CHAPTER 39

OPERATIONAL RESEARCH

Doctoral Theses

01. HUDA (Shameem)
Quality Enhancement and Process Optimization in Label Printing Industry.
Supervisors: Prof. K.K. Aggarwal and Prof. Rubina Mittal
Th 29170

Abstract

The flexographic label printing market plays a crucial role in the global label and packaging industry, serving various sectors such as food and beverages, pharmaceuticals, cosmetics and logistics. Due to ever-changing consumer demands, regulatory compliance, and rising concerns for sustainability, there is an urgent need to improve the quality of products and streamline operations, particularly in micro, small, and medium enterprises (MSMEs). This thesis provides a rational methodology to detect, analyze and remove the critical flaws and reconcile operational objectives with sustainability requirements. The study carried out in this thesis is organized into various phases. Initially, major defects are detected and prioritized using integrated Fuzzy Simple Additive Weighting (SAW) and Additive Ratio Assessment (ARAS). Further, the barriers to sustainable quality improvement are analyzed with the help of fuzzy Total Interpretive Structural Modelling (TISM). To implement the quality improvement program, the Six Sigma DMAIC (Define-Measure-Analyze-Improve-Control) methodology removes causes and eliminates variability in various stages of the label printing process. Moving towards "lean" for further process enhancement, a lean tool selection methodology is tailored to this industry to enhance flow efficiency and waste reduction. Finally, a Multi-Objective Optimization model is developed utilizing a weighted goal programming (WGP) approach to harmonize economic performance with environmental and social goals. Empirical confirmation through case studies proves significant quality consistency, resource effectiveness, environmental regulation, and customer satisfaction improvements. Combining quality management, lean tools, and sustainability modelling fills the gap, especially for resource-scarce MSMEs in emerging economies. This thesis provides a double contribution: it enhances the theoretical literature on quality and sustainability in printing industries and provides a solid, actionable model for manufacturers seeking excellence, resilience, and long-term competitiveness in the changing global marketplace.

Contents

1. Introduction 2. Identifying and Analyzing the Critical Defects and Barriers in the Label Printing Industry 3. Defect Reduction and Quality Improvement in the Label Printing Industry with the Help of Six Sigma DMAIC 4. Selecting the Best Lean Tool for Sustainable Growth of the Label Printing Industry 5. Multi-Objective Optimization for Sustainable Label Printing: Balancing TBL Goals 6. Conclusion and Directions for Future Research. List of Publications. Bibliography.

02. NUPUR

Multi-Method Approach to Portfolio Optimization: Integrating Machine Learning and Metaheuristic Techniques.

Supervisors: Dr. Veena Jain and Dr. Rishi Rajan Sahay

Th 2

Abstract

Portfolio optimization is a fundamental problem in financial decision-making, aimed at achieving an optimal trade-off between return and risk under multiple practical constraints. Classical approaches, particularly the mean-variance models, rely on assumptions such as normally distributed returns, symmetric risk, and limited or no consideration of non-financial criteria, such as Environmental, Social, and Governance (ESG) factor, which limit their effectiveness in modern financial markets. The data-driven approach is employed in the thesis to determine the distribution of wealth among assets because the portfolio optimization problem is presented as a non-linear NP-hard problem that is challenging to answer by analytical approaches. The thesis proposes a multi-method portfolio optimization approach that integrates machine learning techniques, multi-criteria decision-making (MCDM) methods, and metaheuristic optimization algorithms. The proposed structure combines clustering and MCDM for asset selection, forecasting models for return prediction, and metaheuristics for optimization of multi-objective portfolio optimization models which capture realistic market dynamics and investor preferences. The portfolio optimization models incorporate higher-order moments of return, downside risk measures such as semi-variance and Conditional Value at Risk (CVaR), entropy-based diversification, and ESG constraints. These complex non-linear models are solved using metaheuristic algorithms, including the BAT Algorithm, Multi-Verse Optimizer, Teaching–Learning-Based Optimization, Jaya algorithm, hybrid metaheuristics, and the Chernobyl Disaster Optimizer. Empirical analysis of Indian stock market data shows that the proposed integrated framework outperforms traditional benchmark models.

Contents

1. Introduction 2. Clustering, Deep Learning-Based Forecasting, and Metaheuristic Approach for Portfolio Optimization 3. TODIM-Based Stock Ranking, Ensemble Forecasting, and Metaheuristic Approach for Portfolio Optimization 4. ESG-Integrated Portfolio Optimization Using Machine Learning and Metaheuristic Approaches 5. Conclusion and Future Research Scope. Bibliography.

03. SHARMA (Shiwani)

Integrated Framework for Collaborative Third-Party Reverse Supply Chain with Risk Assessment.

