In 21st century, particularly with the globalization of the world economy and revolutionary developments of information technology, the critical challenge to manufacturing enterprises is to become more flexible, responsive and quickly adapt to the environmental changes under a dynamic and uncertain business environment. Moreover, these changes generally reflect on their supply chain. The ability to manage the complete Supply Chain Network (SCN) architecture and to optimize decisions is increasingly being recognized as a crucial competitive factor in order to make good decisions within a SCN architecture.

Supply chain management has been recently introduced to address the integration of organizational functions. In order to achieve high performance, supply chain functions must operate in an integrated and coordinated manner. Several challenging problems associated with integrated supply chain design are tackled in this thesis by modeling supply chain networks and with the application of new heuristic optimizers. These problems are most representative in the supply chain theory’s research and applications. Actually, these real world models are difficult to solve with conventional optimization algorithms and commercial solver tools available in the market, when the complexity of the problem increases. Hence, many advanced techniques of operations research along with new heuristic evolutionary and social behavior algorithms were implemented, as the addition of valid cuts and they act as decision-support tools. The objective of these tools is to facilitate decision making for enterprises in this context.
This research focuses on development of mathematical models, analysis and performance evaluation of multi stage multi-echelon supply chain networks using particle swarm optimization algorithms.

This study has been carried out in four phases. In the first phase, an attempt is made to develop the integer programming mathematical model to tackle an important issue in the three stage multi echelon SCN design to find the network strategy that can give the least cost of procurement, manufacturing and distribution flow with the application of genetic algorithm and new variations of Particle Swarm Optimization (PSO) algorithms. The application of these new PSO optimizers have not been studied in integrated supply chain literature to date, for the performance analysis and optimization of an integrated supply chain network architecture problems. As the solution methods, applications of the four variants of particle swarm optimization algorithms have been proposed to solve the real world supply chain network architecture problems. Total Supply Chain network operating Cost (TSCC) is used as a measure of supply chain performance and it was found that the PSO algorithms gives better quality results in significantly fewer fitness and constraint evaluations in comparison with Genetic Algorithm(GA). Hence, the proposed applications of variants of Particle Swarm Optimization (PSO) algorithms provides an effective way to design structured supply chain business process architectures.

In the second phase, the study on four stage multi-echelon supply chain network architecture has been carried out with an objective of minimization of TSCC and maximization of Profit. This four echelon supply chain problems has been solved with the application of best performing Non
Linear Inertia Weight PSO (NLIW-PSO) algorithm as it was out performed among all the variants of PSO algorithms used for solving the three echelon SCN problem.

Typically all supply chain problems are characterized by decisions that are competing or conflicting by nature and are most common, especially in industrial engineering and management applications, due to the multi-criteria nature of most real world problems. Modeling these problems using multi-objective optimization approach, gives the decision maker a set of trade-off near optimal solutions for decision-making. Hence, in the third phase of this research, is to develop, multi-objective mathematical model to solve three stage and four stage supply chain network architecture problem to find out trade-off solutions among the different sets of conflicting objectives considered for the study.

In the final phase of the study, two industrial case studies are considered to substantiate, validate the effectiveness of the best performing PSO variant. The NLIW-PSO out performing algorithm has been applied to the industrial SCN case studies and the results were compared with industry records (book values) maintained by the organization. It seen that considerable savings would have been achieved form the application of NLIW-PSO algorithm for solving real world three echelon supply chain network problems.

It is hoped that the modeling, analysis, insights, and concepts provided for these various supply chain network based problems that arise in diverse sourcing, routing, location allocation, production, distribution and
supply chain network design contexts, will provide guidelines for studying many other problems that arise in related situations.

It is concluded that the present study on the performance analysis demonstrates the application of new PSO algorithms. It is found that the PSO algorithms are more effective and competitive to the existing state-of-the-art heuristic algorithms in terms of quality of the solutions and computational complexity for the performance analysis of multi-stage multi-echelon supply chain network architectures.