Literature Review

1. A MCDM-Based Evaluation Approach for Imbalanced Classification Methods in Financial Risk Prediction

Citation: Song, Y., & Peng, Y. (2019). A MCDM-Based Evaluation Approach for Imbalanced Classification Methods in Financial Risk Prediction. *IEEE Access*, *7*, 84897–84907.

https://doi.org/10.1109/ACCESS.2019.2924923

Abstract

Various classifiers have been proposed for financial risk prediction, but the traditional use of a single performance metric is insufficient for imbalanced classification problems. This paper proposes a multi-criteria decision making (MCDM)-based approach to evaluate these classifiers by considering multiple performance metrics simultaneously. An experimental study was conducted on seven imbalanced financial datasets from the UCI Machine Learning Repository. The TOPSIS method, a well-known MCDM technique, was used to rank imbalanced classifiers based on six popular evaluation criteria. The results indicate that the TOPSIS ranking provides a more reasonable and comprehensive evaluation than any single criterion. The study also found that Synthetic Minority Oversampling Technique (SMOTE)-based ensemble methods outperform other approaches, with SMOTEBoost-C4.5, SMOTE-C4.5, and SMOTE-MLP identified as the top three classifiers.

Conclusion

The primary goal of this paper was to evaluate imbalanced classifiers in financial risk prediction by simultaneously considering multiple performance measures through a multi-criteria decision making (MCDM) method. Since financial risk data is inherently imbalanced, selecting an effective algorithm is a critical task. The experiment utilized four standard classifiers combined with resampling, cost-sensitive, and hybrid techniques on seven financial datasets, evaluated against six performance metrics. To ensure objectivity, the entropy-based method was used to calculate the criteria weights from the evaluating matrix without input from the decision maker. The TOPSIS method was then applied to rank the classifiers. The final rankings showed that SMOTE-based ensemble classifiers, specifically SMOTEBoost-C4.5, SMOTE-C4.5, and

SMOT-MLP, outperformed other methods. This MCDM-based approach effectively addresses the limitations of single-criterion evaluations.

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2. A Novel Hybrid Model for Loan Default Prediction in Maritime Finance Based on Topological Data Analysis and Machine Learning

Citation: Kheneifard, M. A., & Amiri, B. (2025). A Novel Hybrid Model for Loan Default Prediction in Maritime Finance Based on Topological Data Analysis and Machine Learning. *IEEE Access*, *13*, 81474-81493.

https://doi.org/10.1109/ACCESS.2025.3566066

Abstract

The global shipping industry, crucial to international trade, faces significant financial vulnerabilities due to cyclical asset values and high leverage, which make traditional credit risk models inadequate. This paper introduces a new framework that combines topological data analysis (TDA) with machine learning (ML) to improve default prediction in maritime finance. By creating correlation-based networks of shipping firms and extracting topological features, the model captures nonlinear risk patterns that conventional metrics overlook. These network properties and financial indicators are used to train Graph Neural Networks (GNNs). When tested on a dataset of shipping loans, the TDA-enhanced models showed significant improvements, increasing logistic regression accuracy from 62.8% to 85.1% and achieving ROC-AUC scores of 0.931 for SVM and 0.973 for XGBoost. The results confirm that incorporating TDA-derived features enhances the early detection of financial distress by capturing systemic risks from market shocks, offering a robust tool for lenders and policymakers.

Conclusion

This study introduced a novel framework integrating Topological Data Analysis (TDA) and Machine Learning (ML) to address the unique challenges of default prediction in the volatile maritime finance sector. By constructing correlation-based networks and extracting persistent homological features, the model identifies latent risk patterns that conventional metrics often miss. The TDA-enhanced models demonstrated substantial performance improvements on a comprehensive dataset of shipping loans. The integration of topological features allowed the models to better capture systemic risks and complex interdependencies within the industry. Key predictors like loan amount, vessel

age, and debt-to-equity ratios were confirmed as significant risk factors. This hybrid TDA-ML approach not only improves predictive accuracy but also offers actionable insights for credit assessment, helping to foster resilience in a sector vital to global trade. Future research could involve expanding the dataset globally and exploring dynamic network representations to better capture evolving market conditions.

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3. Classification Methods Applied to Credit Scoring with Collateral

Citation: Teles, G., Rodrigues, J. J. P. C., Saleem, K., & Kozlov, S. A. (2020). Classification Methods Applied to Credit Scoring with Collateral. *IEEE Systems Journal*, *14*(3), 4557–4566.

https://doi.org/10.1109/JSYST.2019.2937552

Abstract

Credit operations are essential for financial institutions, but errors in granting credit can lead to significant financial losses. This article presents a meta-analysis of 84 studies to compare the results of various classification methods used for credit scoring. The analysis reveals that Support Vector Machine (SVM) is the most frequently used classifier and performs well, but it typically does not incorporate collateral in its approach. The study highlights that collateral is not usually the first consideration in credit scoring systems. The paper proposes using a statistical methodology to compare these methods, considering different probability distributions and survival data.

