<table>
<thead>
<tr>
<th>Section</th>
<th>Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>3.1</td>
<td>Introduction</td>
</tr>
<tr>
<td>3.2</td>
<td>Problem Statement</td>
</tr>
<tr>
<td>3.3</td>
<td>Scope of the Study</td>
</tr>
<tr>
<td>3.4</td>
<td>Research Objectives</td>
</tr>
<tr>
<td>3.5</td>
<td>Formulation of Research Hypotheses</td>
</tr>
<tr>
<td>3.5.1</td>
<td>Hypotheses based on some Issues Related to Green Supply Management Practice</td>
</tr>
<tr>
<td>3.5.2</td>
<td>Hypotheses pertaining to Similarities/Dissimilarities among Different Sectors and Varied group of Enterprises</td>
</tr>
<tr>
<td>3.5.3</td>
<td>Hypotheses based on Individual Factors</td>
</tr>
<tr>
<td>3.6</td>
<td>Development of Conceptual Model</td>
</tr>
<tr>
<td>3.7</td>
<td>Research Design</td>
</tr>
<tr>
<td>3.8</td>
<td>Questionnaire Development</td>
</tr>
<tr>
<td>3.8.1</td>
<td>Structure and Content Validity of the Questionnaire</td>
</tr>
<tr>
<td>3.9</td>
<td>Questionnaire Administration</td>
</tr>
<tr>
<td>3.9.1</td>
<td>Target Industrial Sectors and their Rationale of Selection</td>
</tr>
<tr>
<td>3.9.2</td>
<td>Pilot Study</td>
</tr>
<tr>
<td>3.9.3</td>
<td>Questionnaire Administration</td>
</tr>
<tr>
<td>3.10</td>
<td>Data Sources</td>
</tr>
<tr>
<td>3.11</td>
<td>Pattern of Analysis</td>
</tr>
<tr>
<td>3.12</td>
<td>Limitations of the Study</td>
</tr>
<tr>
<td>3.13</td>
<td>Chapter Summary</td>
</tr>
</tbody>
</table>
Chapter 3
Research Methodology

3.1 Introduction

This chapter details out the problem statement, scope of the study, research objectives, formulation of hypotheses, research design, questionnaire development and its administration. In addition, this chapter briefly describes the research strategy and pattern of analysis employed in this study. Finally, the limitations of the study are also discussed.

3.2 Problem Statement

Industrial activity is essential for a country’s socio-economic development. Manufacturing organizations use inputs (resources and energy), have throughput systems (manufacturing, logistics) and generate outputs (products and wastes). Therefore, they cause destruction to the natural environment in various forms of pollution and natural resource depletion.

As nation’s population and standard of living increases, businesses need to continually improve their environmental performance. This presents a new challenge to manufacturing enterprises. They are required to develop ways to balance industrial development and environmental protection. This calls for re-orienting business processes of the entire product value chain. They are called upon to address environmental concerns associated with resource use, waste and pollution.

Business organizations are answerable not only to law but to the future generations as well. There is, therefore, a need for a holistic approach to the business processes. This approach calls for integrating environmental concerns in the business operations. Environmental management is vital from ethical and moral standpoint. It makes good economic sense as well. The future of current business is dependent upon how well it conserves environment and natural resources.
The second half of the 20th century has witnessed unprecedented expansion in the Indian economy. Production of a broad range of consumer goods, has led to rapid increase in consumption of energy, materials and other natural resources. It has started posing grave challenges and threats to the natural environment. The conflict between economy and ecology is assuming dangerous proportion. There is a need to address the issue of fundamentally unsustainable patterns of production in the manufacturing sector. It is imperative that we address these issues. The present study is a step in this direction. It aims to understand range of issues that have a bearing on integrating environmental concerns in the key business processes among enterprises belonging to manufacturing sector in India.

3.3 Scope of the Study

This study aims to integrate environmental concerns in the key business processes of manufacturing sector in India. In this study, the following key business processes have been focused upon:

- Product development,
- Procurement/purchasing,
- Manufacturing,
- End-of-life management of product (Reverse logistics)
- Performance evaluation (from environmental perspective)
- Other miscellaneous/related management practices (like employee training, performance evaluation, goal setting etc.) that ensures environmental friendly enterprise.

These business processes are primarily part of the supply chain processes of a manufacturing enterprise. Supply chain, as we know, is the network of facilities and activities that performs the functions of product development, procurement of materials from vendors, movement of materials among facilities, manufacturing of products, distribution of finished goods to customers, after-sales support, and waste disposal (Marbert and Venkataramanan, 1998; Swaminathan and Tayur, 2003)

Adding the green component to supply-chain management calls for blending supply-chain management and natural environment (Srivastava, 2007). Therefore, it may be noted that green business practices have been used as an umbrella term,
which indicates an environmental friendly approach among business organizations in general, and manufacturing organizations, in particular (as this study is focused on this particular sector of the Indian economy).

