SOME STUDIES ON GREEN LOGISTICS PRACTICES AND PERFORMANCE ISSUES IN SELECT INDIAN MANUFACTURING INDUSTRY

By

DEEPTI CHHABRA

(Roll No. 2k13/Ph.D./ME/07)

Submitted to Delhi Technological University for Fulfilment of the Requirement for the Degree of

DOCTOR OF PHILOSOPHY
IN
MECHANICAL ENGINEERING

DEPARTMENT OF MECHANICAL ENGINEERING

DELHI TECHNOLOGICAL UNIVERSITY, DELHI

September 2021

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DECLARATION BY THE CANDIDATE

I declare that the thesis entitled "SOME STUDIES ON GREEN LOGISTICS PRACTICES AND PERFORMANCE ISSUES IN SELECT INDIAN MANUFACTURING INDUSTRY" submitted by me for the degree of Doctor of Philosophy is a bonafide record of work carried out by me under the guidance of my supervisors Prof. S.K. Garg and Prof. R.K. Singh, has not formed the basis for the award of any degree, diploma, associate-ship, fellowship, titles in this or any other University or other similar institution of higher learning.

(Deepti Chhabra)

Research Scholar

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DELHI TECHNOLOGICAL UNIVERSITY, DELHI

CERTIFICATE

This is to certify that the Ph.D. thesis entitled "Some Studies on Green Logistics Practices and Performance Issues in Select Indian Manufacturing Industry" being submitted by Ms. DEEPTI CHHABRA to Delhi Technological University, Delhi, India, for the award of the degree of Doctor of Philosophy in Mechanical Engineering, is a bonafide record of original research work carried out by him under our guidance and supervision. The work presented in this thesis has not been submitted to any other university or institution for the award of any degree or diploma.

Supervisor: **Supervisor:**

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Dedicated to my loving husband Ajay, my son Aarush, my daughter Arisha and my loving Parents

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Acknowledgment

"*Acknowledgement is possession. When you acknowledge, think, or have conviction in something, it actually will come true*".

-Stephen Richards

At the pinnacle of my dissertation, I am thankful to remember my family, professors, colleagues, relatives, and well-wishers, as this thesis would not have taken shape without their heartfelt support and live participation.

"*No one who achieves success does so without acknowledging the help of others. The wise and confident acknowledge this help with gratitude*".

-Alfred North Whitehead

First of all, I would like to take this opportunity to express my deep appreciation to my Supervisor Prof. S.K.Garg, Professor at the Department of Mechanical Engineering, Delhi Technological University, for his guidance. With a great sense of appreciation, I would like to thank him for his scholarly suggestions, his compassionate disposition, and his advice throughout the work. I enjoyed working in a research environment that inspired great thought and skillful guidance by him.

It is a great pleasure to express my deep appreciation and gratitude to my Supervisor Prof. R.K.Singh, Professor at the Department of Operations Management, Management Development Institute, Gurgaon. His determination and keen interest, above all his overwhelming attitude, his relentless support, and objective assessment, helped me to carry out my research work. His dedication and profound comprehension of the subject were a source of inspiration.

I wish to express my warm and sincere thanks to Prof. Yogesh Singh, ViceChancellor, Delhi Technological University, Delhi for providing me with the infrastructure and other necessary facilities to execute the present study in the University.

I wish to express my sincere thanks to the Dean (DRC), Prof. R.S. Mishra for his kind support and guidance during the entire academic and administrative work related to the thesis.

I also sincerely thank the former and current HOD of the Mechanical Department of DTU, Prof Vipin, and Prof. Shamsher for their great help and cooperation.

An authentic credit goes to the noble help provided by Prof. Abid Haleem for the periodic evaluation of my work and to his useful and inspiring recommendations, which have led me to believe in my research work.

I would like to give a special mention and admiration to Dr. Alok Chauhan and Dr. Ritu Chauhan for their keen interest, untiring encouragement, and constant moral support throughout my research work.

