Chapter 10
Conclusion

In line with the objective of this thesis "Strategic Directions for Resolving Critical Issues of Design and Process Management of Supply Chain", effective strategies using modern scientific tools and techniques, to deal with the commonly encountered problems in the following mentioned modules of a Supply Chain are ascertained.

- Selection of Vendors.
- Selection of a State Explicit Procurement Policies for outsourced items.
- Deciding Optimum Product Quantities with targeted Responsiveness.
- Establishing Mathematical Relationships between the causes and various effects of the Supply Chain phenomenon, such as Supply Chain Profit, Supply Chain Total Cost, Supply Chain Hold Cost, Supply Chain Transport Cost.
- Establishing a Holistic, Cross boundary, Fuzzy performance evaluation approach to benchmark the Supply Chain leading to Supply Chain Development.

Different Tools used for developing these models are:

- Field Data Base Modelling
- Analytical Hierarchy Process
- Fuzzy logy
- Relative Reliability Risk Evaluation
- Analytical Modelling using MATLAB 7.0
- Simulation Modelling using PROMODEL 7.0
- Data Mining / Exploratory Data Analysis in MATLAB 7.0 Environment
- Artificial Neural Network Simulation in MATLAB 7.0 Environment
- Reliabilities of these models are also established by using Chauvenet's criterion.

This Project definitely provides guidelines to analyze and optimize the Supply Chain operation especially of the existing Fast Moving Consumer / Engineering Goods (FMCG / FMEG) products. The Models established in this thesis are of course useful
in designing, planning and establishing new Supply Chains also. First step towards optimization is analyzing the existing Supply Chain Operation. This research proposes an Integrated, Innovative approach to calculate the overall Key /Global Performance Index (GPI) of the Supply Chain using a Fuzzy Cross Boundary method as illustrated in Chapter No. 9. The value of the GPI thus obtained suggests where the Supply Chain stands compared to its planned Goal. This Performance Measurement method also dictates the areas of the Supply Chain needing improvement thus leads to the Supply Chain Development. Once the critical areas are located, this project identifies means and methods to optimize the functional performance pertaining to these areas.

The Supply Chain Activity consists of three fundamental blocks: Input, Process and Output. Input Block consists of Vendors and Vendor Management. This research proposes three new approaches to optimize Vendor Selection-Vendor Development function viz. R^3I, AHP and Fuzzy. It also points out the intricacies and gives the comparison in between these approaches. It is highly recommended that present-day industries should make use of the R^3I Model to rank between new vendor proposals where no record of vendor’s past performance is available, to arrive at the most appropriate decision in least time. A new Vendor Selection-Vendor Development Model totally encompassing maximum number of vendor development criteria is also presented in Chapter No. 3, which makes an effective use of Analytical Hierarchy Process. The uncertainties in judging the vendor selection criteria are covered by proposing a Fuzzy Based Model using simple fuzzy algebra, to arrive at proper selection decision. The Models proposed in Chapter No. 3 can however be used for any type of Supply Chain with appropriate customization.

Sourcing and outsourcing Decisions have also taken on increased importance to improve efficiency and competitiveness of Supply Chains. In Chapter No. 4, a new methodology is presented to select a most appropriate type of Procurement Policy for any outsourced item.

This thesis also introduces the concept and use of Field Data Base Modelling especially for Supply Chain Process Management to achieve optimization. The
existing Supply Chain Operation is allowed to take place as it is. However data about all it's minute parameters is collected over a period of time by field work and site visits. After validation and verification, these data are used to build Analytical and Simulation Models of that Supply Chain Activity as illustrated in Chapters Nos. 5 and 6 respectively. After solving the Analytical Model, within the set of constraints, an optimum solution is obtained. After experimentation on the Simulation Model, Best Fit Point for the Supply Chain is obtained. Optimum Point and Best Fit Point can then be compared. It is then recommended to set the Supply Chain parameters to those corresponding to this solution point to get maximum profit at the targeted responses.

Through exhaustive work, a conceptual framework and a software tool to analyze Supply Chain costs associated with a specified three echelon serial Supply Chain Design for a typical FMCG / FMEG uniproduct as explained in Chapter Nos. 5 and 6, are developed. Determining Supply Chain Total Cost is a complex challenge. This work developed the concept of Hierarchical, Inter-related, Multi-level Supply Chain cost Architecture. Within this Architecture, Supply Chain costs can be expressed as a sum of only three Supply Chain cost factors (Production, Procurement, and Inventory Holding). The reduction of a large number of potential cost factors eases communication about Supply Chain Total Costs within an organization. A Field Data Base Model of an existing Supply Chain, with it's governing parameters is established as illustrated in Chapter No. 5 and 6. This Model is then optimized to determine the Optimum Operating Point of the Supply Chain which obviously yields maximum profit. Experiments are carried out on the simulation model as explained earlier in Chapter No. 6, to generate data to predict the cause and effect relationship between Supply Chain variables.