Supervisors: SR. Prof. P. C. Jha and Prof. Jyoti Dhingra Darbari

Th 29171

Abstract

Amidst the rapid development and growth experienced by the Indian electronics industry, characterized by short product life cycles and

increased end-of-life/end-of-use products, reverse logistics (RL) emerges as a strategic imperative for sustainable supply chain management. In this regard, small and medium-sized enterprises (SMEs) face significant challenges, including financial, operational, technological, and managerial limitations, compelling them to outsource RL services partially or completely to third-party reverse logistics providers (3PRLPs). However, outsourcing is often associated with limitations for strategic control and sustainable value creation, while collaboration is associated with mutual decision-making, shared risk, transparency, and mutual alignment of sustainability between SMEs and 3PRLPs. Therefore, collaboration between 3PRLPs and SMEs is perceived to create opportunities for cost savings, resource recovery, compliance with regulations, and sustainability, it is associated with significant sustainability challenges, outsourcing risks, and cooperation uncertainties. In this regard, this thesis aims to address these interrelated issues by proposing a comprehensive and holistic framework to support sustainable RL collaboration within the Indian electronics industry. For this purpose, it undertakes a comprehensive and systematic evaluation of sustainability criteria to support 3PRLP assessment and selection, critical success factors to support 3PRLP collaboration, outsourcing and relational risks along with their interdependencies, key challenges and opportunities to support collaborative RL system implementation, and ultimately proposes optimized RL network configuration to support cost efficiency, performance enhancement maximization, and risk minimization under different conditions of strategic priorities. In its attempt to address these critical issues from a singular perspective involving sustainability, structural analysis, risk evaluation, and multi-objective decision modeling, this thesis aims to be not only theoretically relevant but also to provide valuable support to SMEs to successfully adopt sustainable RL systems by collaborating with 3PRLPs and balance enhanced competitiveness with sustainability within the Indian electronics industry.

Contents

1. Introduction 2. Identification and Analysis of Key Sustainable Criteria and Critical Success Factors For 3prlp Selection Using Mcdm Approach 3. A Risk Assessment Modelling Approach for Analysing the Risks of Outsourcing To 3prlps For Sustainable Rl Implementation 4. An Integrated Decision Framework for Assessment of The Opportunities and Bstacles In Collaboration With 3prlps For Rl Implementation in Ce Transition Process 5. Fuzzy Bow-Tie Risk Performance Analysis of Collaborative RL Supply Chain with Ce Perspective 6. Multi-Objective Decision-Making Modelling for A RL Network Configuration with Ce Objectives Under Third-Party Collaboration. Conclusion. Limitations and Future Scope. Bibliography.

04. YADAV (Asha)
Mathematical Modeling Framework for Software Reliability, Complexity and Vulnerability Management.
Supervisors: Prof. Ompal Singh
Th 29172

Abstract

In the present digital era, software systems serve as the backbone of critical sectors such as healthcare, transportation, finance, communication,

governance and national infrastructure. The growing dependence on software-intensive systems has significantly increased the impact of software failures and security breaches, resulting in financial losses, safety risks, operational disruptions and erosion of user trust. Consequently, ensuring software reliability and security throughout the software development lifecycle has become a critical challenge. Software reliability is defined as the probability that a software system performs its intended functions without failure under specified conditions for a given time period. Unlike hardware, software failures stem from development and maintenance faults that may remain latent and manifest under specific operational conditions. Traditional Software Reliability Growth Models (SRGMs) rely on idealized assumptions such as constant fault detection rates and perfect debugging, which are often unrealistic in modern, dynamic development environments. Factors such as varying testing strategies, developer expertise, change-point phenomena and imperfect debugging lead to bug infusion. Which significantly influence reliability growth and release-time decisions. Modern software systems also evolve continuously, leading to increased internal complexity or software entropy, which adversely affects long-term reliability. In parallel, software vulnerabilities pose serious security threats, with their discovery and exploitation governed by uncertain and stochastic processes involving external actors. Effective vulnerability management further depends on efficient patch development and deployment influenced by learning behavior over time. Motivated by these challenges, this research proposes advanced mathematical and AI-driven modeling frameworks that incorporate environmental effects, change points, bug infusion, software entropy, uncertainty in vulnerability discovery, learning-based patch management and intelligent vulnerability prediction. Numerical methods and multi-criteria decision-making techniques are employed to address analytical complexity and release planning trade-offs. The proposed models are validated using real software project data, demonstrating their practical applicability and relevance.

Contents

1. Introduction 2. Modeling Software Reliability Using Change-Point Phenomena and Bug Infusion–Based Growth Patterns 3. Software Entropy and Complexity Modeling 4. Approximation Methods for Software Reliability Growth Assessment Modeling Software Vulnerability Discovery and Fixation: Incorporating Uncertainty, Learning Functions and AI Powered Prediction. Conclusion, Limitations and Scope of Future Research. References