To reiterate, for the purpose this study, key business processes would include major supply chain management processes mentioned above. As this study focuses on integrating environmental concerns in the key business processes of manufacturing sector in India, the primary focus would be to understand green supply chain management (GSCM) practices. Therefore, in this study 'integrating environmental concerns in key business processes' may be taken to mean GSCM practices. Also, the term green may be taken to imply environmental friendliness wherever used in conjunction with business processes and/or practices.

As regards specific coverage in terms of industrial sectors covered, it may be noted that the study primarily focused on three key industrial sectors, namely:

- Automobile including auto components
- Electrical and Electronics goods
- Chemical and Paint

The rationale of selection of these sectors specifically has been provided in Section 3.9.1.

3.4 Research Objectives

As noted above, manufacturing sector has been characterized by high consumption of natural resources. It is also a potent source of waste generation, ecosystem disruption, and depletion of natural resources. This study attempts to understand state of environmental consciousness in manufacturing sector in India. Based on that stock taking, it attempts to propose approaches that may facilitate integration of environmental concerns in the key business processes in manufacturing sector in India. Specifically the study aims:

- To assess the current state of environmental concerns in Indian manufacturing sector.
- To gain an insight into the current state of GSCM practices in targeted companies.
• To explore differences, if any, with regard to GSCM practices across varied industrial sectors and nature of industrial enterprise.
• To identify barriers and enablers impacting implementation of GSCM.
• To propose models by crystallizing relationships and driving power & dependence of the barriers and enablers.
• To ascertain validity of the conceptual model (presented in Figure 3.1) interlinking environmental concerns, barriers, enablers, GSCM practices and performance (environmental, competitive and economic).

3.5 Formulation of Research Hypotheses

For this study, three sets of hypotheses have been formulated. In total, there are twenty four hypotheses. The first set of hypotheses (hypothesis 1- hypothesis 8) relates to GSCM practices. This set of hypotheses focuses on establishing relationship among varied GSCM practices. The second set of hypotheses (hypothesis 9 - hypothesis 14) ascertain similarities/dissimilarities with regard to select GSCM practices across chosen industrial sectors as also varied type of enterprises like, OEM & suppliers, listed and non-listed companies and their scale of operation (SMEs and Large enterprises). The third set of hypotheses (hypothesis 15 - hypothesis 24) seeks to establish relationship between and among two factors that are expected to drive one another. These variables were identified through two brainstorming sessions with eight informed experts, two from academia and six from industries. These experts belonged to the selected industrial sectors covering OEM as well as supplier segment. These experts had more than ten years of experience in operations, supply chain and environmental management functions.

Green supply chain management practices help to enhance environmental performance, minimize waste and achieve cost savings and, consequently promote efficiency and synergy among business partners and their lead corporations, and this synergy is expected to enhance corporate image, marketing exposure, and competitive advantage (Lin, 2007). Review of the existing literature and discussions with experts have led to the formulation of following hypotheses:
3.5.1 Hypotheses based on some Issues Related to Green Supply Management Practices

**Hypothesis 1:** Green procurement practices in an organization are positively influenced by (i) green product development, (ii) adoption of reverse logistics practices, and (iii) customers’ demand for environmental performance improvement.

**Hypothesis 2:** Certification to ISO: 14001 Environmental Management System is positively influenced by (i) green procurement practices, (ii) customer’s demand for environmental performance improvement, and (iii) governmental subsidized program/tax incentive for green products/processes.

**Hypothesis 3:** Organizational environmental competitiveness is positively influenced by (i) eco-labeling of products, (ii) green product development, and (iii) availability of cleaner technology.

**Hypothesis 4:** Pollution prevention activities are positively influenced by (i) reverse logistics practices in supply chain, (ii) top management commitment, and (iii) economic benefits through carbon trading.

**Hypothesis 5:** Market demand for green products is negatively influenced by (i) lack of support and guidance from regulatory authorities, (ii) lack of eco-literacy amongst the supply chain partners, and (iii) inadequate adoption of reverse logistics practices.

**Hypothesis 6:** Proactive environmental policy (even beyond compliance to legislative requirements) is facilitated by (i) environmental accounting, (ii) balanced scorecard for environmental performance measurement, and (iii) environmental criteria in the performance review of employees.

