

Particle swarm optimization approach for the supply-chain

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Abstract

Supply chain management (SCM) is a critical component of modern business operations, encompassing the planning and management of all activities involved in sourcing, procurement, conversion, and logistics management. This paper aims to provide a comprehensive overview of supply chain management, exploring its fundamental concepts, then proposes an approach for it. Supply chain management has evolved into a vital area of study and practice within the field of operations management. The SCM problem involves the coordination and integration of these flows both within and among companies. The objective of SCM is to maximize customer value and achieve a sustainable competitive advantage. This paper will explore the key components of supply chain management, the challenges faced by organizations, and the innovations that are transforming the landscape of SCM. In this paper we define goals for SCM. Next we solve the problem with the Multi-Objective Particle Swarm Optimization (MOSOP). Since there is more than one goal, we use PARETO theorem that is allow us to optimize different goals simultaneously. Multi-Objective approach causes to trade-off between optimum values of goals, so it has more potential to adopt with the real world conditions.

Keywords: Supply Chan; Evolutionary Optimization; Particle Swarm Optimization; Multi Objective

1. Introduction

A supply chain is a network. This network can be including all individuals, organizations, resources and etc. Supply chains involve every thing that is necessary to manufactory and deliver a product. The network of supply chain has sis fundamental steps: sourcing raw materials, refining materials into the basic parts, combining basic parts to create a product, order fulfillment, product delivery and customer support. The amount of time it takes any one to processes is known as Lead Time.

There is several common supply chain business models that supply chains fit into. The models have two main focuses: responsiveness and efficiency. Each model strives for some combination of both but approaches those goals differently. In addition, models tend to favor one over the other. Organizations can evaluate the value proposition of each in relation to their goals and constraints, and choose which suits them best.

The model of supply chain may represent as several types: continuous flow model, agile model, fast chain model, flexible model, and custom configured model and efficient chain model. All of these types suffer unsatisfied business and partners. It means partners may have own goal and different goals are opposite to each other.

An efficient approach to cover the problem of opposition of partner's goals is using Multi-Objective Optimization (MOO). This issue that is based on the PARETO theorem, is looking for optimum values to increase one object (goal) and do not cause to decrease other objects. There are methods for multi-objective optimization but one famous family of them is Meta-Heuristic Algorithms. In this paper, a continuous flow model of resources of supply chain is showed at the first

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step. Next, two objects are defined and in the third step, the model is solved with multi-objective particle swarm optimization.

2. Related Papers

Zainurrafiqi et. al. employ a structured approach to investigate the effects of supply chain digitalization, green supply chain management, and supply chain resilience on the competitiveness and performance of Micro, Small, and Medium Enterprises (MSMEs) [1]. These methods collectively enable the researchers to draw meaningful conclusions about the impact of supply chain digitalization, green supply chain practices, and resilience on the performance and competitiveness of MSMEs, providing valuable insights for managers in the field.

Herold et. al explores the intersection of neo-institutional theories and supply chain management [2]. The authors identify specific patterns of complexity that influence supply chain susceptibility. The study presents three institutional responses aimed at addressing supply chain susceptibility and enhancing resilience. The authors derive six propositions that articulate how complexity can be reduced for supply chain susceptibility and increased for supply chain resilience. These propositions serve as a theoretical framework for understanding the dynamics at play in supply chains. The paper builds on existing literature to contextualize the relevance of neo-institutional theories in supply chain management, highlighting gaps and opportunities for further research. Overall, the methods used in this paper combine theoretical exploration with practical implications, aiming to provide a comprehensive understanding of how institutional complexity affects supply chain dynamics. This approach not only contributes to academic discourse but also offers valuable insights for practitioners in the field.

Tera. et al. employs a structured methodology to explore the relationship between supply chain digitalization (SCD) and supply chain performance (SCP) [3]. The study gathered data through a cross-sectional method, which involves collecting data at a single point in time. This approach is useful for understanding the current state of supply chain practices among firms. The study measured key variables such as SCD, SCP, supply chain visibility (SCV), and supply chain survivability (SCS). The relationships between these variables were analyzed to understand how SCD influences SCP, both directly and indirectly through SCV. The researchers likely employed statistical techniques to analyze the data collected. While the specific statistical methods are not detailed in the abstract, such studies typically use regression analysis to assess the relationships between variables and to test the mediating and moderating effects. Overall, the methodology combines quantitative data collection and analysis to provide a comprehensive understanding of the dynamics within supply chains during disruptions.

