Sr.No.	Title of Paper	Methodology	Remarks
1.	AI-Powered Fraud Risk Scoring for Buy Now, Pay Later (BNPL) Platforms(2025)[1]	The paper proposes a phased, hybrid implementation using advanced algorithms and large transaction datasets, combined with human oversight.	The authors conclude that a phased, hybrid approach combining AI models with human oversight is crucial for successful AI fraud risk scoring
2.	The influence of the buy-now-pay-later payment mode on consumer spending decisions(2025)[2]	The authors used transaction data and a series of experiments to test the "numerosity effect".	The study offers practical guidance for retailers and policymakers on how to leverage and manage the effect of installment prices on consumer spending..
3.	Adoption of Buy Now, Pay Later (BNPL): A Time Inconsistency Perspective(2025)[3]	The methodology involved creating two game-theoretic models, one with traditional payment and one with BNPL, to compare their outcomes.	BNPL can boost sales and expand financial access but may encourage overspending and debt cycles, highlighting the need for regulation.
4.	A credit card fraud detection approach based on ensemble machine learning classifier with hybrid data sampling(2025)[4]	The method used an ensemble classifier combining SMOTE-ENN, with AdaBoost, Random Forest, and KNN models.	Results show the combined approach detects fraud more effectively than existing methods, supporting the development of stronger, more adaptive systems.
5.	Regulatory and Ethical Challenges in Al-Driven and Machine learning Credit Risk Assessment for Buy Now, Pay Later (BNPL) in U.S. E-Commerce: Compliance, Fair Lending, and Algorithmic Bias(2025)[5]	The approach involved a deep dive into policies and research to see if they followed key U.S. consumer protection laws, like the Equal Credit Opportunity Act (ECOA) and the Fair Credit Reporting Act (FCRA).	The authors conclude that AI models in BNPL raise concerns about fair lending and algorithmic bias, necessitating careful deployment and oversight to ensure equitable access to credit and consumer protection
6.	AI and Blockchain Integration: Enhancing Security and Transparency in Financial Transactions(2024)[6]	The research uses a comprehensive review of existing literature and case studies. It discusses the use of AI's data processing capabilities alongside a Blockchain's immutable ledger	The integration significantly improves security through real-time fraud detection and anomaly identification while upholding data integrity and transparency.
7.	Transforming Banking Security: The Role of Deep Learning in Fraud Detection Systems(2024)[7]	The study compares Logistic Regression and XGBoost with an LSTM network, selected for their ability to handle complex time-series data.	The LSTM model performed best, achieving 98.5% accuracy and an AUC of 0.94 by capturing complex sequential transaction patterns.
8.	Enhancing fraud detection in accounting through AI: Techniques and case studies (2024)[8]	The review discusses the use of machine learning, natural language processing (NLP), and data mining. Case studies are used to illustrate practical applications.	AI provides powerful, proactive tools for fraud detection and will become increasingly essential as financial transactions expand.
9.	Enhancing audit accuracy: The role of AI in detecting financial anomalies and fraud (2024)[9]	The authors review AI techniques including machine learning and advanced analytics, and discuss their integration with technologies such as blockchain and RPA.	AI enhances auditing through real-time monitoring and predictive risk detection, but challenges like data quality and algorithmic bias remain.
10.	BNPL in the Consumerism World: About the Excessive Debt Trap(2024)[10]	The study relies on secondary data from a thematic literature review of scientific publications and industry reports focusing on the Polish BNPL market.	The authors conclude that BNPL can lead to excessive debt, particularly when consumers lack financial knowledge, and that regulation and oversight may be necessary to ensure

