CHAPTER 7
CONCLUSIONS

Today’s business environment is characterized by accelerated technological change, shortened product life cycle, and increasing globalization. Almost every function within organizations has been influenced by external and internal pressures to become environmentally sound. Issues such as green consumerism and green product development have impacted marketing. Finance, information systems and technology, human resources and training, engineering and research, and development are all organizational functions that have been influenced by these environmental pressures. The traditional reactive responses to these pressures are now being supplemented and replaced by more proactive, strategic, and competitive responses. Many businesses have begun to realize that there is some profitability in environmentally conscious business practices. As organizations adopt environmentally conscious manufacturing, they need new method of performance measurement to check the progress in all spheres of organization. The thesis work focused on the development and validation of performance measures for environmentally conscious manufacturing.

In chapter 2, some of the well-known traditional and non-traditional techniques of performance measures as well as some popular conceptual performance measurement frameworks have been reviewed. The review has revealed that traditional performance measurement systems are invalid for the measurement of environmentally conscious manufacturing practices as they are based on outdated traditional cost management systems, lagging metrics, not related to corporate strategy, inflexible, expensive and contradict continuous improvement. Without controlling and improving the strategic and operational measures like product characteristics, process characteristics, technology, human resources, etc., companies will not be able to meet the governmental, economical and societal pressure to reduce the impact of their processes and products on environment. The limited literature available on the performance measurement of ECM reveals that the ECM has not been measured and justified in term of financial and non-financial terms from the product life cycle perspective, i.e. considering ECM as a system.

In chapter 3, performance measures and their variables/items have been identified for environmentally conscious manufacturing. The methodology used for the development and validation of the performance measures for environmentally conscious manufacturing is also presented in this chapter. A set of eleven performance measures for environmentally conscious manufacturing is also presented in this chapter.
conscious manufacturing - Top Management Commitment, Middle Management Commitment, Employee Involvement, Employee Training, Human and Technological Resources, Product Design/Product Characteristics, Process Design/Process Characteristics, Logistics Design, Vendor Management, Costs, Benefits - has been identified from the review of literature and the discussions held with the practitioners. A summary of review of 78 research publications from environmentally conscious manufacturing is also presented for the purpose of theoretical justification (content validity) of the eleven performance measures. Using the previously mentioned 78 research papers, 93 representative variables/items defining the scope and meaning of the eleven performance measures for ECM were identified.

Chapter 4 describes the development of a survey instrument and its pre-testing along with the data collection methodology. Content validity is also demonstrated in the documentation of the steps followed in the development of survey instrument, its pre-testing and analysis. Chapter 5 discusses descriptive and importance index analyses of the collected data. The analysis of data from the survey has been divided in three parts, descriptive analysis, importance index analysis and statistical analysis. The descriptive data reflects the solicitation of 285 respondents. A large number of respondents belong to small scale enterprises (47%) and medium enterprises (24%). Approximately 3/4th of respondents are from Small and Medium Enterprises (SMEs). 19% of respondents are from large scale industry and another 10% from tiny/micro segment. It clearly reflects that the collected data is relevant to all type of organizations.

The responding organization by sector include a wide spectrum of sectors, which are challenges to the ECM, like textile (5%), chemical (6%), rubber/plastics (5%), cement (1%), fabrication (3%), machinery (10%), electrical & electronics (8%), automotive (13%), pharmaceutical (6%), steel/iron (14%), food (12%), and other (17%). A high proportion of respondents by designation belonged to the category of middle and upper management. Relative to the size of firm, number of employees and annual sales represent the size of firms; respondents represent all categories of organizations. Examination of the descriptive data reveals that the sample covers all type of organization in different sectors of Indian industry and targeted the key personnel of the organization.

