

## CHAPTER 38

### OPERATIONAL RESEARCH

#### Doctoral Theses

01. ADITI  
**Strategic Buyer-Supplier Collaboration Decision Models for Sustainable Supply Chain Management of Indian Electronic Manufacturing Industry.**  
Supervisor: Prof. P.C. Jha and Prof. Kannan Govindan  
Th 27130

#### Abstract

Owing to Prevalent dynamic market forces, rapidly changing customer requirements higher level of competition, shorten product life cycles, and rising concern towards sustainability, the responsibility of achieving competitive advantage is to be shouldered not only by managers of focal companies but also by their SC partners (Luthra et.al., 2017) this highlights the need for proper establishment and continuous improvement in procurement, production and distribution capabilities at a competitive cost and desired level of quality for meeting the sustainable needs of customers. Since Procurement capability of the company is one of the important aspects in achieving green image in the competitive market challenges, appropriate choice of sustainable Supplier becomes the key asset for the companies which outsource their raw materials components/Semi-finished product/ Finished products or service (Lima-Junior and Carpinetti, 2016; Ahmadi et al., 2017) Most importantly, supplier's Practices and performance exert an enormous impact on the financial, operational and Sustainable Performance of the buying company, thereby playing a significant role in aiding companies to attain a collaborative and sustainable competitive advantage (Lo et sl., 2018). With this Orientation, a strong Partnership with suppliers along with investigation in sustainable supplier management practices can turn out to be a prominent point for the buying companies (Foley et al., 2018) to cite a few examples, companies such as ford , Nissan, Motorola, Honda, Whirlpool, Dell, Pontiac, and IBM have invested in supplier development to improve supplier's capability and have invested in supplier development to improve supplier collaboration process, manufacturing companies are now more inclined and willing to invest their efforts and resources into supplier development initiatives to enhance the sustainable capabilities of supplier.

#### Contents

1. Introduction 2. Modelling of Barrier in Implementing sustainable Manufacturer Supplier Collaboration and Coping Strategies 3. Structural model for analysis of Key performance indicators for Sustainable Manufacturer-Supplier collaboration 4. Analysis of Supplier Evaluation and Selection Strategies for Sustainable Collaboration 5. Supplier Selection models Considering Development Strategies for Sustainable Collaboration: Multi Objective Optimization approach. Conclusions, Limitations future scope and Bibliography.

02. ARUN KUMAR  
**Multiple Criteria Portfolio Selection and Evaluation Under a Fuzzy Environment and Data Envelopment Analysis.**  
Supervisors: Prof. Pankaj Gupta and Mukesh Kumar Mehlawat  
Th 26813

### *Abstract*

The primary objective of any portfolio optimization study is to accurately capture the real-world intricacies of financial markets and develop solutions that satisfy the preferences of the investors. This thesis is a step in the same direction. Several real-world stock market scenarios were considered, and models accurately representing the complexities of the stock market were developed. The methodology of each chapter was illustrated comprehensively using numerical demonstrations. We analyzed the obtained results and demonstrated the efficacy of the approaches. However, our research is not perfect. The approach of each chapter has some limitations that need to be discussed and addressed. It encourages us to pursue further research to overcome the limitations. Thus, this chapter concludes this thesis with a chapter-wise summary and a discussion of possible future research directions.

### *Contents*

1. Introduction 2. DEA based asset evaluation and portfolio selection involving higher moments using  $(\lambda, \rho)$  interval valued fuzzy numbers 3. Portfolio evaluation and rebalancing under credibilistic framework using DEA for positive and negative returns 4. Portfolio evaluation and rebalancing under credibilistic framework using DEA with multiple inputs-outputs. 5. Multi-period portfolio selection and evaluation under credibilistic framework using RDM-DEA for positive and negative returns 6. RDM-DEA based asset evaluation and multi-period portfolio selection under intuitionistic fuzzy framework for positive and negative returns. 7. Conclusions and future work. Bibliography.