A very special and warm thanks to Mr. S.P.Singh (IAS) and the former Principal Secretary (Finance), Delhi Government who encouraged and appreciated me for my research topic and shared his thoughts on the Green Logistics.

With respect, I would like to thank Er. K.S. Chaudhary, DGM, IOCL for his continuous support and suggestions during the research survey whenever needed for my research work.

I deeply appreciate and express my gratitude to my colleague and researcher Dr. Harish Kumar, HOD (Mechanical Engineering) NIT, who motivated and encouraged me during my research work.

A very warm thanks to Dr. Sushila, Mr. Surya Prakash, and Mr. Devesh Trivedi, PG (Academics) for guiding me through the administrative procedures.

I want to thank my department HOD, my colleagues, and my friends especially Ms. Deepti Jaiswal, Dr. Veepsa, Ms. Greeshma, and Mr. Paramveer, at my workplace who always provided a positive environment and kept my morale high.

I would like to express my heartfelt thanks to my special and eternal friends, Ms. Ruchi, Mr. Ankit, Mr. Sumit, Ms. Shanu, Mr. Karan, to name a few for their cheerfulness and joyful spirit, which has always held my morale high.

"*In the Time of Test Family is the Best*"

I am and always be forever grateful to my parents, Mrs. Saroj Chhabra and Mr.T. D. Chhabra, for their boundless love and utmost affection. My parents have always stayed with me through all the bumps and challenges in the course of my research work. I can't imagine myself on this stage without their unceasing and fervent love. I am very thankful to my brother, Jatin Chhabra, who has always wanted the best for me.

My Late Mother-in-Law and Late Father-in-Law, Mrs. Rajwati, and Mr. Balwant Singh had always lighted me with the spiritual wings as they always prayed for my successful journey.

A sincere thanks to my sister-in-law, Dr. Hridesh Chaudhary, and my Jijaji, Mr. K.S.Chaudhary, for their moral support in my work. They strengthened and made it easier for me to cross the hurdles during the research.

This is a very special thank you to my lifelines, my children Aarush and Arisha for giving me endless pleasure and delight during my research work. My whole heart is filled with love to be blessed with my wonderful, sincere, and doting children. Being my best friends, as they always accompanied me with their books, and that made my journey so beautiful and inspiring. The unwavering confidence of my children in me through undeterred, unconquerable, and sedulous encouragement and love has helped me reach this milestone.

Some of the entities have been there forever when I needed someone by my side. Prof. Ajay Singholi (Dean-Academics) my dear husband, is a glorious example of such a personality. My entire research has been a medley of sunshine and rain, teardrops, and laughter, joy, and pain, and he has been a part of everything. Throughout my entire research work, he has always remained a critical stand by me. I can never forget the sleepless nights that he spent with me to accompany me while I was studying. His heartfelt words and his extreme confidence in me have always made me feel high.

Last but not least, I pay respect to the Almighty, the Supreme Soul, who has given life to every soul to function and become a good human being. I feel fortunate as Sai Baba has been showering his love to me throughout. His benevolence has made me outstanding and effective in my academic and personal endeavors.