Farhan conducted a comprehensive literature review to gather existing knowledge and insights related to the supply chain in the defense industry [4]. This method helps in understanding the current state of research and identifying gaps that need to be addressed. The paper utilizes system thinking as a framework to analyze the interconnected components of the supply chain. This approach allows for a holistic view of how various elements within the supply chain interact and affect each other, which is crucial for identifying weaknesses and opportunities for improvement. A SWOT (Strengths, Weaknesses, Opportunities, Threats) analysis is employed to evaluate the domestic defense industry's supply chain. This method helps in identifying internal strengths and weaknesses, as well as external opportunities and threats that could impact the supply chain's effectiveness and resilience. Through the literature review and the application of system thinking and SWOT analysis, the authors identify specific problems affecting the domestic defense industry's supply chain, such as reliance on imported raw materials and issues within the logistics system.

In the contemporary business landscape, effective supply chain management (SCM) is paramount for organizations seeking to thrive amidst evolving market dynamics and heightened customer expectations. Shukla et. al. presents a pioneering approach to SCM that harnesses cutting-edge technologies, namely Kafka and Akka, to revolutionize data integration and decision-making processes [5]. By leveraging Kafka as a robust distributed event streaming platform and Akka as a versatile toolkit for developing concurrent and distributed applications, our system facilitates seamless communication and coordination across diverse nodes within the supply chain network. This paper elucidates the intricacies of the proposed architecture, detailing the implementation methodology and performance evaluation metrics. Through a comprehensive examination, we demonstrate how our solution enhances supply chain visibility, fosters operational agility, and enables real-time responsiveness to market fluctuations and customer demands. Moreover, practical use cases exemplify the transformative impact of presented approach on inventory management optimization, order fulfillment efficiency, and logistics optimization. Furthermore, they delve into the challenges encountered during implementation and deployment, offering insights into potential imitative strategies. Finally, they outline avenues for future research, exploring emerging trends and opportunities in the realm of SCM empowered by Kafka and Akka technologies.

Parvathi et. al. aims to analyze and compare selected physical fitness, physiological, and psychological variables among boys from government, government- aided, and private schools in the Chennai district [6]. The purpose is to understand how different school environments impact these variables and to provide insights that can inform policy and practice in physical education and health promotion. — Methodology: A sample of 300 boys aged 12-15 years was selected through stratified random sampling, with 100 boys from each school type (government, government-aided, and private schools). Physical fitness was measured using the Fitness Gram test battery, physiological variables such as BMI, resting heart rate, and blood pressure were assessed using standard clinical procedures, and psychological variables were evaluated using the Rosenberg Self- Esteem Scale and the Perceived Stress Scale. Data were analyzed using ANOVA to compare the means across the three school types, with post-hoc tests conducted to identify specific group differences. — Conclusion: The study found significant differences in physical fitness, physiological health, and psychological well-being among boys from different types of schools. Boys from private schools exhibited better physical fitness and lower stress levels compared to their peers in government and government-aided schools. These findings highlight the influence of socio-economic factors and access to resources on students' health and suggest the need for targeted interventions in government and government- aided schools to improve physical and psychological well- being among students.

Verny. et al. employs several methods to explore the potential of blockchain technology in supply chain management [7]. The authors conduct a comprehensive review of existing literature to understand the current state of blockchain applications in supply chains. This helps in identifying gaps and opportunities for further research. The paper references various real-world projects and implementations of blockchain technology in supply chains, particularly in Europe and North America. These case studies illustrate how blockchain is currently being utilized in industries such as retail and manufacturing. A significant method proposed in the paper is the development of an online game-based simulation model. This innovative approach allows researchers and practitioners to test and learn how blockchain technology can impact supply chain efficiency. The simulation scenario is designed to provide insights into the dynamics of blockchain integration within supply chains. The authors analyze the disruptive potential of blockchain technology on existing logistics models. This involves assessing how blockchain can eliminate the need for intermediaries and enhance transparency and reliability in transactions. The paper adopts an interdisciplinary perspective by combining insights from technology, logistics, and supply chain management. This holistic view helps in understanding the broader implications of blockchain technology beyond just technical aspects.

Barusman et al. provides several practical implications for business owners and managers [8]. The research indicates that effective supply chain management significantly improves the performance of SMEs. Therefore, business owners should focus on optimizing their supply chain processes to enhance overall efficiency and productivity. The findings suggest that strong supply chain management contributes to a competitive advantage. SMEs should leverage their supply chain capabilities to differentiate themselves in the market, which can lead to better performance outcomes. One of the recommendations is for SMEs to improve information sharing regarding financial conditions with their business partners. This transparency can foster collaboration and support, enabling partners to assist in resolving issues effectively. The study emphasizes the importance of introducing new products as a strategy to enhance performance. SMEs in Tangerang are encouraged to innovate continuously to meet market demands and stay competitive. The research highlights that competitive advantage can mediate the relationship between supply chain management practices and performance. This means that SMEs should not only focus on supply chain management but also on building and maintaining competitive advantages to maximize performance benefits. The study acknowledges that it has not fully explored all factors affecting supply chain management, competitive advantage, and SME performance. This opens avenues for future research to identify additional variables that could influence these relationships, which can be beneficial for practitioners looking to implement comprehensive strategies.