03. BIBYAN (RITU)

#### **A Study on Quantitative Assessment and Optimization of Testing Coverage Based Software Reliability Using Soft Computing Techniques.**

Supervisor: Dr. Sameer Anand

Th 26815

### *Abstract*

Various methodologies have been used throughout the years to quantify and improve software reliability. A variety of quantitative and qualitative strategies for assessing the reliability of software are included in the literature review. However, the everchanging technology and rising expectations in today's fast-paced society create a significant gap between the requirements and existing techniques of reliability evaluation. It is also critical to understand the function of the qualities and elements that influence the software's reliability. We discussed a wide range of fresh and innovative ways to assess reliability growth in this study. The diverse range of work is comprised of a variety of tasks and activities carried out during the various stages of the development process, such as the design, testing, and operational stages. The significance of managing these stages has been deduced from the literature and technological practices, and so an attempt was made to address the fundamental challenges of development. The study also focuses on the advancement of soft computing algorithms in the field of software reliability. It is inspired by the functioning of the human brain and its capacity for reasoning and acquiring knowledge in an uncertain and ambiguous environment. Soft computing includes various computational approaches such as neural networks, fuzzy, and genetic algorithms. The advancement in these approaches has increased the performance, precision, and application across a wide range of fields. The thesis covers the development of bug severity prediction models but also highlights the potential benefits of using soft computing techniques in classifying severe bugs in a system. By providing software engineers with these models, they can proactively address potential issues and prioritize fixing the

most severe bugs. Furthermore, the thesis uses the various types of techniques that can be used to predict the severity of bug reports such as text mining, topic modeling, and sentiment analysis. These models can aid in the development of more efficient and effective software engineering practices, ultimately leading to improved software quality and customer satisfaction.

#### *Contents*

1. Introduction 2. Automated bug serverity prediction using machine 3. Testing coverage-based SRGM and optimization problems using soft computing reliability 4. Multi-release planning for testing coverage-based SRGM using SDE. 5. Change point-based multi-release modelling for testing coverage-based SRGM using SDE. 6. Software quality assessment using multi-criteria decision-making. Conclusions and future scope, Appendix and References.

04. CHOUDHARY ( Nikesh)  
**Performance and Dependability Analysis of 5G Communication Networks: A Stochastic Modeling Approach.**  
 Supervisor: Dr. Vandana Khitan  
Th 27216

#### *Abstract*

In today's fast- paced world, communication networks have become a cornerstone of modern life, facilitating seamless connectivity, real-time information exchange, and fostering unparalleled growth in diverse sectors. As we delve deeper into the intricacies of these networks, it is important to recognize their profound impact, untapped potential, and the challenges that lie ahead. A communication network refers to the interconnected system of nodes and links, enabling the exchange of information, data and resources among devices. These networks serve as the backbone of modern society, providing continuous connectivity and promoting collaboration regardless of geographical boundaries. Among various types of communication networks, such as wired, wireless, cellular and satellite networks, each has been instrumental in shaping human interaction in their unique ways. With the rapid advantages of technology, 5G communication network has emerged as a game-changer in the domain of communication. Offering unprecedented speeds, lower latency, and robust support for a wide range of devices and applications, 5G is poised to redefine end to end connectivity in diverse sectors such as healthcare, education, transportation, and entertainment. Its potential to accommodate massive internet-of-things (IoT) ecosystems elevates its significance further In improving efficiency and providing real-time services.

#### *Contents*

1. Introduction 2.Performance analysis of Call Admission control (CAC) Policy and Handover management in 5G Ultra-Dense Cellular Network 3. Performance Analysis of Session Initiation Protocol (SIP) in 5G communication network 4. Dependability analysis of voice 5G (Vo5G) integrated with high altitude aeronautical platform (HAAP) 5. Dependability analysis of Cloud-based VoIP phone system under advanced persistent Distributed Denial of Service (APDDoS) attack 6. Stochastic Game Modeling and Dependability analysis of hybrid 5G network under Ransomware attack 7. Bibliography, Appendix and List of publication.