Conclusion

The predominant credit scoring models in the banking system are often static and remain unchanged for years. This article reviewed decision support systems (DSS) for credit operations, starting from the Basel Accords, and clarified the role of "intelligence" in these systems by describing various classifiers. Research on credit scoring is vast and can be divided into knowledge-based, data-based, and model-based systems. A detailed meta-analysis of classifiers revealed that the approach to including collateral remains a challenge. The primary objective was to create a model using context-aware information to evaluate if guarantees (collateral) can help recover granted credit. The findings suggest that data mining and machine learning techniques are necessary to find the best classifier for this purpose. Future work could involve measuring the

meta-analysis in other ways, such as risk ratio, and comparing random versus fixed models.

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4. Credit Risk Prediction Based on Improved ADASYN Sampling and Optimized LightGBM

Citation: Song, M., Ma, H., Zhu, Y., & Zhang, M. (2024). Credit Risk Prediction Based on Improved ADASYN Sampling and Optimized LightGBM. *Journal of Social Computing*, *5*(3), 232–241.

https://doi.org/10.23919/JSC.2024.0019

Abstract

This study proposes a credit risk prediction model named KM-ADASYN-TL-FLLightGBM (KADT-FLightGBM). To address the limitations of traditional sampling methods on imbalanced datasets, an improved ADASYN sampling method integrated with a K-means clustering algorithm is constructed. The Tomek Links method is also used to filter the synthetically generated samples. The model is trained using an optimized LightGBM algorithm with Focal Loss on the processed datasets. A comparative analysis on the Lending Club dataset shows that the proposed model effectively minimizes the misclassification of minority classes in credit risk prediction and can serve as a reference for similar studies.

Conclusion

Accurate credit risk prediction models are essential in the lending field to reduce unnecessary financial losses. Data imbalance is a significant factor that affects the performance of these models. This paper proposed an improved LightGBM model that uses Focal Loss (FLightGBM) and a hybrid sampling method called KADT to solve the data imbalance problem. At the data level, the KADT hybrid sampling method successfully balanced the dataset and improved upon the issue of the ADASYN method being susceptible to outlier noise. When compared with other classical sampling methods and ensemble models, the KADT-FLightGBM model demonstrated the best results for credit risk prediction. Future work will focus on using LASSO for feature screening and validating the model on more credit risk datasets.

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5. A SaaS Framework for Credit Risk Analysis Services

Citation: Redondo, J. M., & Ortin, F. (2017). A SaaS Framework for Credit Risk Analysis Services. *IEEE Latin America Transactions*, *15*(3), 474–481.

https://doi.org/10.1109/TLA.2017.7896422

Abstract

Credit Risk Analysis (CRA) software services have become increasingly important due to the recent financial crisis. Integrating CRA services into existing Enterprise Resource Planning (ERP) systems is often costly because of the unique requirements of each company. This paper presents OneRate, a Software as a Service (SaaS) CRA solution that frees companies from the high costs of adapting their ERPs or maintaining separate CRA products. OneRate is highly customizable to the particular needs of each client, allowing customers to benefit from existing CRA capabilities while also having a personalized product. The solution is currently used by over 300 users across 32 different companies.

Conclusion

The development of Credit Risk Analysis (CRA) services using a Software as a Service (SaaS) approach offers significant benefits in terms of maintenance and reduced investment for companies. OneRate provides these services in a personalized manner based on the company's requirements and user roles, utilizing a layered architecture. The product implements a set of general CRA services applicable to most companies, as well as more specific services adapted to particular clients. The successful achievement of the project's objectives was made possible by the appropriate choice of technologies and development procedures. Future work is focused on implementing mobile applications that will communicate with the system's service layer.

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6. Analytic of B2C E-Commerce Credit Mechanism Mixed Strategy Risk Behaviour Based on Logical Game Petri Nets

Citation: Liu, W., Feng, X., Zhang, F., Du, Y., & Yan, C. (2018). Analytic of B2C E-Commerce Credit Mechanism Mixed Strategy Risk Behaviour Based on Logical Game Petri Nets. *IEEE Access*, *6*, 29109–29131.

https://doi.org/10.1109/ACCESS.2018.2838765

Abstract

To address credit risk issues in B2C e-commerce, this paper proposes a credit risk game mechanism based on game theory and logical Petri nets theory. First, a theoretical modelling method called logical game Petri nets is proposed by combining the two theories. Utility functions describing the relationships between enterprises are derived using the least square method to characterize the utility gained by each party. A logical game Petri net model is then constructed to specify interactions within the enterprise competition module. To analyse the model's behaviour, a reachable marking graph is established, and a utility matrix is designed to determine the maximum expected utility for the participants. Through this analysis, the model guarantees both local and global optimal utility for individuals and groups.

