Risk Assessment in Supply Chain Finance

Abstract

Purchase order financing has emerged as a transformative financing solution with profound implications for the entire supply chain ecosystem. In this thesis, we analyze the intricate dynamics of a two-stage supply chain, where a retailer procures from a financially constrained supplier. The retailer's primary goal is to predict market demand optimally to maximize profit, which drives their orders to the suppliers. However, suppliers must navigate their production capabilities within limited monetary constraints, further complicated by informational uncertainties surrounding demand and economic limitations on production capacities.

The present study underscores the critical role played by financial parameters for both retailers and suppliers, with a primary focus on Micro, Small, and Medium-sized Enterprises (MSMEs) and their influence on the associated supply chain. We formulated two distinct optimization models geared towards maximizing the profit of both suppliers and retailers. These models are developed to account for various constraints, including uncertain market demand, production costs, gross margins, newsvendor quantity, independent debt capacity, and informational transparency. To solve these optimization problems, we employ mathematical techniques such as the Lagrange multiplier, Lagrange function, and Karsh-Kuhn-Tucker conditions. Through a comprehensive computational study, we explored the influence of demand uncertainty and analytical factors on the profitability of both retailers and suppliers. Our analysis revealed a noteworthy correlation: as variance in these factors increased, it shared a significant rise in the retailer's commitment level. This heightened commitment, in turn, led to an increase in the supplier's production output and overall profit, ultimately resulting in a fulfilling equilibrium solution. Additionally, we provide proof of dependency of the financial parameter on the cost of debt and the ratio of debt-to-equity by developing a proposition.

A supply chain financing model places a strong emphasis on the dynamic relationship between retailers and suppliers. The retailer predicts the market demand to maximize profit, and accordingly, orders to the suppliers and suppliers utilize the production capabilities in limited monetary value. In such a case, the supplier needs to apply for loans to meet the production commitment. The advent of intelligent lending platforms has streamlined the loan application process, making it quicker and more convenient for applicants. However, distinguishing between potential borrowers and probable defaulters on peer-to-peer lending platforms remains a complex challenge.

Over the past few years, online peer-to-peer lending platforms have gained immense popularity within the financial supply chain. Yet, establishing an efficient financial supply chain tailored for MSMEs (retailers or suppliers) through credit and services provisioning poses significant challenges. MSMEs are essential for the growth and development of the country's economy, as they create jobs, generate income, and foster production and innovation. In recent years, credit risk assessment (CRA) has been an essential process used by financial institutions to evaluate the creditworthiness of MSMEs and determine the likelihood of default. Lenders are primarily focused on maximizing profits while minimizing risk, particularly by extending loans to non-defaulting MSMEs.

To address these challenges, we introduce an innovative *k*-Random Boosting Classifier (*k*-RBC) algorithm to identify potential good and bad borrowers based on historical transactional data and other relevant features. The *k*-RBC algorithm boasts a time complexity of $\mathcal{O}(n^2 log(n))$, and Taiwan's credit card clients' dataset is used to test the algorithm. The results obtained from the study show a significant improvement in comparison to the outputs from existing approaches on the same datasets. Our algorithm gives 90\% accuracy to identify potential good borrowers, whereas existing algorithms achieve up to 87\% accuracy. Furthermore, we comprehensively analyze the importance of borrowers' features and their impact on the lending platform in supply chain finance.

With the rapid expansion of artificial intelligence (AI), generative AI, and big data, there is an increasing necessity to structure and depict the vast reservoir of information effectively. Knowledge graphs (KGs) offer a simpler construction process with respect to domain ontologies considering different sources of information. KGs eliminate the need to define strict domain boundaries and decrease the demands for absolute consistency and completeness. KGs have proven effective in stimulating and linking knowledge. In this thesis, we introduce an innovative knowledge graph-driven credit risk assessment model based on the Relational Graph Convolutional Network (RGCN) and Random Forest (RF) algorithm. RGCN is employed to identify topological structures and relationships, which is currently nascent in traditional credit risk assessment methods. RF categorizes MSMEs based on the enterprise embedding vector generated from RGCN. Extensive experimentation is conducted to assess model performance utilizing the Indian MSMEs database. The balanced accuracy of 92% obtained using the RGCN-RF model demonstrates a considerable advancement over prior techniques in identifying risk-free enterprises.

Keywords: supply chain finance, peer-to-peer lending platform, machine learning, random forest, credit risk assessment, knowledge graph, MSME, relational graph convolutional network.