Important index analysis of the data clearly reflects that the large enterprises give more importance to ECM than SMEs and which in turn give more importance than tiny/micro enterprises. All enterprises view most of the measurement items/variable either very
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important or important. Following can be concluded from the importance index analysis of the entire data:

- Lack of visible commitment of top management to ECM
- Lack of explicit environmental policy
- Lack of framework for employee participation and need of teams to tackle environmental issues
- Indian industry is giving higher importance to the technology than the human resources for ECM implementation
- Lack of internal environmental experts and separate environmental departments
- Lack of training in ECM issues
- Lack of use of remanufactured or used parts
- Lack of information sharing with vendors on environmental issues

Indian industry has given higher importance to low energy consumption, reduction in the use of packaging and disposal of packaging material, vendor involvement in environmental awareness/training/competency programmes, and all costs associated with waste (waste handling, waste categorization, waste treatment, waste disposal and waste storage). Indian industry has not yet thought of ECM implementation as a mean to improve profit, sales turnover or productivity but it still considers the improved working conditions, improved public image and improved staff morale as the top benefits of the ECM. A good indication is that the respondents perceive ECM implementation improves productivity and quality. Large enterprises have separate teams to tackle environmental issues but tiny/micro and SMEs lack this. Only tiny/micro enterprises are considering the use of remanufactured parts. Consideration of environmental issues during the selection of manufacturing processes is done only by large enterprises. SMEs and large enterprises are contemplating the reduction of packaging and proper disposal of packaging material. Micro enterprises may not be contemplating the reduction and disposal of packaging material but they are planning for recollection and use of recycled material for packaging. Tiny/micro enterprises views improvement in brand value, reduction in liabilities and improvement in productivity as top ECM benefits whereas SMEs and large enterprises perceive improved working conditions, improved public image and improved staff morale as the top three benefits of the ECM.

Chapter 6 discusses the reliability and validity analysis of the environmentally conscious manufacturing performance measures and finally proposes performance measures...
for environmentally conscious manufacturing. The results provide sure evidence that the performance measures are highly reliable. The reliability demonstrated with Cronbach’s alpha values, which not only exceeded the acceptable value of 0.7 but are excellent (greater than 0.9) for most of the performance measures. This becomes more important considering that the developed survey instrument is new and used for the first time. The variable of performance measures are also highly correlated among themselves as reflected by the high value of CIMTC (Pearson correlation coefficient). Barlett’s test of sphericity and KMO measures of sample adequacy also show that there exists high strength of relationships among items/variables of performance measures.

Construct validity is very high for all the eleven performance measures of ECM for the entire sample and tiny/micro enterprises. The high eigenvalues and factor loadings verify that the performance measures are uni-directional and independent for the entire sample and tiny/micro enterprises. High values of item loadings also show that all the remaining variable are useful for the measurement of performance measures. For SMEs, the number of performance measures extracted are 12 as there is a strong relationship among the costs associated with waste. The construct validity is found to be very high for all the performance measures for SMEs as reflected by high eigenvalues, item loadings, and factor loadings. Similarly 13 performance measures are found to be reliable and valid for the large enterprises. For large enterprises, the product design/product characteristics measure is sub-factorized into three independent measures of Product Design/Product Characteristics (material), Product Design/Product Characteristics (3R) and Product Design/Product Characteristics (lifecycle). Finally, this chapter presents the reliable and valid performance measures for environmentally conscious manufacturing.

Overall, the results are encouraging for the performance measures which are based on a newly developed theoretical framework. However, it is important to be cognizant of the potential weaknesses of the study as well, so that future efforts can improve upon the performance measures of ECM. The performance measures for SMEs and large enterprises could be further refined. The study has been done on diversified sectors but the sample size has to be more except for automotive, food and steel/iron industry where the sample size was acceptable for generalization. In addition, the instrument has been tested in Indian organizations and further analysis is required to determine its appropriateness for other countries. The measures were developed based upon the self-reported information from the respondents. The variables/items in questionnaire are subjective in nature. Respondents were
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asked to rate items based on their perception, as to extent to which the items are applicable in their respective organizations. Hence the lack of objective measures might have introduced certain amount of bias into the data collected.

The instrument used in the study assigned equal weightage to each factor. It may be a good idea to investigate whether assigning different weights to different factors would improve the quality of assessment of ECM practices as in the case of Malcolm Baldrige National Quality Awards framework for quality assessment. It is also recognized that the construct validation based on factor analysis has its limitation. The wordings of the respective items might have certain impact on the results of the factor analysis. Items worded in similar manner will tend to load together as a single factor.