**Hypothesis 7:** Continuous improvement in organization’s environmental performance is positively influenced by (i) assignment of roles and responsibilities with respect to environmental programs, (ii) setting of quantifiable environmental objectives, and (iii) benchmarking environmental performance.
Hypothesis 8: Risk reduction related to termination of business owing to environmental issues is positively influenced by (i) pollution prevention, (ii) reduced risk of litigation, and (iii) increased productivity.

3.5.2 Hypotheses pertaining to Similarities/Dissimilarities among Different Sectors and Varied group of Enterprises

Hypothesis 9(a): OEM and suppliers differ significantly in considering lean manufacturing practices as an enabler to the integration of environmental concerns in key business processes.

Hypothesis 9(b): Industrial sectors (i.e. automobile, electrical & electronics and chemical & paints) differ significantly in their perception of lean manufacturing practices as an enabler to integration of environmental concerns in key business processes.

Hypothesis 10 (a): There is no difference between listed and non-listed companies regarding their belief in certification to ISO: 14001 EMS as a facilitator for integrating environmental concerns in key business processes.

Hypothesis 10 (b): Industrial sectors (i.e. automobile, electrical & electronics and chemical & paints) differ significantly in their perception of certification to ISO: 14001 EMS as an enabler influencing integration of environmental concerns in key business processes.

Hypothesis 11(a): Large enterprises attach greater importance to educating their suppliers regarding techniques to improve their environmental performance than small scale and medium scale industries (SME).

Hypothesis 11(b): Significant differences exist among industrial sectors (i.e. automobile, electrical & electronics and chemical & paints) regarding importance they attach to educating suppliers in terms of techniques being deployed by them for improving environmental performance.
Hypothesis 12: Large enterprises pay greater attention to regular monitoring of environmental performance indicators than SMEs.

Hypothesis 13: Automobile and electrical & electronics sectors do not differ significantly in considering the design for energy efficiency approach while designing their products.

3.5.3 Hypotheses based on Individual Factors
Hypothesis 14: Lack of support and guidance from regulatory authorities leads to inadequate adoption of reverse logistics practices into supply chain processes.

Hypothesis 15: Inadequate adoption of reverse logistics practices is positively related to financial constraints.

Hypothesis 16: Financial constraints are positively related to inadequate strategic planning.

Hypothesis 17: Competitive advantage through green product/process development positively influences pollution prevention.

Hypothesis 18: Pollution prevention leads to reduced consumption of resources.

Hypothesis 19: Reduced consumption of resources leads to increased productivity.

Hypothesis 20: Increased productivity (an indicator of waste minimization) leads to improvement in return on investment (ROI).

Hypothesis 21: Top management commitment to integration of environmental concerns in business processes is positively related to eco-literacy amongst supply chain partners.

Hypothesis 22: Eco-literacy amongst supply chain partners leads to development of green products.

Hypothesis 23: Green product development leads to eco-labeling of products.
Hypothesis 24: Eco-labeling of products leads to corporate image through environmental responsibility.

3.6 Development of Conceptual Model

The conceptual model has been crystallized after a thorough review of literature. This review covered various aspects of the business operations. This review helped identify eleven latent constructs. These constructs are barriers, enablers, environmental concerns (pollution-related and others), greening of suppliers, total quality environmental management, greening of production, environmental performance (resource conservation and pollution prevention), competitiveness and economic performance. A conceptual model indicating the relationships among these variables is presented as Figure 3.1.

Figure 3.1: Conceptual Model

Source: Developed by Researcher after extensive literature review

3.7 Research Design

The research design used for this study has been presented in Figure 3.2. The shaded boxes suggest the design followed for the present research.
Conclusive Research: The research process is structured and formal, wherein the information needed is clearly defined. A large and representative sample is considered for quantitative data analysis. Generally the findings are used as input into decision making.

Descriptive Research: It has a structured research design normally conducted through surveys. It describes the relationship between independent and dependent variable.

Cross-Sectional Design: It involves the collection of information only once from any given sample of population.

Single Cross-Sectional Design: A cross-sectional design in which one sample of respondents is drawn from the target population and information is obtained once from this sample.

Source: Adapted from Malhotra (2007)

Various research techniques employed in this research are:

- Questionnaire-based survey: Questionnaire-based survey is an established approach to obtain respondents’ opinion on range of issues related to a research problem. In the present research this is used to gain an insight, in terms of breadth as well as depth, regarding environmental practices/ green business practices in Indian companies.
• **Interpretive Structural Modeling (ISM):** This methodology transforms unclear, poorly articulated mental models of systems into visible and well defined models. In this technique, a set of different directly and indirectly related elements are structured into a comprehensive model. In this study this methodology has been used for establishing driving power and dependence of barriers and enablers impacting adoption and implementation of green supply chain practices.