Deepti Chhabra

Abstract

In today's era, environmental issues are critical concerns for all countries all over the world. Therefore, organizations need to deal with these issues as they are continuously under pressure to perform environmentally responsible activities. Logistics is one domain that leads to a negative effect on the environment. Due to globalization, logistics activities have increased enormously. On the global platform, the logistics market will reach a value of USD 6,300 billion by 2024, with a CAGR (compound annual growth rate) of 4.9% during 2019-2024. As a result, the manufacturing enterprises are incorporating new strategies and green policies in their businesses for a better environment and fewer carbon emissions. In developed countries, Green Logistics has become popular in recent times. Although in developing countries, it is still in a preliminary stage and needs more attention. It had been discussed that the developing countries are still lacking in promoting and implementing green practices in logistics. The current study focuses on Green Logistics drivers, barriers, practices, and performance parameters for the Indian manufacturing industry (especially in the Oil and Gas sector). The Oil and Gas industry is chosen for the research study as this is one of the prominent industry and produces very high carbon emissions. The downward vertical of this industry involves the major logistics activities like marketing, wholesaling, etc., and have never been focussed on green logistics. The four major logistics activities are chosen for the study namely green transportation, green warehousing, green packaging, and green value-added services. The Green Logistics Practices are governed by various drivers and barriers, which help in enabling the implementation and might also act as hindrances in the implementation of these practices. These drivers and barriers are the crucial factors thus need to be studied in detail. The application of green logistics practices will also have an impact on the performance both in terms of environmental as well as economic. The primary objective

of this study is to develop a conceptual framework of Green Logistics for the logistics activities involved in the Indian Manufacturing Industry (Oil and Gas) and its effect on Environmental and Economic Performance

The flow of this research goes as follows. Initially, there is a need to justify the Green Logistics over non-Green Logistics which has been done in the study using Analytical Hierarchy Process. In the study, it was justified that Green Logistics is better as compared to non-Green Logistics. Then, the identification and ranking of the crucial barriers have been done using as they are important to be evaluated as the ranking will enable the practitioners to be aware of the major hindrances in the implementation of Green Logistics Practices in the context of the Indian manufacturing industry. This was done using the DEMATEL technique. In the results, the non-interest of the top management came out to be the most important barrier in the implementation of these practices. The significant Green Logistics Drivers which might enhance the implementation of Green Logistics Practices have been studied extensively in the context of the Oil and Gas industry. This study is further extended by listing out the best possible Green Logistics practices and drivers that need to be considered by the industry. The research instrument used for the study is the survey questionnaire and the officials/managers who are working for the downward logistics of the Oil and Gas industry were chosen from. The drivers and practices have been ranked by descriptive analysis using SPSS 25.0. The ranking displayed the most important green logistics drivers are the Government policies as these would motivate the industry officials to implement the Green Logistics Practices. The most important logistics practices for Green Transportation is Standardization, for Green Warehousing is low carbon storage, for Green Packaging it is the use of ecological material, and for Green value-added Practices, it is Environmental reports. The information of the most important practices would enable the management and policymakers of the manufacturing industry to focus more on these areas to achieve better sustainability in the logistics activities. Instead of spending resources on the least important drivers and practices, the most important ones should be implemented. .Eventually, the impact of these Green Logistics Practices on the Economic and Environmental Performances has also been studied and analyzed using Structural equation modeling (SEM). In the study total of seven constructs have been analyzed namely GLTP, GLWP, GLPP, GLVP, EP, EcP, and GEP. The first four constructs represent the Green Logistics practices, the next two represent the Performance Parameters. The last construct is Government and environment policies which were chosen from the items of drivers and in the analysis act as a moderator. This is important to analyze the impact on both the performances as the industry sometimes feels that the green practices would have no economic benefits. The Exploratory Factor analysis. Confirmatory Factor Analysis and the Structure Equation Modelling for hypotheses testing were done during the study The twenty hypotheses have been framed during the study which included the moderation and mediation analysis. Environmental performance has been used as the mediator between Green Logistics Practices and Economic Performance. The analysis shows the effect on the Economic Performance via Environmental Performance for all the four logistics constructs. The next four hypotheses included mediation via Environmental Performance. The next set of eight hypotheses were carried out to find out the effect of practices on both the performances under the moderator impact. Out of all of the twenty hypotheses, only four hypotheses H7, H11, H18, and H19 were rejected, the rest all were significant. Such extensive research studies could help the select Indian manufacturing industry (Oil and Gas) in making strategic decisions about implementing Green Logistics Practices for achieving the environmental goals along with having an idea of the impact of these practices on the economic performances and thus to achieve long term sustainability. The study would motivate the top management to focus on green practices like Staff Training and Environmental reports for developing the habit of Green Logistics. This study is important for the Government while framing various policies and incentives for the Indian Manufacturing industry to promote the implementation of Green Logistics Practices. The findings of this study for different activities of Green Logistics may be linked to developing a long-term strategy for the manufacturing industry. Keeping the Indian Manufacturing Industry understudy, practicing managers, governmental agencies and academia and future researchers will be benefited from the research.

