CHAPTER 3
RESEARCH METHODOLOGY

3.1 INTRODUCTION

The present study is descriptive in nature. The study is titled as “Application of inventory optimization decisions among SMEs in auto sector using FCM and AHP techniques”. Inventory optimization among SMEs is highly depends on their logistics and supply chain management and inventory control practices. These two are complex and difficult in small scale industry. Another major difficulty in SMEs is complex and customized product line. Having explained the back ground to the study, the following paragraphs focused on the research methodology followed in the present project.

3.2 STATEMENT OF THE PROBLEM

Inventory costs have lot of impact on the profitability of the firm and its success. Inventory management and its optimized decisions are depending on the identification of key success factors and right decisions at right moment. In a dynamic market environment, it is necessary to focus on the decision making and the factors influencing decision making in order to optimize the results of inventory function. The survey approach can bring a light on the variables and these have lot of biased information. Testing of the factors influence on inventory decisions by using scientific methods can help to improve the reliability of the factors taken as key variables in decision making. Hence, the present research is focused on two dimensions namely identification of Factors influencing inventory optimization among SMEs in auto sector through a structured questionnaire and grouping them into two sets as internal variables and external variables. Establishing the
relationship between grouped factors and the type of organization structure followed and their influence on inventory optimization decisions, Grouped external factor’s sensitivity on the inventory optimization decision. Based on this the study is titled as “Application of inventory optimization decisions among SMEs in auto sector using FCM and AHP techniques”.

3.3 NEED FOR THE STUDY

Inventory optimization decisions are based on the accuracy of the information, and the reliability of the key variables identification. The present study is focused in identifying the factors influencing the optimization decisions in inventory management. The classification of items as internal and external and measuring the sensitivity of it is tested in the second level of analysis. The primary level of analysis is done by using descriptive and inferential statistics and specially by grouping the items influencing inventory optimization decisions among SMEs in auto sector. Auto sector is a complex and long product line division in the manufacturing sector in the sample area. The survey technique is used to collect the data on the reliability of the factors identified as the influencing items in the optimization of inventory decisions in auto sector. The factors are rerotated and tested under two categories namely internal factors and external factors. Internal factors are more related and based on the organization structure. External factors are more related to external environment conditions.

3.4 OBJECTIVES OF THE STUDY

The present study was undertaken with the following objectives.

1. To study the inventory management and optimization decisions practices followed among SMEs in auto sector.

2. To find out the factors influencing inventory optimization decisions among the SMEs in auto sector.
3. To analyze the role of internal factors sensitivity on the optimization under different organization structures using AHP Technique.

4. To explore the sensitivity of external factors in inventory optimization decisions using FCM technique.

5. To provide suggestions to improve the inventory optimization discuss with suitable parameters.

3.5 HYPOTHESES USED FOR THE STUDY

The following Null Hypotheses (H₀) have been formulated and tested to find out the relationship between the demographics, dimensions of inventory optimization among SMEs in auto sector.

1. There is no significant relationship between the year of establishment and factors influencing inventory cost among the SMEs in auto sector.

2. There is no significant relationship between the year of establishment and techniques used to control the inventory cost among the SMEs in auto sector.

3. There is no significant relationship between the year of establishment and decision parameters used in optimization of inventory decisions among the SMEs in auto sector.

4. There is no significant relationship between the year of establishment and constraints in inventory optimization decision among the SMEs in auto sector.

5. There is no significant relationship between the year of establishment and suggestions to optimize inventory decisions among the SMEs in auto sector.
6. There is no significant relationship between the annual turnover and factors influencing inventory cost among the SMEs in auto sector.

7. There is no significant relationship between the annual turnover and techniques used to control the inventory cost among the SMEs in auto sector.

8. There is no significant relationship between the annual turnover and decision parameters used in optimization of inventory decisions among the SMEs in auto sector.

9. There is no significant relationship between the annual turnover and constraints in inventory optimization decision among the SMEs in auto sector.

10. There is no significant relationship between the annual turnover and suggestions to optimize inventory decisions among the SMEs in auto sector.

11. There is no significant relationship between the initial capital invested and factors influencing inventory cost among the SMEs in auto sector.

12. There is no significant relationship between the initial capital invested and techniques used to control the inventory cost among the SMEs in auto sector.

13. There is no significant relationship between the initial capital invested and decision parameters used in optimization of inventory decisions among the SMEs in auto sector.

14. There is no significant relationship between the initial capital invested and constraints in inventory optimization decision among the SMEs in auto sector.
15. There is no significant relationship between the initial capital invested and suggestions to optimize inventory decisions among the SMEs in auto sector.