• **Structural Equation Modeling (SEM):** It is an analytical method that provides parameter estimates of direct and indirect links between observed and unobserved variables. This method estimates a series of separate but interdependent multiple regression equations simultaneously. It has a unique feature of being able to include variables that are not measured directly and thus called unobserved or latent constructs. This technique has been used to quantify relationship between dependent and independent variables related to: barriers, enablers, environmental concerns, some GSCM practices, environmental, competitiveness and economic performance.

### 3.8 Questionnaire Development

Environmental Management is relatively a new area of study in India. There is lack of enough research work in Indian context. This study attempts to address issues related to environmental concerns and GSCM. It is aimed at assessing the current status of green supply chain practices followed in the Indian industries. To that end, a questionnaire-based survey was conducted. The questionnaire was designed after reviewing the available literature and extensive discussions with six practicing managers of manufacturing industries and two academicians.

To increase the response rate and facilitate respondents, the questionnaire included close-ended questions. A five-point Likert-scale was used for that purpose. However, some of the questions had yes/no options as well. The questionnaire had three sections. Section I dealt with organization’s profile. Section II focused on issues related to environmental concerns, barriers, benefits and enablers of
integration of environmental concerns in key business processes. Section III assessed extent of implementation of specific green supply chain management practices among responding organizations.

3.8.1 Structure and Content Validity of the Questionnaire

The questionnaire was tested for content as also construct validity. The determination of content validity is subjective and judgmental. It indicates the accuracy with which a specified domain of content is sampled and that the instrument has items covering all aspects of the variables being measured (Nunally, 1978). Content validity primarily depends on an appeal to the propriety of content and the way it is presented (Nunally, 1978). The selection of measurement items in this questionnaire was based on exhaustive review of available literature and evaluation by practicing managers and academicians, thus ensuring the content validity of the questionnaire. The content validity was, further, tested during pilot survey as per the guidelines provided by Forza (2002). After a careful review of responses during the pilot survey, some questions were modified to convey their intended meaning. A few questions were deleted as well. The construct validity was tested through an exploratory factor analysis. Factor analysis was conducted to test the uni-dimensionality of the multi-items perceptual measures. As per the suggestions of Kim and Mueller (1978), only those items, which had a factor loading of more than 0.4 were retained in the questionnaire. Non-response bias and reliability tests were also conducted for the survey questionnaire, findings of which are reported in Chapter 4.

3.9 Questionnaire Administration

3.9.1 Target Industrial Sectors and their Rationale of Selection

Three sectors from the Indian manufacturing industry were selected for administration of the questionnaire. These were: (i) automobile, (ii) electrical & electronic goods, and (iii) chemical and paint.

Automobile sector is frequently regarded as a barometer measuring the current wealth of a nation's economy (Childerhouse et al., 2003). The automobile sector is
also considered to be high on resource use intensity, pollution intensity, size of industry, growth potential (and hence potential for the multiplier effect), and export potential (CII, 2001). The companies selected for the survey in this sector included both the auto manufactures and the auto component suppliers. India is one of the fastest growing markets of electrical equipment and consumer electronics, one that is far from saturation (Haldar, 2006). Today, Indian electronics industry is a major enabler for growth, progress, productivity and prosperity (Goel, 2006). This sector produces a wide variety of products in scope and scale with high rate of obsolescence. This leads to lot of waste in the form of valuable materials in them and also poses threat to environment of toxic materials and e-waste. Due to shortening of product life cycle, in this sector, the product recovery activities are becoming a necessity (Hillegerberg et al., 2001). The chemical & paint is traditionally perceived as one of key polluting industry.

These three manufacturing sectors have extensively divergent operations and GSCM practices. Together, these sectors encompass range of practices across the entire manufacturing industry. It is expected that inclusion of these broad industrial groups would provide us an overview of Indian Manufacturing sector on this account.

3.9.2 Pilot Study

Before administrating the questionnaire full scale, a pilot study was carried out among select companies. The pilot study aimed at:

- obtaining feedback of the executives working in the area of operations, supply chain and environmental management,
- carrying out necessary additions in the questionnaire to make it even more comprehensive,
- deleting those questions that may be of limited significance, and
- refining / rephrasing the existing questions to impart greater clarity.