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List of Abbreviations

AHP	:	Analytical hierarchy process
AMOS	:	Analysis of a moment structures
AVE	:	Average variance extracted
CAGR	:	Compound Annual Growth Rate
CFA	:	Confirmatory factor analysis
CFI	:	Comparative fit index
CR	:	Composite reliability
DEMATEL	:	Decision making trial and evaluation laboratory
EcP	:	Economic Performance
EFA	:	Exploratory factor analysis
EP	:	Environmental Performance
GEP	:	Government and Environmental Policies
GFI	:	Goodness-of-fit Index
GHG	:	Green House Gas
GL	:	Green Logistics
GLP	:	Green Logistics Practices
GLPP	:	Green Logistics Packaging Practices
GLTP	:	Green Logistics Transportation Practices
GLVP	:	Green Logistics Value-added Practices
GLWP	:	Green Logistics Warehousing Practices
IFI	:	Incremental fit index
KMO	:	Kaiser-Meyer-Olkin (Test)
MSV	:	Maximum shared variance
MWTQ	:	Minimum Waiting Time in Queue
NGL	:	Non-Green Logistics

NP	:	Number of Pallets
PCA	:	Principal Component Analysis
PM	:	Particulate Matter
RMSEA	:	Root Mean Square Error of Approximation
SEM	:	Structural Equation Modelling
SPSS	:	Statistical Package for the Social Sciences
VTT	:	Value of Travel Time

Chapter- 1

Introduction

1.1 Introduction and Background

In today's era, environmental issues are of critical concern for all countries all over the world. Therefore, organizations need to deal with these issues as they are continuously under pressure to perform environmentally responsible activities. Obligation to the natural positive and friendly environment has become a significant and necessary variable. Logistics is one such domain that leads to a negative effect on the environment. Due to globalization, logistics activities have increased enormously. On the global platform, the logistics market will reach a value of USD 6,300 billion by 2024, with a CAGR (compound annual growth rate) of 4.9% during 2019-2024. However, until 2018, the international logistics market has reached USD 4,730 billion. (Group, 2019). As per the report of the IBEF Knowledge Centre, the logistics sector in India is also expanding with a high growth rate. One of the prominent domestic rating agencies of India mentioned that the logistics industry of India is currently estimated to be around USD 160 billion and it is estimated to have a growth rate of up to 10 percent in the future. The growth is a development over the CAGR of 7.8 percent at which the industry had grown during the last five years (IBEF, 2018).

Logistics system is normally claimed as the significant contributors to overall greenhouse gas(GHG) emission and consumption of energy in the entire world (Murphy and Poist, 2003; Kim and Han, 2011; Oberhofer and Dieplinger, 2014; He et al., 2017). In the US, out of the total GHG emissions, 28% of emissions are mainly from the transportation sector (USEPA, 2021). Due to a large amount of energy consumption during logistics activities, lots of toxic gases (carbon dioxide, sulfide, nitride, harmful dust, etc.) are emitted, and waste is produced, which is damaging the environment (Zhang and Li, 2014**).** India is in the third position as far as the carbon footprint shared by each country is considered as shown in figure 1.1 (Ucusa, 2020). In the context of India, the sources of CO_2 emissions are majorly due to fuel combustion, the energy sector, manufacturing industry, construction industry, logistics, and other sectors**.**