Conclusion

This paper combined logical Petri net theory and game theory to propose the theory of Logical Game Petri nets, providing its formal definition, graphical representation, dynamic properties, and analysis methods. The study of credit risk in B2C e-commerce was conducted by transforming the problem into game behaviour among four main bodies (consumer, enterprise, e-commerce platform, government). The enterprise competition module was analysed by establishing a Logical Game Petri Nets (LGPN) model and its reachable marking graph (RMG), solving the utility function with the least square method, and using a game matrix to analyse four key traces describing the game behaviour. The properties of Local and Global Optimality for individuals and groups were analysed, and the relationship between different business modes and enterprise effectiveness was verified.

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7. AI-Based Hybrid Models for Predicting Loan Risk in the Banking Sector

Citation: Kumar, V., Saheb, S. S., Preeti, Ghayas, A., Kumari, S., Chandel, J. K., Pandey, S. K., & Kumar, S. (2023). AI-Based Hybrid Models for Predicting Loan Risk in the Banking Sector. *Big Data Mining and Analytics*, *6*(4), 478–490.

https://doi.org/10.26599/BDMA.2022.9020037

Abstract

As real-world scenarios become digitized to reduce costs, Machine Learning (ML) models are increasingly used for prediction. Accurate forecasting depends

on understanding these ML models and their features, as different models yield different results for the same dataset. This study investigates the use of ML to quantify mortgage credit risk, using a loan risk model to illustrate how different ML models can be linked. It examines various credit risk calculation approaches, from basic to complex, based on an analysis of mortgage credit defaults during the 2021 economic crisis. A case study on a sample of mortgage loans compares the results of logistic regression, decision tree, and gradient boost to determine which provides the most commercially useful insights.

Conclusion

Financial companies heavily rely on credit risk prediction to avoid erroneous evaluations that can lead to financial losses or missed opportunities. By combining traditional and modern Artificial Intelligence (AI) technologies, a hybrid prediction model can be created that is more accurate than any single methodology alone. Accuracy measurements are crucial for selecting the right ML model for a dataset, as they help reduce issues like underfitting and overfitting. Six hybrid models were constructed by merging logistic regression, discriminant analysis, and decision trees with four types of neural networks. The experimental and statistical analysis demonstrated that the hybrid model can produce a distinct and effective credit risk prediction methodology. The classifier's effectiveness was tested and verified using five real-world credit score datasets.

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8. An Improved Ensemble Method with Data Resampling for Credit Risk Prediction

Citation: Aruleba, I., & Sun, Y. (2025). An Improved Ensemble Method with Data Resampling for Credit Risk Prediction. *IEEE Access*, *13*, 71275–71287.

https://doi.org/10.1109/ACCESS.2025.3563432

Abstract

Predicting credit risk is a critical yet challenging task in the finance sector due to the complexity of financial data. The effectiveness of machine learning (ML) in this area has been limited by the imbalanced nature of credit datasets. This study introduces an improved approach using a stacked ensemble method combined with a hybrid data resampling technique. The ensemble uses random forests, logistic regression, and a convolutional neural network (CNN) as base learners, with a multilayer perceptron (MLP) as the meta-learner. To address

data imbalance, the Synthetic Minority Over-sampling Technique and Edited Nearest Neighbours (SMOTE-ENN) was applied. The proposed model was benchmarked against other high-performing classifiers and showed significant enhancement in prediction, achieving high sensitivity and specificity on both the Australian and German datasets. On two other credit risk datasets, the model's performance metrics, including accuracy, sensitivity, and specificity, improved substantially after data resampling, outperforming other models.

Conclusion

This study demonstrated that combining SMOTE-ENN resampling with a stacked ensemble model significantly improves the accuracy, sensitivity, and specificity of credit risk predictions on imbalanced datasets. The proposed model, tested on Australian and German credit datasets, consistently outperformed traditional ML and other deep learning methods. This highlights the effectiveness of combining advanced resampling techniques with sophisticated model architectures for credit risk assessment. The superior performance suggests these methodologies can better handle the complexities of credit risk prediction, with potential applications in large-scale financial systems for fraud detection and customer segmentation. Although SMOTE-ENN is effective, it has limitations such as the risk of synthetic data overfitting and potential noise introduction from ENN. Future research should compare it with other resampling techniques like ADASYN, explore additional data sources, experiment with more advanced architectures, and focus on explainable AI for transparency.