			consumer protection.
11.	Examining the Role of Artificial Intelligence in Cyber Security (CS): A Systematic Review for Preventing Prospective Solutions in Financial Transactions(2024)[11]	A systematic literature review was conducted on scholarly databases, journals, industry reports, and conference proceedings	The authors conclude that AI significantly improves cybersecurity through advanced threat detection and automated responses, but continuous evaluation and adaptation are crucial to combat increasingly sophisticated threats.
12.	A Survey on Machine Learning Techniques for Insurance Fraud Prediction(2024)[12]	Analysis of various ML algorithms	Concludes that hybrid and ensemble learning methods are more efficient and reliable than single-classifier models for insurance fraud
13.	Financial Fraud Detection Based on Machine and Deep Learning: A Review(2024)[13]	The authors explore various techniques including supervised, unsupervised, and hybrid approaches, with special attention to integrating technologies like blockchain and IoT with AI	Highlights the effectiveness of neural networks and hybrid models. Addresses challenges like data imbalance and "black-box" models
14.	Credit Risk Assessment and Fraud Detection in Financial Transactions Using Machine Learning(2024)[14]	The paper reviews various algorithms, including Logistic Regression, SVMs, Random Forests, Decision Trees, and Deep Neural Networks.	ML offers a transformative opportunity to enhance decision-making and mitigate risk compared to traditional methods
15.	Machine Learning Models for Fraud Detection: A Comprehensive Review and Empirical Analysis(2024)[15]	Comparative empirical analysis.	Highlights the lack of empirical analysis in the literature and compares models based on key metrics like precision, recall, and scalability

Ramchander Malkoochi argues that AI and machine learning are revolutionizing fraud risk scoring for BNPL services. By analyzing large amounts of data, AI can detect complex fraud in real time, improving accuracy and efficiency. The author recommends a hybrid approach combining AI with human oversight for success, while also noting challenges with data privacy and model interpretability.[1]

Rhys Ashby et al. found that BNPL increases consumer spending due to the "numerosity effect"—presenting lower-value installments makes a purchase seem less expensive. The study provides recommendations for retailers and policymakers to manage this effect.[2]

Yini Cheng and Jiazhen Huo looked at the strategic side of BNPL using game theory. They found that companies can use BNPL to take advantage of people's tendency to focus on the present, leading to higher prices and bigger profits. This can put customers in a "debt trap," so they suggest that regulations are needed to protect consumers.[3]

Khanda Hassan Ahmed et al. created a new, hybrid machine-learning model to detect credit card fraud. By using a technique called SMOTE with ENN to handle unbalanced datasets, their model was able to significantly improve accuracy, precision, and the F1-score compared to older methods.[4]

Aashish Mishra et al. focused on the legal and ethical issues of using AI for BNPL credit risk in the U.S. Their study highlights the need to comply with laws like the Equal Credit Opportunity Act (ECOA) and the Fair Credit Reporting Act (FCRA), especially to avoid algorithmic bias that could harm minority groups. They recommend using AI responsibly to ensure fair access to credit.[5]

Daniel Martinez et al. explored combining AI with Blockchain to improve security and transparency in financial transactions. Their study showed that integrating AI's data processing with Blockchain's immutable ledger can significantly reduce risks, with one case reporting a 60% decrease in fraudulent transactions.[6]

Md Al-Imran et al. investigated deep learning for banking fraud detection and found that LSTM outperformed traditional models like Logistic Regression and XGBoost, achieving 98.5% accuracy by capturing sequential transaction patterns.[7]

Beatrice Oyinkansola Adelakun et al. reviewed AI applications in accounting fraud detection, noting that traditional methods struggle with modern data complexity. They highlighted machine learning, NLP, and data mining as effective for identifying anomalies.[8]

Adelakun et al. also examined AI in auditing, explaining that AI enables analysis of all transactions instead of sampling, allowing continuous monitoring. They also noted challenges such as data quality and model bias.[9]

Bartosz Bagniewski et al. studied BNPL usage in Poland and found its convenience may encourage impulse buying and potential debt traps, especially among users with low financial literacy. They stressed the need for strong data security.[10]

Mahfujur Rahman Faraji et al. reviewed AI's role in financial cybersecurity and showed that AI improves automation and rapid threat detection by analyzing large-scale data for inconsistencies.[11]

Komal S. Patil and Prof. Anand Godbole provided an overview of ML in insurance fraud prediction, highlighting ensemble methods for effectively handling overfitting and class imbalance despite higher costs.[12]