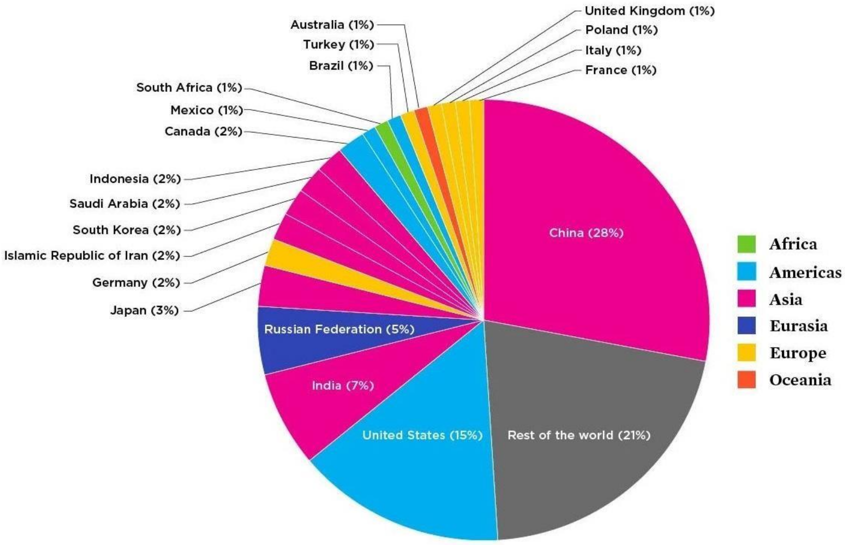

Figure 1.1 Carbon footprint data (Ucusa, 2020)

The Asian region is the most polluted area in the world, particularly in emerging Asian countries such as China, India, Bangladesh, and Pakistan, and its PM 2.5 (Particulate matter) has reached a very high level, which is not safe for living beings. In India, the air at some places has become toxic and hazardous for humans. News reports indicate that the level of PM 2.5 in the air sometimes goes beyond 300 at most places, which is causing many health problems.

The major contributors and causes of air pollution are the energy sector (42%), the manufacturing industry (19%), and the Logistics sector (23%) and rest by other sectors, as indicated by the IEA (International Energy Agency) (IEA, 2016) as shown in figure 1.2**.** Stakeholders are now increasing the pressure on the firms to take responsibility for adverse and harmful effects on the environment caused by their logistics activities. As a result, the manufacturing enterprises are incorporating new strategies and green policies in their businesses for a better environment and fewer carbon emissions (Romanowska, 2004). They need to focus on the environment and to take it as a concern to move towards a reduced carbon economy and reduce the carbon footprint of the country (Viljoen, 2012).

In developed countries, Green Logistics has become popular in recent times. Although in developing countries, it is still in a preliminary stage and needs more attention. It had been discussed that the developing countries are still lacking in promoting and implementing green practices in logistics.