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9. An Investigation of Credit Card Default Prediction in the Imbalanced Datasets

Citation: Alam, T. M., Shaukat, K., Hameed, I. A., Luo, S., Sarwar, M. U., Shabbir, S., Li, J., & Khushi, M. (2020). An Investigation of Credit Card Default Prediction in the Imbalanced Datasets. *IEEE Access*, *8*, 201173–201198.

https://doi.org/10.1109/ACCESS.2020.3033784

Abstract

With the growth of the financial industry, predicting the credit risk of clients has become a major threat for commercial banks. A critical challenge in this area is dealing with imbalanced datasets, where most cases belong to one class. This study develops a model for credit default prediction using several credit-related

datasets, addressing data imbalance with various undersampling and oversampling techniques. Min-Max normalization is used to scale features. The study tests the hypothesis of whether different machine learning models perform similarly and if resampling significantly improves performance, using One-way ANOVA for statistical validation. Results show a significant accuracy improvement from around 65-70% on imbalanced datasets to 84-89% on balanced datasets. The Gradient Boosted Decision Tree (GBDT) method, particularly with K-means SMOTE oversampling, performed best. An interpretable model was also deployed on the web to assist stakeholders in making earlier predictions.

Conclusion

This paper's objective was to train supervised learning algorithms to predict a client's credit card payment behaviour. A key focus was addressing the issue of imbalanced datasets, which is crucial for enhancing model performance; various resampling techniques were used to balance the data. After performing exploratory data analysis and normalization, a Gradient Boosted Decision Tree (GBDT) model was implemented and compared against traditional machine learning models. The GBDT model demonstrated higher prediction accuracy, achieving the best result of 88.7% accuracy when using the K-means SMOTE resampling method on the Taiwan client's credit dataset. The results from this dataset were significantly better than those from the other datasets used. Finally, the proposed model was deployed on the web to assist stakeholders like financial institutions in making decisions by considering a client's payment history and current credit limit. The model confirms that while personal information like age and education affects default behaviour, financial institutions should focus more on financial history.

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10. Credit Risk Analysis Using Quantum Computers

Citation: Egger, D. J., García Gutiérrez, R., Cahué Mestre, J., & Woerner, S. (2021). Credit Risk Analysis Using Quantum Computers. *IEEE Transactions on Computers*, *70*(12), 2136–2145.

https://doi.org/10.1109/TC.2020.3038063

Abstract

This paper presents and analyses a quantum algorithm designed to estimate credit risk more efficiently than classical Monte Carlo simulations. The

algorithm specifically estimates the economic capital requirement, defined as the difference between the Value at Risk and the expected value of a given loss distribution. This is a critical risk metric that determines the capital needed to remain solvent at a specific confidence level. The study implements this problem for a realistic loss distribution and analyses its scalability to a practical problem size. It provides detailed estimates of the required number of qubits, expected circuit depth, and the projected runtime on future fault-tolerant quantum hardware.

Conclusion

This paper developed and analysed a quantum algorithm that provides a quadratic speedup for estimating the economic capital requirement. The algorithm was demonstrated through simulation, and its scaling and expected runtime for realistic problem sizes were analysed under reasonable assumptions about future quantum computers. The authors argued that the results could be extended to more complex uncertainty models or other objectives, like the conditional value at risk, without significant overhead. The specific quantum circuit for the Gaussian conditional independence model was developed. Although significant hardware development is still needed, the quadratic speedup offered by amplitude estimation shows immense potential for quantum computing in credit risk analysis. The analysis was made transparent to allow for adjustments based on new insights into hardware or algorithms, suggesting the current assumptions may be conservative and the technology's potential even greater than outlined.

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11. Digital Risk Assessment Framework for Individuals: Analysis and Recommendations

Citation: Muammar, S., Shehada, D., & Mansoor, W. (2023). Digital Risk Assessment Framework for Individuals: Analysis and Recommendations. *IEEE Access*, *11*, 85561–85570. https://doi.org/10.1109/ACCESS.2023.3293062

This paper proposes a digital risk assessment framework designed for individuals to help them manage risks associated with their online activities. It identifies and quantifies 17 types of digital risks using data from government reports and academic papers, then recommends tailored risk treatment options—acceptance, reduction, transfer, or avoidance—for each. The study concludes

that online scams are the greatest financial risk, while communication-based harms are difficult to quantify.

