

**GRAPH THEORETICAL APPROACH TO BANKRUPTCY PREDICTION OF RETAILERS**

Kwangseek Choe, State University of New York College at Plattsburgh, Plattsburgh, New York, U.S.A.  
Brian Neureuther, State University of New York College at Plattsburgh, Plattsburgh, New York, U.S.A.

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**ABSTRACT**

*This paper examines the applicability of a graph theoretical approach to bankruptcy prediction and assessment of financial health of retailers. A sample of 49 retailers are selected for study. Six financial ratios that are considered to be key performance measures of retailers are identified from a literature review. The interactions of these financial ratios are converted into an adjacency matrix and the matrix permanent is calculated as an index of a retailer's financial health. The comparison of financial health indices derived from the graph theoretical approach with Altman Z-scores demonstrates a high level of the applicability of the graph theoretical approach to bankruptcy prediction of retailers.*

**Keywords:** Graph theory, matrix permanent, bankruptcy prediction, financial health, retailers

**1. INTRODUCTION**

Bankruptcy prediction model has been one of the most attractive research fields in finance and accounting. The assessment of the likelihood that a firm may go bankrupt provides valuable information to current and prospective investors. Numerous statistical tools have been applied to the development of bankruptcy prediction models. One of the most renowned bankruptcy prediction models is Altman's Z-score formula (Altman 1968). Originally, Altman developed his model as a linear combination of five key financial ratios or key performance indications (KPIs) with weights assigned to each KPI. Altman Z-score model was derived from discriminant analysis and has demonstrated its value in assessing the likelihood that a firm may go bankrupt within two years. Altman's model has received a wide acceptance by researchers and practitioners since its inception. Various bankruptcy prediction models derived from the original Altman Z-score formula with different weights of KPIs depending on types of firms and industries have been proposed.

Various types of mathematical models such as option valuation approaches, neural network analysis, univariate models (Beaver 1966), and multidimensional models of Altman and Ohlson have been proposed and tested on bankruptcy prediction. Jackson and Wood (2013) argues that bankruptcy prediction models based on market data such as option valuation models are superior to models based on pure accounting numbers from their empirical research on the comparison of popular bankruptcy prediction models.

This paper proposes the graph theoretical approach to bankruptcy prediction of retailing firms. Graph theory explores the topological properties of a graph designed as a model representing pairwise relations between objects. The usefulness of graph theory lies in that many types of relations and processes in science and technology can be modeled by graphs and the unified formalism of graphs enables us to solve many problems by examining topological properties of graphs (Choe and Zhou 2015).

Since the inception of the graph theory, the graph theoretical approach has been applied in a wide range of fields including computer science, linguistics, chemistry, physics, biology, mathematics, and sociology. (Choe and Zhou 2015). Recently, the applications have extended in the fields of quality management (Grover et al. 2004; Kulkarni 2005), supply chain management (Faisal et al. 2011; Thakkar et al. 2008), and transportation network (Choe 2017). This paper employs the graph theoretical method for the analysis of bankruptcy prediction of retailing firms. A financial health index of a retailer is developed based on the graph theoretical approach and the applicability of the index to bankruptcy prediction of a retailer is tested.