Goel et al. review significant supply chain research conducted by eminent researchers [9]. Kumar focuses on the possible vulnerabilities in whole supply chain and categorizing the vulnerabilities on basis of layers so that it is easy to detect, prioritize the remediation process and remediate identified vulnerabilities [10]. Choi study in demand forecasting [11]. Then it presents a measure that widely used as a method to measure how accurate demand forecasting.

3. Proposed Algorithm

In this section the proposed approaches is described. The proposed approach is based on the Evolutionary Optimization concepts, so the first required thing is the mathematic model. According to the mathematic model, our viewpoint is created and we can obtain the needed information about the problem. Therefore in the following sub-section we explain the mathematic model of the problem. The next sub-section is about the Particle Swarm Optimization (SOP) algorithm that is designed for this problem.

3.1. Model

Let the following model is the mathematical description of the continuous flow model.

Optimize Q_1, Q_2

Such That:

$$Q_1 \leq \mathbb{V}\mathbb{R}, Q_2 \leq \mathbb{P}\mathbb{R}$$

Where the matrix $\mathbb{V}$ shows the value each required resources in the matrix $\mathbb{R}$. Resources can be prepared from different supplements, so the first goal is decreasing of the total price with decreasing Q_1 . Actually keeping and transition of each required resources has own environment pollution. We have to decrease this pollution to reach the Green Environment. The pollution of the resources is shown with matrix $\mathbb{P}$, so the second goal is decreasing Q_2 .

In other words the matrix $\mathbb{R}$ is constant and it has been determined, but the values of the matrix $\mathbb{V}$ and the matrix $\mathbb{P}$ are required.

3.2. Particle Swarm Optimization

In computational science, particle swarm optimization (PSO) is a computational method that optimizes a problem by iteratively trying to improve a candidate solution with regard to a given measure of quality. It solves a problem by having a population of candidate solutions, here dubbed particles, and moving these particles around in the search-space according to simple mathematical formulae over the particle's position and velocity. Each particle's movement is influenced by its local best known position, but is also guided toward the best known positions in the search-space, which are updated as better positions are found by other particles. This is expected to move the swarm toward the best solutions. A basic variant of the PSO algorithm works by having a population (called a swarm) of candidate solutions (called particles). These particles are moved around in the search-space according to a few simple formulae. The movements of the particles are guided by their own best-known position in the search-space as well as the entire swarm's best-known position. When improved positions are being discovered these will then come to guide the movements of the swarm. The process is repeated and by doing so it is hoped, but not guaranteed, that a satisfactory solution will eventually be discovered. In the multi-objective scene, the scenario is changed.

In the multi-objective scene, each particle is the solution for multi goals. To compare between particles, we use the PARETO theorem which says that particle (i) dominates particle(j) if it is better than in at least one goal and not be worst in other goals. If particle (i) and particle (j) cannot dominate each other, they named as non-dominate. In the multi-objective scene, the especial state, named as archive, must be considered to keep non-dominated particles from diversity. Entering into archive and also exiting from archive is determined with a probability function.

4. Experimental Results

There are two goals (as are showed in the mathematical model) and the values of them are opposite to each other. It means one of them wants to increase and another wants to decrease. While we use multi-objective mode, we can handle this problem. Another important parameter is coding the solution in the particles. We design fields (as the number of desired values) in each particle to keep the real value. Since the structure of PSO is stochastic, we run the algorithm 4 times. The following table shows the final results. The results are between 0 and 1, but they can be changed into another range.

Table 1 Results

Round	Q1	Q2
1	0/98	0/72
2	0/73	0/31
3	0/99	0/28
4	0/96	0/81

5. Discussion

In this paper we present an approach to solve the supply-chain problem. the presented approach used the particle swarm optimization algorithm as the intelligent method. The major subject in the intelligent method is designing the probability function. The algorithm can produces another results with the different probability function, but our aim is showing how can solve this problem with intelligent algorithms. Therefore in the next work we can present other functions for the probability.

6. Conclusion

The aim of this paper is Supply-Chain Management (SCM).that is used in business operations and.... Paper presents a mathematical model for the SCM. To solve the presented model, an Evolutionary Algorithm is used.

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