Abstract

As individuals' engagement in the digital world grows, they face numerous risks related to online activities and personal information security. To address the need for guidance, this research proposes a novel Digital Security Management Framework tailored to individual users. The study examines recent threats, quantifies them, and details a list of threats with corresponding risk treatment options. A case study of a family engaging in online banking, shopping, and social media is used to identify and quantify 17 digital risks using a Bernoulli distribution. The results are used to prioritize mitigation measures and recommend suitable treatment options. The findings indicate that online scams pose the highest financial risk, security incidents are a moderate risk, and harms like bullying are hard to quantify.

Conclusion

This paper analysed various digital threats individuals face, drawing on recent reports, particularly the 2021 IC3 report. It categorized these threats and conducted a digital risk assessment, quantifying the probability and potential loss for each to rank them as high, medium, or low risk. Based on this ranking, appropriate treatment options were recommended for each threat. This study is the first to offer a digital risk assessment framework specifically for individuals, providing a valuable resource that empowers them to anticipate common digital threats and implement effective security measures.

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12. Scalable Nonparametric Supervised Learning for Streaming and Massive Data: Applications in Healthcare Monitoring and Credit Risk

Citation: Chaouch, M., & Al-Hamed, O. M. (2025). Scalable Nonparametric Supervised Learning for Streaming and Massive Data: Applications in Healthcare Monitoring and Credit Risk. *IEEE Access*, *13*, 131716-131732. https://doi.org/10.1109/ACCESS.2025.3591883

This paper introduces new nonparametric supervised learning methods for classifying large and streaming datasets, which are common in healthcare and finance. It proposes two classifiers: an offline, kernel-based model that uses Batch Principal Component Analysis (PCA) for dimensionality reduction, and an online model for streaming data that combines online PCA with a recursive

kernel classifier. When applied to fetal health monitoring, the online classifier was nearly as accurate as offline methods but was 15 times faster. In a credit scoring application, it achieved performance comparable to neural networks but was over 600 times faster, making it ideal for real-time financial decisions.

Abstract

This paper presents new nonparametric supervised learning techniques for classifying massive datasets, overcoming the limitations of current methods for big and streaming data. An offline kernel-based classifier is proposed, which is enhanced with Batch Principal Component Analysis (PCA) to reduce dimensionality. An online classifier is also developed for streaming data, combining online PCA with a recursive kernel-based classifier using a stochastic approximation algorithm. In a fatal well-being monitoring application, the online classifier achieved a median misclassification rate (11.92%) comparable to the offline classifier (11.54%) and Random Forest (11.31%) but was 15 times faster. In a larger credit scoring study, the online classifier's F1-score (96.40%) and accuracy (93.08%) were close to neural networks and boosting models but was over 600 times faster, demonstrating its effectiveness for real-time financial decision-making.

Discussion and Conclusion

This paper introduced novel nonparametric supervised learning techniques for classifying massive and streaming datasets. An offline kernel-based classifier was proposed that uses Batch PCA to address the "curse of dimensionality." For streaming data, an online classifier was developed combining online PCA with a kernel-based recursive classifier. In applications for fatal health monitoring and credit risk prediction, both classifiers performed competitively against established machine learning algorithms like Random Forest and Boosting. The online classifier, in particular, achieved comparable accuracy to state-of-the-art models but with significantly less computation time, making it highly suitable for real-time decision-making in data-intensive environments.

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13. The Platform's Credit-Offering Strategy in the Presence of Integrated and Independent Systems

Citation: Li, Q., Zha, Y., Li, L., & Yu, Y. (2022). The Platform's Credit-Offering Strategy in the Presence of Integrated and Independent Systems. *IEEE*

Transactions on Systems, Man, and Cybernetics: Systems, *52*(5), 2933–2944. https://doi.org/10.1109/TSMC.2021.3055836

This article examines how an online platform's decision to offer credit affects a retailer's pricing strategy, considering that consumers perceive a "spillover" effect from using credit. The study analyses two systems: an

integrated system, where the platform is also the retailer, and an **independent system**, where a separate retailer sells on the platform. Key findings show that in the integrated system, the platform offers credit only when the spillover is above a certain threshold and charges interest only for positive spillovers. In the independent system, the platform's strategy is influenced by its revenue-sharing agreement with the retailer, and offering credit doesn't harm the retailer's profit.