Mathematical Relationships are then established to explain Supply Chain behaviour, by using a novel technique of Data Mining / Exploratory Data Analysis, for the four response variables namely

a) Supply Chain Profit
b) Supply Chain Total Cost
c) Supply Chain Hold Cost  
d) Supply Chain Transport Cost,

for the Supply Chain of HINDUSTAN UNILEVER LIMITED - Fast Moving Consumer Goods (FMCG) product as illustrated in Chapter No. 7.

The deduced models are cross validated by using Artificial Neural Network (ANN) Simulation as explained in Chapter No. 8, by comparing the Reliabilities of the developed models. It is then concluded that the Mathematical Relationship established by ANN Simulation can give better predictions about the Supply Chain Activity. So this research proves the applicability and efficiency of ANN Simulation for this type of problem.

The findings of this project are as follows:

- It is shown that Relative Reliability Risk Evaluation ($R^2$) is a better methodology for vendor selection amongst new vendors than the traditional method of Performance Ratings used today by the industries through SAP. The method helps to obtain ordinal rankings of the available choices, where no previous performance data of vendors is available.
- A new structure for vendor selection incorporating six main criteria and thirty eight sub criteria is developed and depicted. The Decision index / Desirability index of the available vendor choices can be obtained by using this innovative methodology making use of Analytical Hierarchy Process (AHP).
- For selection amongst new vendors, where the decision making situations involve high degree of fuzziness and uncertainties, an efficient method is proposed for evaluating vendor systems based on fuzzy number arithmetic.
- It is shown that selection of proper procurement policies for outsourced items in a Supply Chain helps reduce the Supply Chain Total Cost. Four different types of procurement policies are proposed with their inherent characteristics and a novel approach is suggested to select best policy for a given item. It is proved that for the procurement of Diesel tank of a Heavy Commercial Vehicle of
TATA MOTORS LIMITED, JIT Like Policy and not the JIT Policy is best suitable.

- All the above models developed and proposed are the most generalized models and can be applied to any type of Supply Chain with an appropriate customization, however these models are validated here for the Supply Chains of Fast Moving Consumer / Engineering Goods (FMCG / FMEG).

- The Solution obtained for the Analytical Model formulated for the Fast Moving Consumer Goods of the Supply Chain of HINDUSTAN UNILEVER LIMITED, by using Field Data Base Modelling approach, reveals that there exists an optimum level of inventory that should be maintained along the Supply Chain to maximize service level and to minimize Supply Chain Total Cost. The solution also recommends zero stocking policies at the Manufacturer and Distributor of the three echelon serial Supply Chain. The same results are also obtained for the Supply Chain of Fast Moving Engineering Goods.

- Further the Minimum Supply Chain Total Cost obtained by experimenting on the developed simulation model of the Supply Chain of Fast Moving Consumer Goods of HINDUSTAN UNILEVER LIMITED, closely matches with the Minimum Supply Chain Total Cost obtained by solving the Analytical model of the same.

- This research work developed the concept of Hierarchial, Interrelated, Multilevel Supply Chain Cost Architecture.

- The Reliabilities of the four Mathematical Models established by using Data Mining / Exploratory Data Analysis, for the four main Supply Chain Response variables of the Supply Chain of Fast Moving Consumer Goods of HINDUSTAN UNILEVER LIMITED, viz. Supply Chain Profit, Supply Chain Total Cost, Supply Chain Hold Cost and Supply Chain Transport Cost, range between 56% to 67%.

- The Reliabilities of the four Mathematical Models established by using Artificial Neural Network (ANN) Simulation for the four main Supply Chain Response variables of the Supply Chain of Fast Moving Consumer Goods of HINDUSTAN UNILEVER LIMITED, viz. Supply Chain Profit, Supply Chain Total Cost, Supply
Chain Hold Cost and Supply Chain Transport Cost, range between 84% to 99%.

- So this research proves the Applicability and Efficiency of ANN Simulation for this type of problem.
- This research proposed a New Integrated Holistic Performance Measurement Approach for a supply chain, by using Fuzzy logy. By using this approach, Global Performance Index (GPI) of the existing supply chain of Fast Moving Consumer Goods of Hindustan Unilever Limited is calculated which is 5.14 in a scale of [0 10].
- Global Performance Index (GPI) of the existing supply chain of Fast Moving Engineering Goods is calculated which is 4.92 in a scale of [0 10] which indicates that there is ample scope for improving this supply chain performance.

In nutshell, right from the vendor selection – development to optimization of product flow, to optimization of the procurement policy for different outsourced items, to performance evaluation of the integrated holistic Supply Chain, the models established, resolve various issues concerning the Supply Chain by providing maximum profit and a Global Performance Index of the Supply Chain which leads to the Supply Chain Development.