Rojan Zaki Abdulkreem and Adnan Mohsin Abdulazeez reviewed ML and deep learning for fraud detection, emphasizing strong performance on large, imbalanced datasets while noting concerns about the black-box nature of deep models.[13]

Dr. Pankaj Malik et al. reviewed machine learning in credit risk and fraud detection, discussing models such as Logistic Regression, SVM, Random Forest, and DNN, along with challenges like imbalance and interpretability.[14]

Vishakha D. Akhare and Dr. L. K. Vishwamitra analyzed ML and DL models based on recall and scalability, concluding that proper model selection is critical for effective fraud detection systems.[15]

III. ANALYTICAL STUDY OF TECHNOLOGIES

Research on the "Adaptive BNPL with AI" project typically follows a three-stage pipeline: (1) user data acquisition and preprocessing, (2) risk and fraud analysis using machine learning models, and (3) intelligent decision-making and personalization.

A. Data Acquisition and Dataset Characteristics

Existing studies emphasize moving beyond basic KYC to include transactional, behavioral, and alternative data. Typical datasets contain features such as purchase history, repayment behavior, device details, and geolocation. A major challenge is class imbalance between safe and risky users, which affects model performance. Real-time streams from user activity, transactions, and biometric inputs (e.g., video KYC, voice payments) form the main data sources.

B. Machine Learning Models for Financial Risk Assessment

To evaluate creditworthiness, the project employs multiple models selected for performance and interpretability.

1]. Logistic Regression:

Serves as the initial screening model to classify users as safe or risky before BNPL approval. Its key advantage is simplicity and interpretability, ensuring transparency.

2]. Random Forest:

Handles complex data patterns effectively and is well-suited for predicting late payments and estimating credit scores.

3]. XGBoost:

A powerful and widely used FinTech algorithm known for high accuracy and speed, making it reliable for advanced risk assessment.

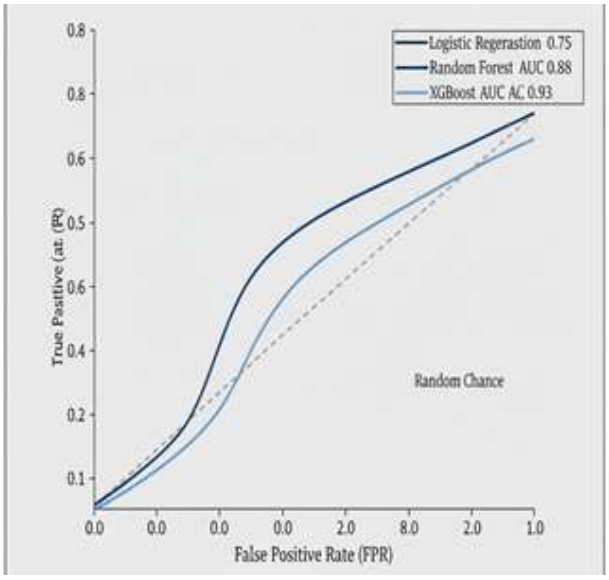

Fig no.1.ROC curve for Credit Risk Model

Table for Fig. 1: ROC Curve AUC Values

Model	AUC Score
Logistic Regression	0.75
Random Forest	0.88
XGBoost	0.93

The Fig no.1,Receiver Operating Characteristic (ROC) curve is a graph that evaluates the performance of a binary classifier, like your credit risk models, across various classification thresholds. It plots two key metrics:

- **True Positive Rate (TPR):** This is the proportion of actual positive cases (e.g., "risky" users) that the model correctly identified.
- **False Positive Rate (FPR):** This is the proportion of actual negative cases (e.g., "safe" users) that were incorrectly flagged as positive.

C. Advanced Security and Fraud Detection Approaches The project adopts a multi-layered fraud prevention strategy to counter sophisticated attacks.

1]. Isolation Forest:
An effective anomaly detection algorithm that identifies unusual transaction behavior without requiring prior fraud examples.