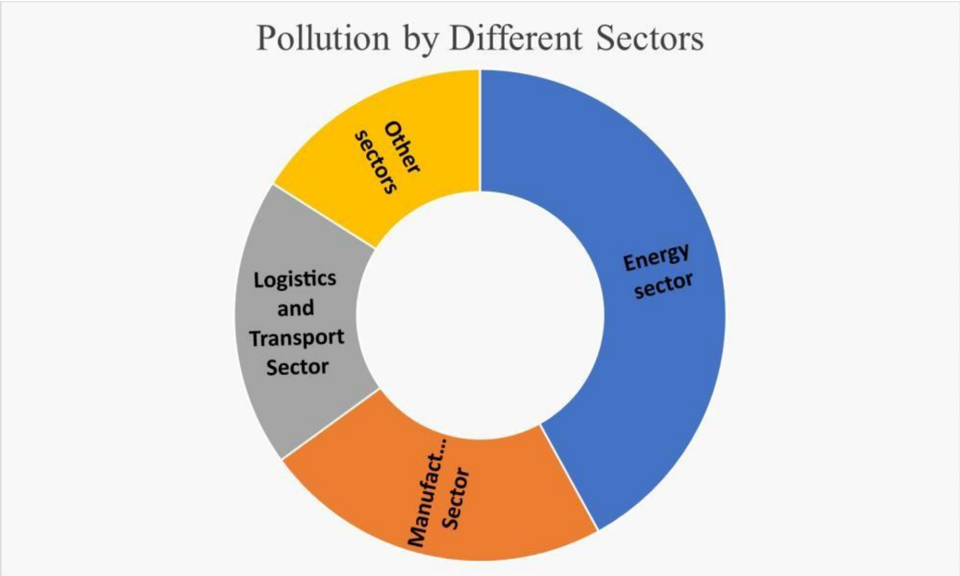

Figure 1.2 Percentage of Pollution caused by Different Sectors (IEA, 2016)

The research study revolves around Green Logistics Practices and Performance issues. This chapter provides a basic introduction, background and motivation to the study, then followed by a brief discussion of the research area, and then delineating research objectives, and finally concluding with the thesis outline. The chapter flow diagram shows the highlights (Figure 1.3).

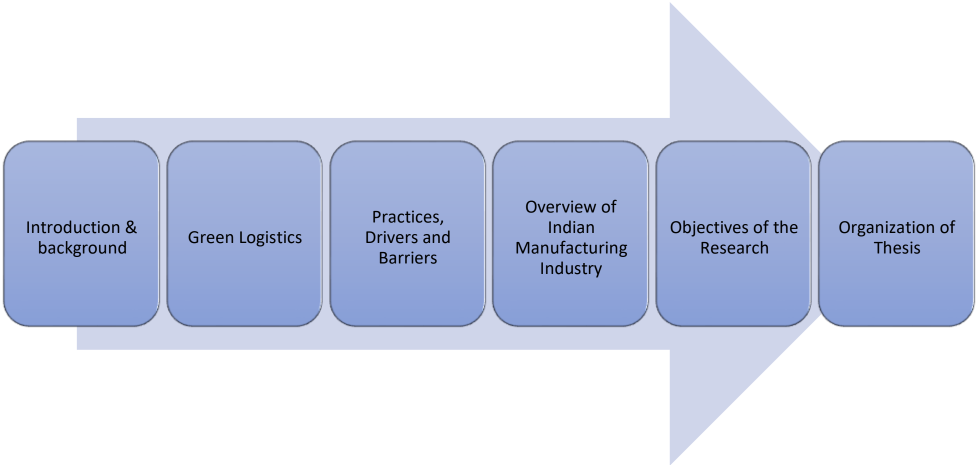

Figure 1.3 Chapter flow diagram

The current study focuses on Green Logistics Practices, which are either being currently implemented or planning to be implemented in the logistics activities of the Indian Manufacturing industry (especially in the Oil and Gas Industry). The Green Logistics Practices are governed by various drivers and barriers, which help in enabling the implementation and might also act as hindrances in the implementation of these practices. These ‘drivers’ and ‘barriers’ are the crucial factors thus need to be studied in detail. The application of Green Logistics Practices will also have an impact on the performance. The performance discussed in the research is not only related to the environment but also the economy. The main objective of this research study is to develop a conceptual framework of green logistics activities involved in the operations in the select Indian manufacturing industry (Oil and Gas) and its effect on the environmental and economic performance. A theoretical framework has been drafted by using this study and exploring the green logistics practices that the select Indian manufacturing industry is either implementing or consider implementing shortly.