05. FAIZAN AHMED  
**Some Contributions to Multi-Attribute Decision-Making Approaches Using Generalized Fuzzy Numbers.**  
 Supervisor: Dr. Pankaj Gupta  
Th 27213

*Abstract*

The Primary endeavour of this thesis was to address and explore various MADM and MAGDM approaches in different uncertain environments. It was done to make the decision-making process more reliable and flexible in dealing with uncertainty that still needs to be explored. We considered several uncertain environments and discussed various generalized forms of fuzzy numbers. We explored the gaps in the literature and tried to address many issues concerning MADM and MAGDM approaches. We illustrated the methodology of each chapter using real life case studies. We analysed the results and demonstrated chapter using real life case studies. We analysed the results and demonstrated the effectiveness of the presented approaches, and comparative and other analyses were performed to validate the approaches. the present study acknowledge that each chapter's methodology and approach ar not exempt from certain in herent limitations, which merit thorough consideration and discussion. It will motivate us to purse research to overcome the limitations.

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1. Introduction 2. MADM approach with triangular fuzzy preference and non-preference information 3. MAGDM approach with  $q$ -rung orthopair fuzzy numbers 4. VIKOR approach for MAGDM problem using intuitionistic fuzzy linguistic numbers 5. GRA approach to a MAGDM problem with interval-valued rung orthopair fuzzy numbers 6. Fuzzy COPRAS method for MAGDM problem using interval valued  $q$ -rung orthopair fuzzy numbers 7. Conclusion and future work. Bibliography.

06. JAIN (Akansha)  
**Mathematical Models for Strategic Transition Towards Omni-Channerl Retailing: A Study from Indian Perspective.**  
 Supervisor: Prof. Usha Ramanathan  
Th 26814

*Abstract*

The concept of OCR has emerged as a key approach for numerous retail firms in today's competitive market and is a topic of interest for many researchers; however, how it should be implemented by retail firms in emerging economies such as India or the strategic adoption of various fulfilment options under OCR is a major concern and remains an unexplored domain. The current thesis illustrates the ways in which firms in emerging economies like India can strategically transition towards OCR. There are six chapters in all. The Chapter 1 is an introductory chapter which describes the impetus for the research work presented in the thesis and discusses some key theoretical concepts in brief. It further demonstrates the research gap in the existing literature wherein it was found that OCR adoption has been explored by researchers from the perspective of developed nations extensively and there is scant literature focusing on retail firms in emerging economies like India whose transformation towards OCR is more difficult due to lack of resources and technological capabilities. Therefore, it substantiated the need for studies guiding the retail firms in emerging economies towards OCR adoption. This gap has been addressed in this thesis. The conclusion and suggested study directions obtained from the other chapters are provided below. Today, OCR has become a standard practise, as retailers are

striving to give their customers a convenient and seamless MC experience. However, there are mixed thoughts regarding the success of OCR and thus there is a need for studies guiding the retailers towards an effective OCR implementation. As a result, a number of researchers have conducted research related to OCR adoption by retail firms. However, there is dearth of research related to OCR adoption in emerging economies like India. For an effective and efficient adoption of OCR firms need to restructure their SCs. Before restructuring the SC for implementing OCR practices, it is vital for retail firms to recognize the CSFs that are imperative and risks that hinder the adoption OCR. Apart from identification, their thorough understanding is also required in order for the retail firms to efficiently implement OCR.

#### *Contents*

1. Introduction 2. A fuzzy tism model for analysing critical success factors for Omni-channel retailing in India. 3. Risk assessment for Omni-channel retailing in India: An FMEA approach. 4. Performance assessment model for Omni-channel retail: a CSW network DEA approach. 5. MCDM based store selection model for BOPS service for an Omni-channel retail chain. 6. Bi-Objective optimization model for capacity expansion for bops service in Omni-Channel retail chain. Conclusion, Limitations and future scope Bibliography

07. KAUR (Jasmine)  
**Contributions to Modeling and Optimal Resource Allocation Related to Software Development Process.**  
 Supervisors: Dr. Ompal Singh and Dr. Adarsh Anad  
Th 27131

#### *Absract*

Discussed the basic term and terminologies associated with the theme of the thesis. The literature of software reliability engineering is very vast. To be able to compile this thesis and propose something new to the literature, many relevant models and concept were studied. But in this chapter, only few notable works which directly contributed to the thesis have been discussed, the key aspects of software development process, the resource allocation problem in SRE, the maintenance phase of the software, concept of patch and vulnerability, etc. have been discussed here. The thesis attempts to study and improve the software development process. The focus is on the agile based models as very few mathematical models which cater to the unique nature of agile based model are currently available. An existing MCDM algorithm Viz IFS TOPISIS has been used to determine the best vulnerability scanner for an organization. The working of the model has been elaborated. This will help the firms in determining the best vulnerability according to their requirement as the proposed methodology can be easily customized.