16. There is no significant relationship between the sources of finance and factors influencing inventory cost among the SMEs in auto sector.

17. There is no significant relationship between the sources of finance and techniques used to control the inventory cost among the SMEs in auto sector.

18. There is no significant relationship between the sources of finance and decision parameters used in optimization of inventory decisions among the SMEs in auto sector.

19. There is no significant relationship between the sources of finance and constraints in inventory optimization decision among the SMEs in auto sector.

20. There is no significant relationship between the sources of finance and suggestions to optimize inventory decisions among the SMEs in auto sector.

21. There is no significant relationship between the mode of entry in to business and factors influencing inventory cost among the SMEs in auto sector.

22. There is no significant relationship between the mode of entry in to business and techniques used to control the inventory cost among the SMEs in auto sector.

23. There is no significant relationship between the mode of entry in to business and decision parameters used in optimization of inventory decisions among the SMEs in auto sector.
24. There is no significant relationship between the mode of entry in to business and constraints in inventory optimization decision among the Small and medium Enterprises (SMEs) in auto sector.

25. There is no significant relationship between the mode of entry in to business and suggestions to optimize inventory decisions among the SMEs in auto sector.

26. There is no significant difference between the mean scores of the factors influencing inventory cost among the SMEs in auto sector.

27. There is no significant difference between the mean scores of the techniques used to control the inventory cost among the SMEs in auto sector.

28. There is no significant difference between the mean scores of the decision parameters used in optimization of inventory decisions among the SMEs in auto sector.

29. There is no significant difference between the mean scores of the constraints in inventory optimization decision among the SMEs in auto sector.

30. There is no significant difference between the mean scores of the suggestions to optimize inventory decisions among the Small and medium Enterprises (SMEs) in auto sector.

3.6 VARIABLES IDENTIFIED

- S1: Availability of funds
- S2: Usage level
- S3: Procurement and carrying cost
- S4: Credit period
- S5: Availability of material
• S6: - Storage facilities
• S7: - Lead time
• S8: - Type of packing and bundling
• S9: - Transport cost
• S10: - Easy to shipment
• S11: - Availability of substitutes/alternatives
• S12: - Government restrictions and taxes.

3.7 SAMPLING DESIGN

The study is mainly based on primary data which was collected from the 394 SMEs in the auto sector selected through multi stage random sampling technique. The sample units are selected covering all types of auto component manufacturing units in the sample area. The sample area is starting from Ennore to ending with Cheyyar in Thiruvallur district to Kancheepuram district respectively. The approximate radius of the sample area is 60 sq km. In addition, the city consists of four major industrial estates where industrial engineering and auto component related parts were manufacturing is also considered in the study. In order to improve the validity of the questionnaire the equal sample representation is taken from the sample area covering all the products in the auto sector. The products ranging from metal tubes, slates, electrical items, electronics, volve systems, plastics and polymers, rubber and leather, cables, glass and decorative, paints and chemicals, cleaning and sifting materials, industrial gases and fuels etc. Each of these divisions targeted with 50 units. The total targeted sample is 500 (10 Divisions with 50 each). On scrutiny of the questionnaires, it is found that, 65 questionnaires are insufficient with data provided and rejected. On mater data sheet preparation, a set of errors are found in the questionnaire like answering all the aspects of the question by giving own explanations. Such questionnaires come around 41. The total number of sample respondents not responded and returned the structured questionnaire given to them accounts to 74 in number. Finally the number of questionnaires taken for analysis is 320.
3.8 SAMPLE PERIOD

The survey was conducted during the year 2011 and the first quarter of the year 2012. The observations made on the inventory management environment for a span of four years i.e., 2008 to 2012. It has helped the researcher to understand the inventory environment and to draw appropriate findings and suggestions. The researcher feels that, auto component manufacturing industry is one among the dynamic sectors in terms of growth and upgrading of technical climate, investment opportunities and investment motives, inventory behavior from time to time in the sample area and in the context of auto sector reforms progress in the state of Tamilnadu.

3.9 PROFILE OF THE AUTO COMPONENT MANUFACTURING INDUSTRY

The Indian Automobile Industry manufactures over 11 million vehicles and exports about 1.5 million each year. The dominant products of the industry are two-wheelers with a market share of over 75 percent and passenger cars with a market share of about 16%. Commercial vehicles and three-wheelers share about 9% of the market between them. About 91% of the vehicles sold are used by households and only about 9 percent for commercial purposes. The industry has a turnover of more than USD $35 billion and provides direct and indirect employment to over 13 million people. The supply chain is similar to the supply chain of the automotive industry in Europe and America.