A total of fifteen executives were personally approached to fill out the questionnaire. Accordingly, the questionnaire was modified and the final
3.9.3 Questionnaire Administration

A total of 550 questionnaires were mailed to different companies of the selected sectors throughout the country. These companies were carefully selected from the directories of public sector, private sector, and government companies, which also include OEM and suppliers in automobile, electrical & electronics goods, and chemical & paint industries. This survey was conducted during Oct 2007-March 2008. One questionnaire each was sent to the selected companies. Questionnaire, including a covering letter and a self-addressed stamped envelop, was mailed to chief executive officer/ managing director/ general manager/ operation manager/ EHS manager etc. Reminders were sent to all the non-respondents, three weeks after the dispatch of initial questionnaire. In addition, personal visits, phone calls and e-mails were also resorted to for eliciting responses. Out of the 550 questionnaires, 157 completed questionnaires were received. Eleven questionnaires were incomplete and were discarded. So, only 146 questionnaires were analyzed. This gives an overall response rate of 26.55%. A response rate of above 20% is considered desirable for survey findings (Yu and Cooper, 1983). Malhotra and Grover (1998) have also suggested a response rate of 20% for positive assessment of the surveys. The respondents profile and the results of the survey are discussed in the next chapter.

3.10 Data Sources

Primary as well as secondary data sources have been used for this study. The primary data for this study has been collected from the companies belonging to the select manufacturing sectors. The mode of data collection from primary sources has been explained in Section 3.9. For secondary data sources various studies specifically related to environmental conscious manufacturing and green supply chain management were scanned in various libraries. Major part of the data has been collected from the libraries of Indian Institute of Technology, Delhi and Indian Institute of Management, Bangalore. Various international journals
published by Emerald, Science Direct, Springer, Inderscience etc. that were available at these libraries, have been extremely useful to the researcher. A substantial part of the data was also sourced from Seminar Library of the Department of Business Administration, AMU, Aligarh, especially from issues of Harvard Business Review.

3.11 Pattern of Analysis
The study used the specifically developed research questionnaire (Appendix A1), as the basic research instrument to collect the data. The data was analyzed using MS-Excel 2002, SPSS (version 13.0) software and LISREL (version 8.5) Structural Equation Modeling software. The descriptive analysis of the data was undertaken using frequency distribution, mean, standard deviation, which are useful to identify differences among several data sets. Cronbach’s reliability test was carried out to test the reliability of the survey questionnaire. For testing the hypotheses, appropriate statistical tools like regression analysis, t-test, ANOVA, correlations test were used.

3.12 Limitations of the Study
- Participation and cooperation of respondents is serious problem in a survey based research. The same was observed in this study. Some respondents appeared reluctant to participate in the survey. They apprehended that that a study on a burning issue may expose the weaknesses of the organization in general and management in particular. This limitation caused a lower than the anticipated response rate from the targeted companies.

- The study assumed that the respondents were reflecting the state of the responding companies. However, their individual perceptions might have influenced their responses and their views may not represent the entire organizational reality. The responses to the questionnaire reflect only the opinions of responding individuals who have filled up the questionnaire and could have some element of bias.
Another significant limitation of the survey is the relative homogeneity of the respondent managers in the response sample. Majority of the respondents to the survey represented the top management in the organizations who held high ranking positions such as proprietors, chief executive officer, vice-president, general manager, plant manager, etc. These respondents could be in the best position to opine on the strategic aspects of green supply chain management practices. However, lower levels of managers are more involved in the operational aspects. Therefore, a good insight on operational issues related to GSCM could have been obtained from functional managers.

There was lack of empirical studies in this field, specifically in Indian context. This limitation also affected the research. Such previous studies could have made the foundation of this effort even more robust and strong.

The study focused upon the key business processes related to product development, procurement/purchasing, manufacturing, end-of-life management of products (reverse logistics), environmental performance evaluation and some miscellaneous management practices only. However, there are other business processes also that have a bearing on the environmental management in an enterprise. For examples, processes like planning and forecasting, inventory management, logistics, distribution of final products, after-sales support etc. too might impact the environmental performance of an enterprise. The inclusion of all of them would have made the study unwieldy. Therefore, only key business processes were focused upon. This, too, may be considered as a limitation of this study.

The study was restricted to three industrial sectors. Although these sectors represent a significant part of Indian manufacturing sector, still they may reflect only partial reality of the entire Indian manufacturing sector.

3.13 Chapter Summary
This chapter elucidated the problem statement, scope of the study, research objectives, research design and the steps involved in questionnaire development.
and administration. Research hypotheses framed were also listed. It also explained
the pattern of analysis and the various research techniques employed in the
research. Finally, the limitations of the study were highlighted. In the next chapter
we present the analysis of the survey findings.