#### *Contents*

1. Introduction 2. Resource Allocation for Agile-based Software Development 3. Optimizing Sprints for Agile based software Development required trade-Off between two attributes under Consideration 4. Software Reliability Modeling Inculcating of Patch 5. Modeling and Resource Allocation for Software Vulnerability Management 6. MCDM Approach for Vulnerability Scanner Selection. Conclusion, Reference and Appendix.

08. MAHESHWARI (Sumit)  
**Sustainable Inventory Models under Various Pragmatic Scenarios.**  
 Supervisors: Prof. Chandra K. Jaggi and Dr. Amrina Kausar  
Th 27218

## Abstract

Sustainable inventory models can offer several advantages and reasons for further investigation. Sustainable inventory models focus on reducing waste and optimizing resource utilization. To handle imperfect production /preservation technology/closed-loop supply chains, promote environmental sustainability by incorporating rework, preserving the items for a longer time, and remanufacturing processes. Integrating reworked /preserved/ remanufacturing often requires less energy and fewer resources compared to manufacturing new products from scratch. The optimization of selling prices for the products allows you to maximize total profit. By carefully setting the selling prices based on factors such as production costs, markets demand, and customer preferences, you can find the optimal balance that generates the highest profit for your system. Developing expertise to handle imperfect/deteriorated/end-of-life/used products gives the organization a competitive edge. As sustainability becomes increasingly important to customers being able to offer reworked/remanufactured at competitive conscious consumers and open up new opportunities.

## Contents

1. Introduction 2. Literature Review 3. Inventory Strategies for imperfect Quality items with Varying Demand 4.Exploring Preservation Strategies to combat Deterioration 5. Sustainable Inventory Model for Two-layer Supply Chain 6. Sustainable Inventory Model for Three-Layer Supply Chain 7. Conclusion and Directions for future Research. List of Publication, Bibliography and Appendix.

09. NEHA

### **Software Testing Management Using Quantitative reliability analysis and Machine learning algorithms.**

Supervisors: Prof. Anu Gupta Aggarwal and Dr. Abhishek Tandon

Th 27217

## Abstract

Software testing is the process of assessing a program's or system's characteristics to Make sure it achieves the desired results. Testing is planning and carrying out test cases in an organised manner in order to find and fix errors as quickly and cheaply as possible. Testing has both technical and economic aspects. Techniques, methods, measurements, and tools are used in the technical aspects of testing to make sure the software under test is reliable and fault-free. However, recent years have seen a radical shift in the nature, size, and complexity of software. Modern software products are frequently too huge and complex for programmers to comprehend and modify all at once. Developers often divide huge, sophisticated software packages into smaller modules. A modular software system refers to the collection of various smaller programs, which are simpler to comprehend, test, and modify. Modular software systems present unique testing challenges. The testing of individual modules must be comprehensive and thorough to ensure that the system as a whole is reliable and free from faults. However, testing each module in isolation may not reveal all possible interactions and dependencies with other modules in the system. Therefore, testing of modular software systems must also take into account the interactions and dependencies between modules. Hence, software testing is a process that involves both technical and economic aspects. The growing size and complexity of modern software products have led to the development of modular software systems. Effective testing of modular software systems requires comprehensive testing of individual modules and consideration of the interactions and dependencies between modules. The economic aspects of software testing are strongly tied to the testing team's restricted availability of time and resources. These limits might lead to testing phase compression and a

trade-off between budget, time, resources, and quality. As a result, it is critical for organisations to efficiently manage their testing process in order to deliver software on time, under budget, and in accordance with customer specifications. Overall, economic aspects of software testing necessitate careful management of time and resources in order to achieve the optimum results. Organisations can use modelling to optimise their testing processes, enhance software quality, and deliver software solutions that satisfy customer needs while staying on budget and on schedule.