Interestingly, the level of trade exports in this sector in India has been medium and imports have been low. However, this is rapidly changing and both exports and imports are increasing. The demand determinants of the industry are factors like affordability, product innovation, infrastructure and price of fuel. Also, the basis of competition in the sector is high and increasing, and its life cycle stage is growth. With a rapidly growing middle class, all the advantages of this sector in India are yet to be leveraged. With a high cost of developing production facilities, limited accessibility to new technology, and increasing competition, the barriers to
enter the Indian Automotive sector are high. On the other hand, India has a well-
developed tax structure. The power to levy taxes and duties is distributed among the three tiers of Government. The cost structure of the industry is fairly traditional, but the profitability of motor vehicle manufacturers has been rising over the past five years. Major players, like Tata Motors and Maruti Suzuki have material cost of about 80% but are recording profits after tax of about 6% to 11%.

The level of technology change in the Motor vehicle Industry has been high but, the rate of change in technology has been medium. Investment in the technology by the producers has been high. System-suppliers of integrated components and sub-systems have become the order of the day. However, further investment in new technologies will help the industry be more competitive. Over the past few years, the industry has been volatile. Currently, India's increasing per capita disposable income which is expected to rise by 106% by 2015 and growth in exports is playing a major role in the rise and competitiveness of the industry. Tata Motors is leading the commercial vehicle segment with a market share of about 64%. Maruti Suzuki is leading the passenger vehicle segment with a market share of 46%. Hyundai Motor India Limited and Mahindra and Mahindra are focusing expanding their footprint in the overseas market. Hero MotoCorp is occupying over 41% and sharing 26% of the two-wheeler market in India with Bajaj Auto. Bajaj Auto in itself is occupying about 58% of the three-wheeler market.

Consumers are very important of the survival of the Motor Vehicle manufacturing industry. In 2008-09, customer sentiment dropped, which burn on the augmentation in demand of cars. Steel is the major input used by manufacturers and the rise in price of steel is putting a cost pressure on manufacturers and cost is getting transferred to the end consumer. The price of oil and petrol affect the driving habits of consumers and the type of car they buy.

The key to success in the industry is to improve labor productivity, labor flexibility, and capital efficiency. Having quality manpower, infrastructure improvements, and raw material availability also play a major role. Access to latest and most efficient technology and techniques will bring competitive advantage to
the major players. Utilizing manufacturing plants to optimum level and understanding implications from the government policies are the essentials in the Automotive Industry of India. Both, Industry and Indian Government are obligated to intervene the Indian Automotive industry. The Indian government should facilitate infrastructure creation, create favorable and predictable business environment, attract investment and promote research and development. The role of Industry will primarily be in designing and manufacturing products of world-class quality establishing cost competitiveness and improving productivity in labor and in capital. With a combined effort, the Indian Automotive industry will emerge as the destination of choice in the world for design and manufacturing of automobiles. The Indian market offers endless possibilities for investors.

The supply chain of automotive industry in India is very similar to the supply chain of the automotive industry in Europe and America. The order of the industry arises from the bottom of the supply chain i.e., from the consumers and goes through the automakers and climbs up until the third tier suppliers. However, the products, as channeled in every traditional automotive industry, flow from the top of the supply chain to reach the consumers. Automakers in India are the key to the supply chain and are responsible for the products and innovation in the industry. The description and the role of each of the contributors to the supply chain are discussed below.

**Third Tier Suppliers:** These companies provide basic products like rubber, glass, steel, plastic and aluminum to the second tier suppliers.

**Second Tier Suppliers:** These companies design vehicle systems or bodies for First Tier Suppliers and OEMs. They work on designs provided by the first tier suppliers or OEMs. They also provide engineering resources for detailed designs. Some of their services may include welding, fabrication, shearing, bending etc.

**First Tier Suppliers:** These companies provide major systems directly to assemblers. These companies have global coverage to follow their customers to various locations around the world. They design and innovate to provide "black-
box" solutions for the requirements of their customers. Black-box solutions are solutions created by suppliers using their own technology to meet the performance and interface requirements set by assemblers. First tier suppliers are responsible not only for the assembly of parts into complete units like dashboard, brakes-axle-suspension, seats, or cockpit but also for the management of second-tier suppliers.

Automakers/Vehicle Manufacturers/Original Equipment Manufacturers (OEMs): After researching consumers' wants and needs, automakers begin designing models which are tailored to consumers' demands. The design process normally takes five years. These companies have manufacturing units where engines are manufactured and parts supplied by first tier suppliers and second tier suppliers are assembled. Automakers are the key to the supply chain of the automotive industry. Examples of these companies are Tata Motors, Maruti Suzuki, Toyota, and Honda. Innovation, design capability and branding are the main focus of these companies.