Abstract

The rise of credit purchasing has forced retailers to adjust their strategies in response to online platforms offering credit. This paper models a platform's credit-offering strategy and the retailer's response, focusing on consumer spillover—the perceived net benefit of using credit. The model accounts for consumers with varying incomes and product valuations. Two scenarios are studied: an

integrated system, where the platform acts as the retailer, and an **independent system**, where a third-party retailer sells on the platform. In the integrated system, the platform offers credit only when the spillover is above a negative threshold and charges interest when the spillover is positive. In the independent system, the revenue-sharing percentage is a key factor; the platform never offers interest-free credit when this percentage is low, and its credit offerings do not harm the retailer's profit. Interestingly, demand may decrease with moderate spillover, contrary to the expected outcome of offering credit.

Conclusion

This study analysed how credit offered by e-commerce platforms impacts retailers and consumers in different retailing systems. The analysis built a framework to explore the strategic interactions between a platform and a retailer when consumer credit is available. In an

integrated system, the platform offers credit only when the consumer "spillover" (perceived benefit) is above a certain threshold, and the retailer's pricing strategy is nonmonotonic in response. In an

independent system, the decision to offer credit depends on the revenue-sharing agreement and the spillover value. The model revealed that offering credit does not always increase demand; it may decrease when the spillover is moderate. This provides practical insights for platforms and retailers on designing credit-offering strategies, aligning with practices observed at companies like JD.com.

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14. OptDevNet: A Optimized Deep Event-Based Network Framework for Credit Card Fraud Detection

Citation: Adil, M., Yinjun, Z., Jamjoom, M. M., & Ullah, Z. (2024). OptDevNet: A Optimized Deep Event-Based Network Framework for Credit Card Fraud Detection. *IEEE Access*, *12*, 132421-132433. https://doi.org/10.1109/ACCESS.2024.3458944

This paper addresses the challenge of credit card fraud by proposing a new framework called the Optimized Deep Event-based Network (OptDevNet). Traditional machine learning techniques for fraud detection have often been tested on limited datasets, potentially limiting their real-world effectiveness. The authors evaluated five existing machine learning classifiers on a standard credit card fraud dataset and found that their proposed OptDevNet model performed better in detecting fraudulent transactions. The results suggest that the OptDevNet framework is a promising candidate for real-world deployment to combat malicious financial activities.

Abstract

Credit card fraud is a major financial problem for both consumers and financial institutions. Researchers have used machine learning to detect fraud in transaction data, but these methods are often tested on specific datasets that may not reflect real-world complexity. To address this, this paper evaluates existing classifiers and introduces the Optimized Deep Event-based Network (OptDevNet) framework. The authors tested five different machine learning classifiers on the well-known Credit Card Fraud Detection (CCFD) Dataset. The analysis showed that the proposed OptDevNet model outperformed these classifiers in accurately detecting fraudulent transactions, indicating its potential for effective real-world application in preventing financial fraud.

Conclusion

This study introduced the Optimized Deep Event-based Network (OptDevNet) framework to detect and prevent fraudulent credit card transactions. The motivation for this research stems from the growing threat of credit card fraud and the limitations of existing machine learning (ML) and deep learning (DL) algorithms, which often depend on specific use cases and input data features. While traditional DL models like CNNs have shown promise, they have not yet achieved outstanding results. The proposed OptDevNet model was evaluated against other algorithms, including SVM, logistic regression, random forest, and KNN, on the CCFD dataset. The analysis demonstrated that OptDevNet achieved exceptional accuracy, outperforming both the tested algorithms and existing state-of-the-art methods. The authors are confident that the proposed model will effectively meet the needs of stakeholders in the financial industry.

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15. Enhancing Credit Risk Decision-Making in Supply Chain Finance With Interpretable Machine Learning Model

Citation: Zhou, G., & Wang, S. (2025). Enhancing Credit Risk Decision-Making in Supply Chain Finance With Interpretable Machine Learning Model. *IEEE Access*, *13*, 14239-14251. https://doi.org/10.1109/ACCESS.2025.3530433

This paper addresses the challenges of credit risk assessment in supply chain finance, where traditional "black-box" models lack transparency. The study uses interpretable machine learning models—specifically XGBoost, Random Forest (RF), LSSVM, and CNN—to evaluate credit risks. By employing Shapley Additive Explanation (SHAP), the research identifies the most influential risk factors, such as the asset-liability ratio and cash ratio. The findings show that XGBoost offers superior performance and interpretability, providing valuable guidance for companies and financial institutions to make more sustainable financial decisions.

Abstract

The growing complexity of supply chain finance makes effective credit risk assessment difficult, as traditional "black-box" models do not explain the factors behind their predictions. This study analyses the performance of several interpretable machine learning models—Extreme Gradient Boosting (XGBoost), Random Forest (RF), Least Squares Support Vector Machine (LSSVM), and Convolutional Neural Network (CNN)—for this task. Using Shapley Additive Explanation (SHAP) and an ablation experiment, the study identifies key risk drivers, including the asset-liability ratio, cash ratio, and

quick ratio. The results demonstrate the superior performance and interpretability of the XGBoost model via the SHAP algorithm. These insights offer practical guidance for financial institutions, promoting a more sustainable allocation of financial resources.