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1. Introduction 2. Reliability Growth models under different Scenarios of software testing Environment 3. Unified approach for testing coverage based Flexible software Reliability Model 4. Impact of Slippage Cost on software delivery time 5. Reliability Planning for Modular Software System under Fuzzy Environment 6. Machine Learning Based Prediction Models for Software Debugging 7. Conclusion, Limitations and future Direction for Research.

10. SHARMA (Rashi R.)  
**Decision Modelling Approaches for Sustainable Performance Enhancement of Multi-Tier Food Supply Chain.**  
 Supervisors: Prof. P.C. Jha and Dr. Jyoti Dhingra Darbari  
Th 27132

*Abstract*

The idea of sustainability has emerged as key approaches for numerous FPFs and is a topic of interest for many researchers, but how it should be pursued in the FPF of across its upstream SC is a matter of big concern and is still an unexplored domain. The current thesis illustrates the different ways to integrate the concepts of sustainability across the entire AFSC especially for the flour milling industry. It is divided into seven chapters. The introductory chapter states motivation behind in the research work presented in the thesis and discusses some key theoretical concepts in brief. The second chapter explains the method adopted for literature review and presents the related literature. The concepts of sustainability has caught significant interest from academia, experts, and policymakers as a possible resolution for environmental, Social and economic problems of the existing competitive situation. Despite this rise in interest, there is dearth of research related to implementation of sustainable practices in AFSC especially in case of emerging economies like India. Before implementing sustainable initiatives in AFSC, it is vital to recognize the barriers the impede and enablers of drivers towards adoption of sustainable practices apart from identification, their thorough understanding is also required in order FPF to efficiently utilize the resources and attain sustainable goals.

*Contents*

1. Introduction 2. Development of Structural models for Barrier and Enabler Analysis towards Sustainability adoption 3. Multi Criteria Modelling for Performance Assessment of Sustainable Practices 4. Sustainable Supplier and Optimal Order Allocation Models in a Multi-Tier supplier Network 5. Group Decision Making approach to Study the Impact of Sustainability Driven Strategies in Multi-tier Supplier Network. Conclusions, limitations and Future Scope. Bibliography.

11. SOLANKI (Rahul)  
**Multi-Criteria Approach for Analysis and Modelling of Carbon Regulatory Policies Implementation in Manufacturing Supply Chains.**  
 Supervisor: Prof. P.C. Jha, Prof. Diego Galar and Prof. Devika Kannan  
Th 27133