Dealers: Once the vehicles are ready they are shipped to the regional branch and from there, to the authorized dealers of the companies. The dealers then sell the vehicles to the end customers.

Parts and Accessory: These companies provide products like tires, windshields, and air bags etc. to automakers and dealers or directly to customers.

Service Providers: Some of the services to the customers include servicing of vehicles, repairing parts, or financing of vehicles. Many dealers provide these services but, customers can also choose to go to independent service providers.
The sample area is presented in the following Figure 3.1:

Figure 3.1 Area map of Auto Corridiar Tamilnadu, Chennai, Oragadam
3.10 SOURCES OF DATA

The present study uses both primary and secondary data. Primary data is collected from the auto component manufacturing units in the sample area through a structured questionnaire. In few cases to understand the depth of the issue and the sensitivity of the variables in the study, the scholar personally met experts in the industry having professional experience and had a personal interview using both structured and unstructured interview schedule. This helps in understanding the issue at broad prospective and to analyse the same in the research point of view. The secondary data is collected from both print and electronic media. The print media includes, reports, magazines, journals, published research papers, thesis works, unpublished industry reports, news paper reports and the other text books. The electronic media sources includes digital data bases, web portals, indexed journals in open access portals, industry association reports etc.

3.11 STRUCTURE OF THE QUESTIONNAIRE

The Primary data required for the research were collected by conducting a survey among the sample. For conducting a survey, a structured questionnaire was prepared. The questionnaire consists of four parts.

Part A deals with profile of the SMEs in auto sector on various demographical attributes and investment related variables.

Part B deals with factors influencing inventory optimization decisions among the SMEs in auto sector using five point Likerts scale.

Part C deals with measuring the internal factors affecting inventory optimization decisions among SMEs in auto sector using five point Likerts scale.

Part D deals with measuring the external factors affecting inventory optimization decisions among SMEs in auto sector using five point Likerts scale.
Part E deals with level of approval on the suggestions to improve inventory optimization decisions among SMEs in auto sector using five point Likerts scale.

The questionnaire is ends with an open ended question asking the any other information likes to give by for the improvement of the identifying the key variables in the optimization of inventory decisions among SMEs in auto sector.

3.12 PILOT STUDY AND RELIABILITY TEST

Initially a pilot study was conducted with 100 SMEs from four sectors (25 from Metal base, 25 from polymer and plastic base, 25 from light engineering base and 25 from Volve systems and tube products in the sample area). The relevance of some questions was slightly modified for final version of questionnaire. The reliability coefficient of the questionnaire is computed using Corn Bach’s Alpha and the value is 0.87, which shows that the instrument is reliable.

Sample size Calculator:

At sample size is determined by using scientific method. Since the population size is not known, by using pilot study of the sample of 100 respondents, by allowing the Standard Error 5% level. The sample size was determined by using the following formula.

\[ N = \frac{(Z \times SD)^2}{E^2} \]

Where \( Z \) = Standard value corresponding to a confidence level of 95% = 1.96
\( S = \) Standard Deviation of pilot study of sample
\( E = \) error = 5% = 0.05

The sample size should be \( N = \frac{(1.96 \times 0.456)^2}{0.05^2} = 319.429 \)

Though the sample size is determined at 320, we have taken sufficient care in the elimination of unfilled, half filled and Double entry samples, samples with erratic data marketing is scrutinized and removed.
(Actual distribution sample is 500 and the exact the sample is taken for the analysis)
3.13 TOOLS AND TECHNIQUES USED FOR ANALYSIS

Frequency analysis: Percentage refers to a special kind of ratio. Percentages are used in making comparison of two or more series of data. Percentage are used to describe relationships. Percentage can also be used to compare the relative term, the distribution of two or more series of data.

**t-test:** A t-test is any statistical hypothesis test in which the test statistic has a Student's t distribution if the null hypothesis is true. It is applied when the population is assumed to be normally distributed but the sample sizes are small enough that the statistic on which inference is based is not normally distributed because it relies on an uncertain estimate of standard deviation rather than on a precisely known value.

Among the most frequently used t tests are:

- A test of whether the mean of a normally distributed population has a value specified in a null hypothesis.