Conclusion

This study provided actionable insights for optimizing credit risk assessment in supply chain finance by combining machine learning with interpretable analysis. The key findings are:

- A new credit risk assessment indicator system was designed, incorporating the core enterprise, SMEs, and the supply chain.
- Empirical analysis using XGBoost, CNN, RF, and LSSVM models on 851 enterprise samples showed that XGBoost had the highest accuracy and stability in predicting credit risk.
- The SHAP algorithm was used to explain the XGBoost model, revealing that the asset-liability ratio is a key positive indicator of default risk, while higher cash and quick ratios have adverse effects.
- Ablation experiments confirmed the critical role of these financial indicators.

Limitations include the potential for model inaccuracy due to small sample sizes, and future work will focus on expanding datasets and further optimizing the model.

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16. Machine Learning for Financial Risk Management: A Survey

Citation: Mashrur, A., Luo, W., Zaidi, N. A., & Robles-Kelly, A. (2020). Machine Learning for Financial Risk Management: A Survey. *IEEE Access*, *8*, 203203–203223. https://doi.org/10.1109/ACCESS.2020.3036322

This paper provides a comprehensive survey of the growing body of research on machine learning for financial risk management (FRM). It aims to help machine learning researchers navigate the complex domain knowledge by presenting a taxonomy of FRM tasks and connecting them to relevant machine learning methods. The survey also highlights significant publications from the past decade, identifies major challenges researchers are facing, and points to emerging trends and promising future research directions.

Abstract

Financial risk management (FRM) is vital for businesses to avoid losses and maximize profits. As FRM relies heavily on data-driven decisions, machine learning (ML) offers promising new methods, leading to its increased adoption in recent years. However, ML researchers often find it difficult to navigate the complex domain knowledge and the rapidly expanding literature. This paper addresses this gap by providing a systematic survey of ML research for FRM. Its contributions are fourfold: it presents a taxonomy of FRM tasks linked to relevant ML methods, highlights key publications from the last decade, identifies major challenges in the field, and outlines emerging trends and future research directions.

Conclusion

This paper reviewed recent applications of machine learning in financial risk management, identifying both well-studied areas and those needing more research.

Well-studied areas like volatility forecasting, credit rating, bankruptcy prediction, and fraud detection have seen extensive use of advanced models, including deep learning. In contrast, areas like mortality forecasting, loss reserving, and claims modelling have received less attention. The FRM domain stands to benefit significantly from recent machine learning breakthroughs, especially in deep learning, such as new uncertainty estimation methods and robust algorithms for small or noisy data. Key research questions central to FRM, including federated learning for data privacy and the explainability and fairness of models, will likely drive future machine learning development.

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17. Enhancing Fairness in Credit Assessment: Mitigation Strategies and Implementation

Citation: Kisten, M., & Khosa, M. (2024). Enhancing Fairness in Credit Assessment: Mitigation Strategies and Implementation. *IEEE Access*, *12*, 177277-177284. https://doi.org/10.1109/ACCESS.2024.3505836

This paper examines how to assess and integrate fairness into credit assessment models, which have historically raised concerns about bias. It investigates various bias mitigation techniques applied at three stages:

pre-processing, **in-processing**, and **post-processing**. The study evaluates these techniques to show their effectiveness in reducing disparities, particularly age-based bias. The authors emphasize the need for a nuanced analysis of the trade-offs between fairness and predictive accuracy. The research provides practical insights for policymakers and financial institutions aiming to create more equitable credit evaluation systems.

Abstract

Credit assessment is a critical process that determines an individual's financial opportunities, but traditional models often face scrutiny for fairness and potential biases. This paper investigates the assessment and integration of fairness in these models by exploring bias mitigation techniques at three key stages: pre-processing, in-processing, and post-processing. Through a systematic evaluation, the study demonstrates that these techniques can effectively reduce disparities. The findings highlight the importance of addressing age-based bias but also stress the need to analyze the trade-offs between fairness and predictive accuracy. This work offers practical insights for financial institutions and contributes to the ongoing effort to develop more transparent, accountable, and inclusive credit assessment frameworks.