The flow of this research goes as follows. Initially, the significant drivers and barriers, which might enhance or hinder the implementation of Green Logistics

Practices, have been studied extensively. This study is further extended by listing out the best possible green logistics practices that need to be considered by the Indian Manufacturing Industry (especially the Oil and Gas industry). And eventually, their Economic and Environmental Performances have been studied with respect to green logistics practices. Such extensive research studies could help the Indian Manufacturing industry in making strategic decisions about implementing green logistics practices for achieving the environmental goals along with having an idea of the impact of these practices on the Environmental Performance and Economic Performances thus achieving long-term sustainability.

1.2 Green Logistics

The growing concern about the environment is the rationale behind the shift towards greening the logistics, which should not only focus on government rules but also meet the customers' requirements and fulfill the environmental responsibilities. Green Logistics has an impact not only on the environment but on the economy and society too. Lee & Klassen (2008) defines Green Logistics as the logistics activities carried out by an industry or an organization that takes into consideration the green issues and assimilates them with the supply chain to enhance the environmental performance. It is also defined as the main expansion of modern logistics. Green logistics is a sustainable logistics system, which includes green logistics activities such as transportation, warehousing, distribution, and packaging along with the value-added services (Yang, et al., 2019). Green Logistics is used to highlight various practices that reduce the environmental problems of logistics operations by keeping a balance between economic and environmental performances. Green logistics can be considered as the advancement of the existing logistics, which highlights the performance of these activities involved in logistics in an environmentally friendly way to comprehend the growth of the economy while preserving the available and existing resources and thus protecting the environment from the ill effects of the activities (Zang, et al., 2020). A survey from EyeforTransport (O'Reilly, 2007) revealed that almost 25% of sampled enterprises across the US, UK, Gulf countries, and the Asia Pacific have collaborated with third-party logistics services to support their image to be more environmentally friendly or try to move their green and sustainable projects forward. The adoption of green logistics leads to the reduction of the negative impacts of logistics activities on the environment which include gas emissions, waste, noise, and thus helps to achieve the stable development of both in the economy, and environment (Wang et al., 2018).

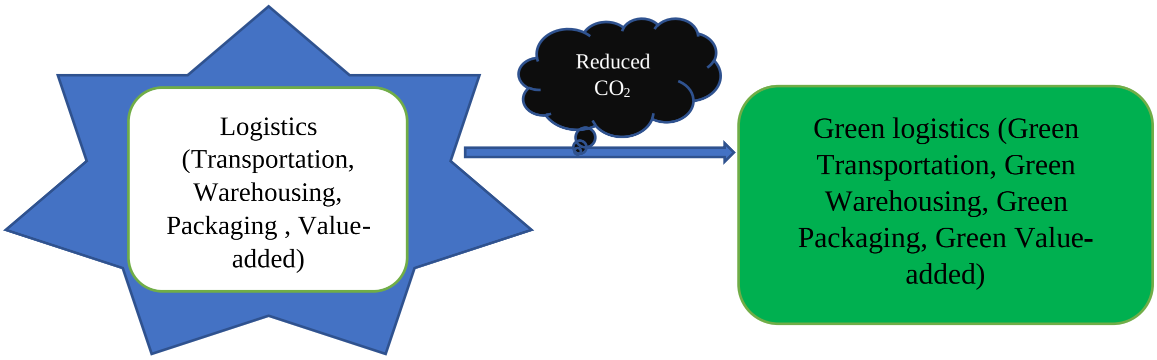

Figure 1.4 Green Logistics with reduced CO_2 (source; Self)

In other words, Green Logistics tends to suppress the damage and harm due to s logistics to the environment during the different logistics activities and helps in the cleansing of the environment, in a way that logistics resources are fully and properly used. This makes it possible to achieve environmentally friendly and sustainable development. Green Logistics activities take into account the extent of the environmental impact of various distribution strategies, the decrease of energy during the logistics activities, the reduced quantity of waste, and thus management of its treatment (Sibihi and Eglese, 2009).