- A test of the null hypothesis that the means of two normally distributed populations are equal. Given two data sets, each characterized by its mean, standard deviation and number of data points; We can use some kind of test to determine whether the means are distinct, provided that the underlying distributions can be assumed to be normal. All such tests are usually called Student's t tests, though strictly speaking that name should only be used if the variances of the two populations are also assumed to be equal; the form of the test used when this assumption is dropped is sometimes called Welch's t test. There are different versions of the t test depending on whether the two samples are

  - Unpaired, independent of each other (e.g., individuals randomly assigned into two groups, measured after an intervention and compared with the other group), or
- Paired, so that each member of one sample has a unique relationship with a particular member of the other sample (e.g., the same people measured before and after an intervention).

If the calculated p-value is below the threshold chosen for statistical significance (usually the 0.10, the 0.05, or 0.01 level), then the null hypothesis which usually states that the two groups do not differ is rejected in favor of an alternative hypothesis, which typically states that the groups do differ.

- A test of whether the slope of a regression line differs significantly from 0.

Once a $t$ value is determined, a p-value can be found using a table of values from Student's t-distribution.

**Analysis of variance (ANOVA):** Analysis of variance (ANOVA) is a collection of statistical models, and their associated procedures, in which the observed variance is partitioned into components due to different explanatory variables. The initial techniques of the analysis of variance were developed by the statistician and geneticist R. A. Fisher in the 1920s and 1930s, and are sometimes known as Fisher's ANOVA or Fisher's analysis of variance, due to the use of Fisher's F-distribution as part of the test of statistical significance. Partitioning of the sum of squares: The fundamental technique is a partitioning of the total sum of squares into components related to the effects used in the model. For example, we show the model for a simplified ANOVA with one type of treatment at different levels.

$$SS_{Total} = SS_{Error} + SS_{Treatments}$$

The number of degrees of freedom (abbreviated $df$) can be partitioned in a similar way and specifies the chi-square distribution which describes the associated sums of squares.

$$df_{Total} = df_{Error} + df_{Treatments}$$
The F-test: The F-test is used for comparisons of the components of the total deviation. For example, in one-way, or single-factor ANOVA, statistical significance is tested for by comparing the F test statistic

\[
F = \frac{\text{variance of the group means}}{\text{mean of the within group variances}}
\]

\[
F^* = \frac{\text{MSTR}}{\text{MSE}}
\]

\[
\text{MSTR} = \frac{\text{SSTR}}{I-1}
\]

where \( I = \) number of treatments

and

\[
\text{MSTR} = \frac{\text{SSE}}{n_T - I}
\]

\( n_T = \) total number of cases

To the F-distribution with \( I-1, n_T \) degrees of freedom. Using the F-distribution is a natural candidate because the test statistic is the quotient of two mean sums of squares which have a chi-square distribution.

Method

Rank all data from all groups together; i.e., rank the data from 1 to N ignoring group membership. Assign any tied values the average of the ranks they would have received had they not been tied.

The test statistic is given by:
\[ K = (N - 1) \frac{\sum_{i=1}^{g} n_i (\bar{r}_i - \bar{r})^2}{\sum_{i=1}^{g} \sum_{j=1}^{n_i} (r_{ij} - \bar{r})^2} \]

where

- \( n_i \) is the number of observations in group \( i \)
- \( r_{ij} \) is the rank (among all observations) of observation \( j \) from group \( i \)
- \( N \) is the total number of observations across all groups

\[ \bar{r}_i = \frac{\sum_{j=1}^{n_i} 1 \ r_{ij}}{n_i}, \quad \bar{r} = (N + 1) / 2 \] is the average of all the \( r_{ij} \).

Notice that the denominator of the expression for \( K \) is exactly \( (N - 1) \ N(N + 1) / 12 \).

A correction for ties can be made by dividing \( K \) by \( 1 - \frac{\sum_{i=1}^{G} (t_i^3 - t_i)}{N^3 - N} \),

where \( G \) is the number of groupings of different tied ranks, and \( t_i \) is the number of tied values within group \( i \) that are tied at a particular value. This correction usually makes little difference in the value of \( K \) unless there are a large number of ties.

Finally, the p-value is approximated by \( \Pr (X_{g-1}^2 \geq K) \). If some \( n_i \)'s are small (i.e., less than 5) the probability distribution of \( K \) can be quite different from this chi-square distribution. If a table of the chi-square probability distribution is available, the critical value of chi-square, \( X_{a_{g-1}}^2 \), can be found by entering the table at \( g - 1 \) degrees of freedom and looking under the desired significance or alpha level. The null hypothesis of equal population medians would then be rejected if \( K \geq X_{a_{g-1}}^2 \). Appropriate multiple comparisons would then be performed on the group medians.
Chi-square analysis: Chi-squared test is used as a statistical tool in this project. Also it invokes no assumption about the form of original distribution from which the observations are made. In this method we test if two attributes considered are dependent or not. Chi – Square is an importance non – parametric test and as such no test is necessary in respect of the type of population. We require only the degree of freedom (implicit of course the size of the sample) for using this test. As a non – parametric test, Chi – square can be used (i) as a test of goodness of fit and (ii) as a test of independence.