2]. Convolutional Neural Networks (CNNs):
Used for real-time deepfake detection during video-based identity verification by analyzing facial features and motion patterns.

3]. Location-Aware Fraud Detection:
Compares the user's device location with the transaction location; any significant mismatch signals potential fraud or account compromise.

IV. SYSTEM EVALUATION

The reviewed studies show clear progress in applying AI to finance, moving from rule-based systems to advanced deep learning frameworks. Earlier methods relied on basic identity checks and simple models like Logistic Regression, while modern approaches use stronger algorithms such as Random Forest and XGBoost, which deliver better performance in credit risk assessment and fraud detection.

However, important limitations remain. Many platforms still use fragmented data and static models, limiting adaptability. They often lack robust real-time fraud detection and personalized repayment planning. Additionally, the absence of a fully integrated platform combining deepfake-resistant KYC with advanced BNPL features represents a key research and market gap.

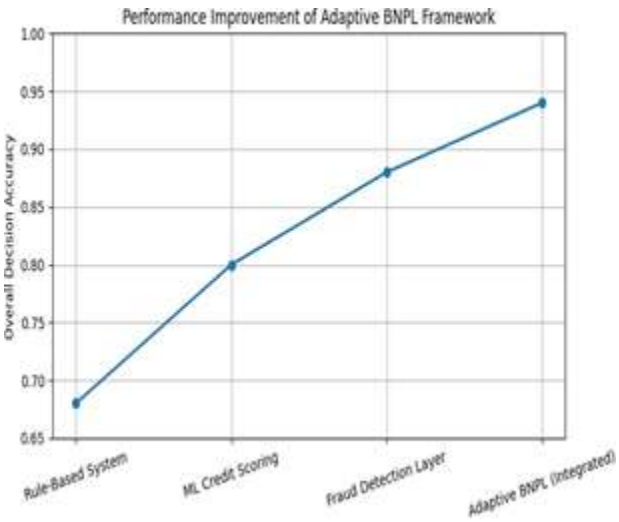

Fig no- 2. System Evolution Stage

Table for Fig 2: System Evolution Stage

System Evolution Stage	Overall Accuracy
Rule-Based System	0.68
ML Credit Scoring	0.80
Fraud Detection Layer	0.88
Adaptive BNPL	0.94

Fig. 2 This graph illustrates the performance improvement of the Adaptive BNPL framework across different system stages. It shows a steady increase in overall decision accuracy as the system evolves from a basic rule-based approach to a fully integrated AI-driven BNPL solution, highlighting the effectiveness of layered machine learning and fraud detection enhancements.

Fig no-3. Real-Time Deepfake Detection for KYC

Fig. 3 shows the system's fraud detection flow. A request is first analyzed by Isolation Forest for anomalies, then by a CNN for deepfake detection during KYC, and finally checked against the user's location. This illustrates the project's multi-layered security approach, providing stronger protection than single-layer systems.

V. CONCLUSION

A review of existing literature reveals a persistent gap in the BNPL landscape: while prior studies have addressed fraud detection and credit scoring independently, a unified platform integrating these capabilities within an intelligent, adaptive framework remains absent.

To address this, the proposed Advanced BNPL with AI system integrates multiple machine learning methodologies into a cohesive architecture. Specifically, XGBoost and Random Forest algorithms are employed for credit risk assessment, Isolation Forest is utilized for real-time anomaly and fraud detection, Natural Language Processing (NLP) facilitates conversational user interaction, and Convolutional Neural Networks (CNN) support deepfake identification during identity verification.

The system further incorporates behavioral and alternative data sources to extend financial accessibility to individuals lacking conventional credit histories — a demographic frequently underserved by traditional lending infrastructure.

Notwithstanding its technical contributions, the system acknowledges critical ethical considerations, particularly regarding algorithmic bias and model transparency, which must be systematically addressed to ensure equitable and accountable deployment. In summation, the proposed platform constitutes a significant advancement toward a more secure, intelligent, and inclusive digital financial ecosystem..