*Abstract*

The advanced technological developments provide the customers with new and updated versions of the consumer products, enticing them to upgrade at a faster rate, resulting in profuse consumption of natural resources, waste generation and emission of carbon dioxide. Resultantly, unregulated business practices have further deteriorated the environment, leading to severe challenges, such as, greenhouse effects and ozone layer depletion. According to the 'Inter-Governmental Panel on Climate Change' (IPCC), supply chain (SC) operations are persistently affecting natural course of climate change. With significant improvements among the manufacturing industries in recent years, there has been a rapid increase in carbon emissions (CEs) levels. In this regard, manufacturing organizations around the globe are experiencing immense pressure from the legislative institutions, governments, and non-profit regulatory bodies to adopt proactive policies, for minimizing their CEs level. One of the most effective ways to mitigate CEs and reduce ecological degradation is through the adoption of carbon regulatory environmental policies (CRPs), which effectively balances trade-off among ecological protection, economic developments and social welfare. The imposition of such regulations is not only vital for carbon efficient operations among SCs, but also for the sustainable development. Currently, many national governments have sought different carbon environmental policies to enhance their ecological sustainability and to ensure enhanced sustainable performance. Most Indian manufacturing organizations are skeptical towards adopting such stringent environmental policies into their existing SC network because of significant difficulties. The integration of new regulations in SC is faced with numerous challenges, such as, technological, reputational, political and financial. Furthermore, awareness among consumers and involvement of industrial managers have resulted in need for ameliorating sustainability at all SC levels, which leads to additional complexities and challenges. Therefore, successful implementation of CRPs among MSCs is practically achievable if all the stakeholders contribute and addresses sustainability issues in their own capacities. It is an extremely onerous task to develop mathematical models for effective and efficient implementation of CRPs from the Indian manufacturing sector's perspective. In order to take the proactive stance towards cleaner environment, the paradigm shift towards adopting the CRPs can prove to be one of the most powerful tool that can transform the manufacturing operations of an organization into ecologically sustainable one by mitigating excessive CEs. Over the last few decades, the involvement of academic researchers, industrial practitioners and stakeholders has resulted in higher ecological sustainability demands from the organizations which add up to new complexities among MSCs. For addressing the constant needs of various decision makers, MSCs have been evolving incessantly in the past few years. However, implementation of CRPs among MSCs of emerging economies is a challenging task, which can satisfy the needs of all decision-maker, and uplift organizations' economic and ecological performance. This leads us to defining the scope of the present research work. It is imperative for the manufacturing organizations in India to adopt CRPs and upgrade their SC network to comply with international legislation and global carbon emission reduction goals, while reducing their dependency on natural resources and enhancing its overall sustainable performance. By doing so, it can furnish a major strategic solution for Indian SMEs to improve their sustainable image in the competitive business environment. For achieving the successful implementation of CRPs among MSCs, it is absolutely essential for the SMEs to review their crucial SC operational decisions and to understand the ways to integrate ecological sustainability into their strategic, tactical and operational levels of SCs while simultaneously improving their economic efficiency. For instance, as all the activities of SCs contribute to the potential rise in CEs level; among various other decisions that can create an obstruction for the SME in implementing the CRPs and thus requiring more attention could be - to decide the quantum of appropriate carbon-tax to be levied on the organizations for maximizing their economic output and ecological gain.



Consequently, such a decision influences the networks strategic planning in the long run. The fundamental research domain of the thesis is confined to the manufacturing sector of India, looking for integrating innovative measures to address the persistent problem in mitigating excessive CEs. The various addressed problems pertain to different manufacturing SMEs spread across different states of India. Understanding crucial implementation hindrances, and inhibitors of CRPs adoption can help manufacturers in finding motivation for incorporating CRPs in their SCs and thereby become ecologically more conscious, encouraging them to move towards carbon efficient future. Overall, it is important for MSCs to understand the need of adopting CRPs in their business operations, analyse effective carbon tax price for India, and determine best recovery system for product returns which can provide them maximum ecological sustainability under CRP.

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1. Introduction 2. Barrier analysis towards Carbon Regulatory Environmental Policies Implementation in Manufacturing Supply Chains 3. Identification and Analysis of Drivers towards Implementation of carbon Regulatory environmental policies in Manufacturing supply Chains 4. Analysing the Risks of Carbons Regulatory Environmental Policies Adoption in Manufacturing Supply Chains 5. Multi-Objective Optimization for Reverse Logistics Network Design under Carbon tax Regulation 6. Conclusions, limitations and future scope. Bibliography.

12. VIVEK KUMAR

**Modeling Software Reliability and optimizing release timed policies for software products.**

Supervisor: Prof. Ompal Singh

Th 27214

### *Abstract*

In today's hyper-competitive market, software producers have to deliver reliable software on time to avoid the manipulation of the market by its competitors. In the last few decades, we have seen enormous growth in the software industry due to the increasing needs of users for their various requirements for the smooth functioning of day-to-day activities. In other words, we can say that without reliable software products, our survival will be very difficult today. Therefore to overcome these difficulties, software firms continuously develop highly reliable and secure software products. Achieving highly reliable software is not an easy task, and it takes time. The testing process consumes most of the time during the software development process. A rough estimate says that firms spend more than half of the total budget on software testing only. Therefore, this phase needs to be given utmost priority during the whole software development process. The testing phase remains indispensable, yet software companies are increasingly pressed by market competition, requiring them to expedite software releases. Therefore, software firms adopted a new strategy to tackle both issues by releasing the software a bit early to be in the market competition and continuing to test the software during the post-release phase to ensure fewer failures occur in the operational phase. Software firms allocate their testing team to identify errors encountered during the operational phase and remove them before the users report them. Furthermore, the chances that the testing team identifies the faults before the users are higher due to their involvement during software development. The other reasons could be the expertise of the testing team and the focused time spent on the software for fault removal, which makes the testing team more efficient than the normal user of the software. Hence the chance that the failure is experienced by the users is less. However, if the failure is experienced by the users, these failures are reported to the software firms, which finally come to the testing team to check and debug the underlying faults. This failure reporting by users helps the testing team to remove a greater number of

faults from the software and reduces the chances of the next failures. However, failure reported by the user end comes with a higher cost than the cost of detecting a fault by the internal testing team.