$\chi^2$ test enables us to explain whether or not two attributes are associated. In order that we may apply the chi – square test either as a test to judge the significance of association between attributes, it is necessary that the observed as well as theoretical or expected frequencies must be grouped in the same way and theoretical distribution must be adjusted to give the same total frequency as we find in case of observed distribution.

$$\chi^2 = \sum \left( \frac{(O - E)^2}{E} \right)$$

Multiple Linear Regressions: In statistics, linear regression is a form of regression analysis in which the relationship between one or more independent variables and another variable, called dependent variable, is modeled by a least squares function, called linear regression equation. This function is a linear combination of one or more model parameters, called regression coefficients. A linear regression equation with one independent variable represents a straight line. The results are subject to statistical analysis.

The theoretical multiple linear regression model assumes a possibly imperfect relationship between Y, the regress and, regressions $X_1$, ..., $X_m$. A disturbance term $\varepsilon$, which is a random variable too, is added to this assumed relationship to capture the influence of everything else on Y other than $X_1$, ..., $X_m$. Hence, the multiple linear regression model takes the following form:

$$Y = \beta_0 + \beta_1X_1 + \beta_2X_2 + ... + \beta_mX_m + \varepsilon$$
Note that the regressions are also called independent variables, exogenous variables, covariates, input variables or predictor variables. Models which do not conform to this specification may be treated by nonlinear regression. A linear regression model need not be a linear function of the independent variable: linear in this context means that the conditional mean of Y is linear in the parameters β. For example, the model $Y = \beta_1 X + \beta_2 X^2 + \epsilon$ is linear in the parameters $\beta_1$ and $\beta_2$, but it is not linear in X, a nonlinear function of X.

**Mathematical Modeling**

Mathematical modeling is only resource in critical situation.

Modeling: The use of mathematics as a tool to explain and make predictions of natural phenomena “Mathematics consists of the study and development of methods for prediction

- **Why are models useful:**
  - Mathematics = concise language that encourages clarity of communication
  - Can safely test hypotheses like drug treatment), and confirm or reject without actual completion and also economical
  - Can predict system performance under untested or untested conditions

- **How models can be limited (trade-offs):**
  - Easy math, Unrealistic model
  - Realistic model, Too many parameters
  - Caution: unrealistic conclusions possible

**Model validation**

When a data-compatible model is constructed and the model values are determined, the behaviour of the system under different conditions can be predicted and compared to further measurements with the aid of the model.
Mat lab Applications

MATLAB is a high-performance language for technical computing. It integrates computation, visualization, and programming in an easy-to-use environment where problems and solutions are expressed in familiar mathematical notation. Typical uses include:

- Math and computation
- Algorithm development
- Modeling, simulation, and prototyping
- Data analysis, exploration, and visualization
- Scientific and engineering graphics
- Application development, including Graphical User Interface building

Using MATLAB, you can analyze data, develop algorithms, and create models and applications. The language, tools, and built-in math functions enable you to explore multiple approaches and reach a solution faster than with spreadsheets. MATLAB is an interactive system whose basic data element is an array that does not require dimensioning. This allows you to solve many technical computing problems, especially those with matrix and vector formulations, in a fraction of the time. MATLAB has evolved over a period of years with input from many users. In university environments, it is the standard instructional tool for introductory and advanced courses in mathematics, engineering, and science. In industry, MATLAB is the tool of choice for high-productivity research, development, and analysis.

This is a high-level matrix/array language with control flow statements, functions, data structures, input/output, and object-oriented programming features. It allows both "programming in the small" to rapidly create quick and dirty throw-away programs, and "programming in the large" to create complete large and complex application programs. This is the set of tools and facilities that you work with as the MATLAB user or programmer. It includes facilities for managing the
variables in your workspace and importing and exporting data. It also includes tools for developing, managing, debugging, and profiling M-files, MATLAB's applications.

The MATLAB mathematical function library. This is a vast collection of computational algorithms ranging from elementary functions like sum, sine, cosine, and complex arithmetic, to more sophisticated functions like matrix inverse, matrix eigenvalues, Bessel functions, and fast Fourier transforms.

