

**UNIVERSITI TEKNOLOGI MARA**

**AN IMPROVED ANT COLONY  
OPTIMIZATION ALGORITHM  
USING THE HELLINGER DISTANCE  
TO PREDICT HIGH-DIMENSIONAL  
AND IMBALANCED BANKRUPTCY  
DATA OF SHARIAH-COMPLIANT  
SECURITIES IN MALAYSIA**

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## ABSTRACT

Bankruptcy prediction is a critical area of study due to its significance in mitigating economic losses for stakeholders. However, the complexity and imbalance of bankruptcy datasets pose challenges to accurate prediction. This study addresses these challenges by utilizing attribute reduction techniques to manage high-dimensional data and identify optimal subsets for bankruptcy prediction. Additionally, since bankruptcy datasets are inherently imbalanced, with significantly fewer bankrupt companies compared to successful firms, conventional prediction algorithms often exhibit bias toward the dominant class. To overcome this limitation, this study proposes an enhanced Ant Colony Optimization (ACO) classification algorithm, named HD-AntMiner, which incorporates Hellinger distance (HD) as a heuristic function. The HD mitigates bias toward the majority class, improving classification performance for minority instances. The HD-AntMiner was applied to a dataset of 759 Shariah-compliant companies in Malaysia, and its performance was validated using 10-fold cross-validation to ensure robustness and reliability. A series of six experiments were conducted to evaluate the effectiveness of the proposed model. The first experiment compared HD-AntMiner with established classifiers such as PART, J48, and Ant-Miner using publicly available benchmark datasets. The results demonstrated that HD-AntMiner achieved superior accuracy, particularly in predicting minority class instances. The second experiment focused on comparing HD-AntMiner with Ant-Miner in the context of Shariah-compliant securities companies, where HD-AntMiner consistently outperformed Ant-Miner in terms of accuracy and classification efficiency. Further experiments explored the impact of attribute reduction on model performance. Various attribute selection techniques were employed to determine the optimal subset of attributes, leading to improvements in accuracy and F-score. The highest accuracy of 87.88% and an F-score of 0.798 were achieved using an optimal subset of 10 attributes. Additionally, redundant attribute was identified and removed to further refine the model. The final experiment validated the enhanced model's performance across different configurations, demonstrating its effectiveness in bankruptcy prediction. Overall, the results confirmed that HD-AntMiner outperformed Ant-Miner and other conventional classifiers in handling imbalanced datasets. By leveraging attribute reduction and HD, the proposed model improved classification accuracy, particularly for minority class predictions. This study enhances the development of bankruptcy prediction models by introducing a more reliable and effective method for assessing bankruptcy risks. The proposed model can serve as a valuable tool for Shariah-compliant securities companies in Malaysia, helping them make informed decisions to mitigate potential bankruptcy risks.

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# **CHAPTER 1**

## **INTRODUCTION**

This chapter provides an overview of the study, including the research background, problem statement, research questions and objectives, scope, and significance.

### **1.1 Introduction**

This chapter establishes the foundation for this study by highlighting the importance of bankruptcy prediction, particularly for Shariah-compliant securities companies. Furthermore, it discusses the challenges associated with bankruptcy prediction and the role of computational techniques in improving classification accuracy. This chapter concludes by emphasizing the relevance of the research in bankruptcy risk assessment and decision-making.

### **1.2 Research Background**

Bankruptcy prediction is very essential for companies to be aware of their financial condition and sustain their business because bankruptcy can lead to the discontinuity of the companies' operation. Bankruptcy is a legal proceeding initiated when the company is unable to pay its creditors or meet its financial commitments (Tuovila et al., 2024). While internal factors such as poor financial management contribute to bankruptcy, external factors like economic downturns also play a significant role. For instance, the COVID-19 pandemic has profoundly impacted the Malaysian economy, leading to a decrease in domestic consumption and creating spillover effects of reduced demand across various sectors and economies via trade and production linkages (Yusuf & Oyelaki, 2022).

The COVID-19 pandemic has negatively impacted various crucial sectors, including retail, markets, entertainment and tourism. Numerous businesses have announced closure due to the necessity of complying with lockdown measures and adhering to social distance protocols. The Malaysian Prime Minister also reported that