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1. Introduction 2. Software Release and Testing stop time decision with change point 3. Analyzing the effect of Testing efforts on software time to market decisions 4. Modeling reliability Growth process and release time problem for open source software projects 5. Stochastic Reliability Growth Models with dynamic Fault introduction rate.

13. YADAV (Sanjay)  
**Some contributions to multi-objective portfolio selection under uncertainty.**  
 Supervisors: Prof. Pankaj Gupta  
Th 26816

#### *Abstract*

The primary objective of any portfolio optimization study is to accurately capture the real-world intricacies of financial markets and develop solution approaches that inspire confidence among investors. This thesis is a step in the same direction. Several real-world stock market scenarios were considered, and models accurately representing the complexities of the stock market were developed. The methodology of each chapter was illustrated comprehensively using empirical demonstrations. We analyzed the obtained results and demonstrated the efficacy of the presented approaches. However, our research is by no means perfect. The approach of each chapter has some limitations that need to be discussed and addressed. It encourages us to pursue further research to overcome the limitations. Thus, this chapter concludes the thesis with a chapter-wise summary and a discussion of possible future research directions.

#### *Contents*

1. Introduction 2. Institutions fuzzy portfolio selection using entropy and higher moments. 3. Intuitionistic fuzzy multi-period portfolio selection. 4. Intuitionistic fuzzy multi-objective sustainable portfolio selection. 5. Uncertain multi-objective multi-period portfolio selection with different investor attitudes. 6. Credibilistic multi-objective multi-period efficient portfolio selection. 7. Conclusions and future work. Bibliography.

14. YADAV (Shikha)  
**Analysing the impact of carbon policies on inventory systems for sustainable on inventory systems for sustainable development.**  
 Supervisor: Dr. Aditi Khanna  
Th 27215

#### *Abstract*

Presently, there is a growing public awareness and concern regarding environmental issues and personal health, leading to an augmented need for fresh food. Ensuring the quality and safety of food and perishable products for consumption requires strict adherence to the freshness and expiration date, as consumers become more conscious of the expiration date, Product freshness become increasingly vital. To maintain freshness, proper handling, storage and transportation are essential. In contrast, the expiration date is the date until which a product is considered safe to consume if properly stored. The manufacturer determines the expiration date by implementing stringent quality assurance and testing protocols. Health hazards may results from consuming products after their expiration date, given that their quality, flavour and safety

may gradually decline. Adhering to storage guidelines and practicing appropriate handling techniques are critical in maintaining the freshness and safety of products until their expiration dates. In a dynamic international business landscape, effective inventory management requires consideration of product quality alongside order quantity and replenishment schedule. The industry faces a substantial challenge in ensuring the quality of replenishment schedule. The industry faces a substantial challenge in ensuring the quality and replenishment schedule. The industry faces a substantial challenge in ensuring the quality of naturally degrading products, given that consumers will not tolerate substandard products merely because they are available from multiple vendors. The present thesis reveals the immense potential for businesses to contribute to sustainable development. As a result of the ongoing and substantial challenges posed by climate change, the implementation of environmental sustainable inventory management practices not only emerges as a moral imperative but also as a tactical benefit.

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1. Introduction 2. Inventory replenishment model for freshness and stock dependent demand under cap-and-trade mechanism 3. Optimal inventory strategies for perishable products with expiration date and price-reliant demand under carbon tax policy 4. Exploring the impact of carbon-emission on inventory models with preservation technology investment 5. Sustainable inventory management for flexible production systems 6.conclusion and future research directions. Bibliography, Appendices and list of Publication