**Overview of SPSS**

SPSS stands for Statistical Package for the Social Sciences. It is general statistical software tailored to the needs of social scientists and the general public. Compared to other software, it is more intuitive and easier to learn; the trade-off is less flexibility and fewer options in advanced statistics than some other statistical software like S-Plus. SPSS is good for organizing and analyzing data. Theoretically, there is no limit to the size of data files, so you can work on large data files in SPSS when you cannot do so in Excel. This version also allows easy input/output management, such as exchanging files with other software, changing the appearance of output, or cutting and pasting into different programs. For example, SPSS now allows the input of Excel data files. The best way to learn how to use SPSS is to work with it. Even if you don’t have particular data of interest, SPSS provides a wide variety of data that you can play around with. SPSS is one of the three most influential statistics software tools internationally. With SPSS, various kinds of statistics and analysis are available, such as descriptive statistics, mean comparison, the general linear model, correlation analysis, regression analysis, log-linear models, cluster analysis, data reduction, survival analysis, time series analysis and multiple responses, all of which can be used to draw charts directly.

**Overall significance:** SPSS will offer variety of statistical tests. Usually, though, overall significance is tested using what SPSS calls the Model Chi-square, which is derived from the likelihood of observing the actual data under the assumption that the model that has been fitted is accurate. It is convenient to use -2 times the log
(base e) of this likelihood; we call this -2LL. The difference between -2LL for the best-fitting model and -2LL for the null hypothesis model (in which all the b values are set to zero) is distributed like chi-squared, with degrees of freedom equal to the number of predictors; this difference is the Model chi-square that SPSS refers to. Very conveniently, the difference between -2LL values for models with successive terms added also has a chi-squared distribution, so when we use a stepwise procedure, we can use chi-squared tests to find out if adding one or more extra predictors significantly improves the fit of our model.

**AHP Model**

**AHP Process (Analytic Hierarchy process):** The weights assigned to the various factors namely Process Control, Cost benefits, Time saving, Material consumption, and customer satisfaction are normalized using the Met labs package and the ranks were obtained. The weights are assigned on the basis of supply chain observation and the factors influencing the optimization in supply chains. The same criteria are followed in all the methods. The assigned weights are changed in accordance with the changes in the observation and level of influence of variables in each of the models. To process the variables weights through Analytical hierarchy process (AHP), Met Labs package is used. Based on the rankings obtained through eh model, key element is identified to make the supply chain more effective and optimized.

**FCM Model (Fuzzy Cognitive mapping)**

Cognitive map (CM) models were introduced by Axelrod in the late 1970’s and were widely used for analyzing the sociological problems and decision making in sociological problems. The introduction of fuzzy logic give new representing capabilities to CM’s and led to development of fuzzy cognitive maps (Fcm) by Kosoko in the late 1980’s.

FCM create models as collections of concepts and the various causal relations that exist between these concepts. The model is examined by both statically using graph theory concepts and dynamically through simulations. The reliability of
an FCM model depends on whether its construction method follows rules that ensure its reliability. Since the model is created by the personal opinions and points of view of the experts on the specific topic, the reliability of the model is heavily depended on the level of expertise of the domain experts.

3.14 FRAMEWORK OF ANALYSIS

The analysis of the present study is made in two parts with a primary objective to identify the key variables determine the inventory optimization among SMEs in auto sector. Part-I deals with analyzing the profile of the SMEs in the sample area and to identify the key variables of inventory optimization using survey results and applying the statistical tools. The factors grouped are titled as internal factors and external factors. In part-II, the validity of the internal factors is tested with the organization structure and reliability using AHP model. The external variables sensitivity is tested by using FCM technique. The ranking of variables indicates the sensitivity of the factor. Hence, the two level process of analysis improves the reliability of the factors and helps in optimizing the inventory by way of focusing on key variables.

3.15 LIMITATIONS OF THE STUDY

All the Inventory Control Methods have their limitation in terms of the usage and applicability. The VED analysis is most commonly used in spare parts management and not so popularly used in general inventory management. FSN analysis fails when used in manufacturing environment where raw materials may be issued for production and eventually the produced items may remain in inventory giving a wrong picture of consumption. SDE analysis mostly depends on how the vendors are managed. Strategic purchasing plays a vital role and inaccurate information can distort the analysis. HML analysis cannot be used unless they really have a major impact on the total inventory, in the sense that some high value items may have very low transactions and in most cases are found in MTO and PTO situations. XYZ analysis is done on inventory in the stores which can vary dramatically every month for which the analysis is done. Various external factors
like lost/delayed sales orders and supplies can influence the analysis. The most effectively used analysis in the industry today is ABC analysis and they have the following limitations

1. Highly critical parts low in consumption value may be over looked
2. Periodic updating and review becomes critical
3. Cannot precisely consider all problems of Inventory control like thousands of low value items

Money-based measures of inventory are not always best suited for operations. Also considering only costs and compromising on other factors like service levels, efficiencies etc can impact business. Of course at the micro level customers demand at item level must be planned and controlled to match supply and demand. The days of supply and quantities on hand may become unambiguous and does not reveal if this inventory is appropriate. Aggregate dollars and a historical view aren’t very useful to operations, which needs to match supply and demand of specific items in future.