FUTURE SCOPE

1. **Real-World Impact (Deployment)**

-The Integration Hurdle: Linking advanced AI (e.g., LSTMs) with legacy systems while ensuring millisecond-level decisions.

-The Never-Ending Upgrade: Fraud evolves, requiring MLOps to continuously monitor, retrain, and maintain model performance.

-Scaling for Everyone: Systems must scale reliably from large loans to small BNPL transactions without performance loss.

2. The Ethical Compass (Bias, Privacy, and Trust)

-The Fairness Fight (Algorithmic Bias): Historical data can embed bias; active bias detection and mitigation are essential to ensure fair, inclusive outcomes.

-The Privacy Promise (Data Security): Sensitive financial data demands privacy-preserving AI (e.g., Federated Learning) to protect user information.

-Opening the Black Box (Transparency): Explainable AI (XAI) is necessary so regulators and users understand model decisions, building trust and accountability.

REFERENCES

1. M. R. Mahmud and M. R. Hoque, "Advanced AI-Driven Credit Risk Assessment for Buy Now, Pay Later (BNPL) and E-Commerce Financing: Leveraging Machine Learning, Alternative Data, and Predictive Analytics for Enhanced Financial Scoring," Advanced Science, Engineering and Management, vol. 6, no. 2, pp. 24-35, 2024. (Mahmud and Hoque #)
2. M. Al-Imran, E. H. Ayon, M. R. Islam, F. Mahmud, S. Akter,
   M. K. Alam, M. T. Hasan, S. Afrin, J. F. Shorna, and M. M. Aziz, "Transforming Banking Security: The Role of Deep Learning in Fraud Detection Systems," The American Journal of Engineering and Technology, vol. 6, no. 11, pp. 20–32, 2024. (Al-Imran #)
3. B. Bagniewski, J. Kubiczek, and Z. Żuchowska, "BNPL in the Consumerism World: About the Excessive Debt Trap," Journal of Finance and Financial Law, vol. 4, no. 44, pp. 49–62, 2024. (B. Bagniewski et al. #)
4. V. Gandhi and T. Gajjar, "Enhancing Fraud Detection in Financial Transactions through Cyber Security Measures," International Journal of Scientific Research in Computer Science, Engineering and Information Technology, vol. 10, no. 2, pp. 364–371, 2024. (Gandhi and Gajjar #)
5. B. O. Adelakun, B. O. Antwi, D. T. Fatogun, and O. P. Olaiya, "Enhancing Audit Accuracy: The Role of AI in Detecting Financial Anomalies and Fraud," Finance & Accounting Research Journal, vol. 6, no. 6, pp. 1049–1068, 2024. (Adelakun and Antwi #)
6. P. Malik, A. Chourasia, R. Pandit, S. Bawane, and J. Surana, "Credit Risk Assessment and Fraud Detection in Financial Transactions Using Machine Learning," Journal of Electrical Systems, vol. 20, no. 3s, pp. 2061–2069, 2024. (Malik and Chourasia #)
7. S. Shankar, "A Research on Buy Now Pay Later Model of Amazon," International Journal of Engineering Technology and Management Sciences, vol. 6, no. 5, p. 784, 2022. (Shankar #)
8. D. Martinez, L. Magdalena, and A. N. Savitri, "AI and Blockchain Integration: Enhancing Security and Transparency in Financial Transactions," International Transactions on Artificial Intelligence, vol. 3, no. 1, pp. 11–20, 2024. (Martinez and Magdalena #)
9. K. Katterbauer, H. Syed, S. Y. Genc, and L. Cleenewerck, "AI Driven Islamic Buy Now Pay Later (BNPL) – A Legal Analysis," Journal of Management and Islamic Finance, vol. 3, no. 1, pp. 1–19, 2023. (Katterbauer et al. #)
10. M. N. Ashtiani and B. Raahemi, "Intelligent Fraud Detection in Financial Statements Using Machine Learning and Data Mining: A Systematic Literature Review," IEEE Access, vol. 10, pp. 72504–72525, 2022. (Ashtiani and Raahemi #)