Conclusion

To achieve fairness in credit assessment, it is necessary to address the biases in traditional models that can perpetuate inequality. This paper explored this challenge by implementing and evaluating various bias mitigation strategies across pre-processing, in-processing, and post-processing stages. The findings show that while fairness can be improved, there is an unavoidable trade-off between reducing bias and maintaining model accuracy. Building on insights from the 2023 FDCR seminar, this research provides actionable recommendations for balancing these competing goals. Ultimately, adopting fairness-oriented models not only enhances transparency and trust but also ensures that credit assessments are equitable for all applicants, irrespective of age.

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18. Credit Risk Analysis Using Machine and Deep Learning Models

Citation: Addo, P. M., Guegan, D., & Hassani, B. (2018). Credit Risk Analysis Using Machine and Deep Learning Models. *Risks*, *6*(2), 38. https://doi.org/10.3390/risks6020038

This study builds and compares binary classifiers for predicting loan default probability using machine and deep learning models on real-world data. The top 10 most important features from these models were selected and used to test the stability of the classifiers on separate data. The findings show that tree-based models (like random forest and gradient boosting) are more stable and perform better than multilayer artificial neural networks. The results raise questions about the widespread use of deep learning systems in business environments.

Abstract

As technology and data availability advance, banks and lending institutions are updating their business models, with a focus on reliable credit risk prediction and monitoring. This study constructs binary classifiers using machine and deep learning models to predict loan default probability on real data. After selecting the top 10 most important features from the initial models, their performance was re-evaluated to test the stability of the classifiers. The results indicate that tree-based models demonstrate greater stability compared to models based on multilayer artificial neural networks, prompting a discussion on the intensive use of deep learning systems in enterprise settings.

Conclusion

This study highlights the significant role of Big Data and data science in credit risk modeling. The research demonstrated the importance of data quality checks and balancing imbalanced datasets to avoid biased results. It also underscored that the choice of features and algorithms are critical components in the decision-making process for issuing loans. The findings suggest that regulators and policymakers must regulate data science techniques to ensure performance and avoid discrimination. The study also showed the importance of using a variety of models, as performance metrics can differ, and noted that more complex models with numerous hyper-parameters, like deep learning, do not always outperform tree-based models. Ultimately, tree-based models proved to be the most stable and effective classifiers for this task.

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19. Scalable Nonparametric Supervised Learning for Streaming and Massive Data: Applications in Healthcare Monitoring and Credit Risk

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Healthcare Monitoring and Credit Risk. *IEEE Access*, *13*, 131716-131732. https://doi.org/10.1109/ACCESS.2025.3591883

This paper introduces innovative nonparametric supervised learning methods designed for classifying massive and streaming datasets, overcoming limitations of traditional algorithms in areas like healthcare and finance. The study proposes two main classifiers: an **offline kernel-based classifier** using Batch Principal Component Analysis (PCA) to handle high-dimensional data, and an **online classifier** for real-time streaming data that combines online PCA with a recursive estimation algorithm. In real-world tests on fatal health monitoring and credit scoring, the online classifier demonstrated accuracy comparable to top models like Random Forest and neural networks but was **15 to 600 times faster**, making it highly effective for time-sensitive applications.

Abstract

This paper introduces novel nonparametric supervised learning techniques for classifying massive datasets, addressing key limitations of existing methods in Big and Streaming Data frameworks. An offline kernel-based classifier is proposed, enhanced by Batch Principal Component Analysis (PCA) for dimensionality reduction to mitigate the "curse of dimensionality". Additionally, an online classifier is developed for streaming data, combining online PCA with a kernel-based recursive classifier using a stochastic approximation algorithm. An application to fatal well-being monitoring shows the online classifier achieves a competitive misclassification rate (11.92%) comparable to the offline classifier (11.54%) and Random Forest (11.31%), while being 15 times faster. A second study on a larger credit scoring database confirms these findings, with the online classifier achieving an F1-score of 96.40% and accuracy of 93.08%, closely matching neural networks and boosting, but over 600 times faster, demonstrating its effectiveness for real-time financial decision-making.

Discussion and Conclusion

This paper introduced novel nonparametric supervised learning techniques for classifying massive datasets. An offline kernel-based classifier was proposed, which is highly flexible and learns directly from data but is susceptible to the "curse of dimensionality". This issue was addressed by using Batch PCA for dimensionality reduction. A second, online classifier was developed for massive or streaming datasets, which uses online PCA for real-time dimensionality reduction and a recursive kernel-based classifier. Applications in real-time fatal well-being monitoring and large-scale credit risk prediction demonstrated that

both classifiers performed competitively against established algorithms like Random Forest and Boosting. The online classifier, in particular, achieved comparable accuracy while requiring significantly less computation time, highlighting its favourable computation-time/accuracy trade-off for real-time, data-intensive scenarios.