Various MRP tools and techniques address both of these shortcomings by coordinating the quantities and timing of the deliveries from know to projected requirements. With realistic lead times and realistic forecasts, the resulting inventories would be optimal for the circumstances. Lack of realism in these areas, however, undermined the operation of MRP systems, yielding less-than-desired service and more-than-desired inventory. Generally, Lean Systems mean Smaller Days of Supply and more productive use of inventory. Such lean systems come with their own risks. Very lean systems can crash easily. A small disruption at the suppliers end especially in Lean systems can bring the assembly operations to a grinding halt if sufficient buffers are not maintained. These are commonly seen in auto industries.

1. The present study is conducted only in the state of Tamilnadu covering three districts, namely Thiruvallur and kanceepuram and chengalpat.
2. The sample size is restricted to only 320.
3. Approaching SMEs and collecting data involves, time and cost for the selected sample is yet another limitation.

4. The statistical tests applied for the analysis is mere appropriate. The accuracy of the results is taken care of through the larger sample size.

5. The suggestions drawn by considering the micro and macro environment of business and society prevailing in the sample area.

3.16 SCOPE FOR FURTHER RESEARCH

The present study covers three districts in the state of Tamilnadu. In future a comparative study can be made between any two states in the country. Specific variables are driven the inventory optimization of various types of products by nature. Micro studies may give depth of the issue and its sensitivity in a much more clear manner. SMEs situated in SEZs, MEPZs and Industrial estates and independent private estates are differing in size of the business and the type of issues faced. This dimension can give further clarity on the issue.

3.17 CHAPTERISATION

The total study is divided into five chapters.

The total study is divided into five chapters. The first chapter titled as Introduction, which starts with background to the study, followed by dimensions of inventory management, inventory costs, inventory control, factors influencing inventory decisions among SMEs, strategies to resolve inventory decisions in inventory, optimization of inventory in SMEs, need for optimization, implications in inventory control, inventory management models, inventory importance in SMEs and its success factors etc is explained in a simple manner. The chapter is concluded with chapter summary.

The second chapter titled as Review of Literature, covers the various studies related to inventory management in manufacturing industries, inventory optimization, inventory control, inventory management technologies, inventory costs and control mechanisms, inventory handling strategies in SMEs, inventory management through IT solutions, Modern management techniques used in
inventory costs and control, inventory management models etc. Finally the chapter is concluded with Research gap identification and explaining the salient features of present research.

The Third chapter titled as Research Methodology deals with the statement of problem, need for the study, objectives of the study, sampling design, structure of the questionnaire, Pilot study and reliability of questionnaire, tools and techniques used for analysis, frame work of analysis, chapterization, scope for further research and limitations of the study.

The fourth chapter titled as Analysis of Factors Influencing Inventory Optimization Decisions includes introduction to analysis, descriptive statistics, inferential statistics and interpretation of results of the data analysis. Descriptive statistics deals with classification, tabulation and establishing relationship between demographic variables of the SMEs and the inventory optimization decisions and its implications. Inferential statistics deals with the testing of the relationship between the variables framed in the hypothesis and to draw a conclusion about the influence of demographical factors, on the factors influencing inventory optimization decisions. The last (i.e. Fifth) chapter titled as Summary of Findings, Suggestions and Conclusion presents the major findings drawn from the analysis, suggestions developed and drafted on the basis of findings and conclusion.

3.18 CHAPTER SUMMARY

The research methodology provides the path in analyzing the results and making interpretations in the light of set objectives. In this chapter, the researcher presented his plan of research and the organization of the contents. The logical sequence followed in this chapter helps in arranging the contents. The statement of the problem, objectives of the study, sampling profile, data sources, tools and techniques of data collection and analysis, frame work of analysis, and limitations of the study is presented in this chapter. The frame work drafted in the methodology is used in analyzing the data. The statistical results of the data along with the observations and inferences are presented in the following chapter.