As per Martinsen and Bjorklund (2012), the demands for Green Logistics activities are increasing. This trend leads to an increased interest in green logistics. The

Manufacturing Industry and other enterprises are compelled to improve their efficiency and also environmental performance by introducing the green concept in their logistics systems. In response to that, academicians, educators, and managers are discussing the issues in the logistics activities related to the environment. Many reports have been published, and forecasts have been made to show the importance and criticality of this part of knowledge by supporting the pro-environmental actions of the manufacturing industry. However, the development of ecological issues in logistics activities particularly in developing countries is still in its initial stage.

1.3 Practices, Drivers, and Barriers of Green Logistics

In current times, complexities in the business environment have forced the logistics activities in a way that they have to make these activities and processes more green and environment friendly by including operations that consider the environmental effects of their processes (Garza-Reyes, 2015a; Vinodh et al., 2016; de Oliveira et al., 2018). In agreement with this, green practices have developed as a concept to help enterprises to improve their Economic Performance and Environmental Performance (Cherrafi et al., 2016a; Garza-Reyes, 2016b). Thus, to fulfill the environmental demands to reduce harmful effects on the environment and confirm societal safety, many firms have pervaded several eco-friendly practices into their logistics activities, leading towards the formation of Green Logistics Practices. This has led the practitioners and scholars to examine the strength of the environmental practices to protect the environment and ensure the steadiness of the firms through improved profits (Baah et al. 2020; Agyabeng-Mensah et al. 2019; Wang et al. 2018; Turki et al., 2018).
The definition of Green Logistics Practices involves green initiatives, namely the set of specific organizational techniques and methods to achieve sustainable goals and enabling technologies such as IT-based systems supporting these practices (Centobelli et al., 2017). There is no clear

definition of green practices precisely for logistics activities. Martinsen and Huge-Brodin (2010) convened green practices into transportrelated measures like the type of fuels, type of vehicle technology, mode choice, behavioral aspects, transport management, and beyond-transport initiatives like the design of logistics system, environmental management system, emissions, and energy data(Isaksson, 2010). The survey report EyeforTransport (O'Reilly, 2007) shows the various GL practices commonly followed in the world are route planning to reduce the vehicle mileage, enhancing the efficiency of energy, and creating green warehouse and distribution centers.

An international logistics organization, NFI provides transportation, warehousing, and distribution centers and later published a report on how to develop green and environmentally responsible logistics (NFI, 2014), and thus recognized the many practices that can be executed to attain green logistics goals. The green logistics practices followed by NFI are transportation, warehousing, packaging, and value-added services (NFI, 2014). In similar lines and based on the literature (Kaaria and Asaari, 2016), green logistics practices considered in this research are green transportation, green warehousing, green packaging, and green value-added services. These practices have been explained below.

Green Transportation is one of the main activities of the logistics that affect the environment and thus produce harmful emissions like NO_2, SO_2, and PM (Dekker et al., 2011). Various practices like standardization of the trucks, clean vehicles, monitoring systems, backhauling, etc. come under the green transportation practices.

Green Warehousing means that the characteristics of the warehousing system must have a sense of environmental responsiveness. This also means that the bad effect of the activities on the environment due to the warehousing should also be reduced.

Automated warehousing facilities, fewer inventories, low carbon storage are few green warehousing practices.

Green Packaging is the packaging where the packing material can be reused, recycled, and should not bring any problem to the environment (Guirong & Zongjian, 2012). The few green packaging practices include the use of minimum packing material, new safe materials, messages on the packaging for the environment, etc.

Green Value-Added Services can promote the environmental provisions by helping them control their direct logistics flow (Thiell et al., 2011). The value-added services practices are the additional practices that help to enhance the green logistics further. The practices like giving staff training, making sustainable audit reports, etc are the few which leads to better logistics in terms of sustainability and environment.

The trend towards environmentally friendly practices in logistics is initiated by some governing factors known as the Green Logistics Drivers. Eltayeb and Zailani (2009) examined the key motivators and the results showed that there is a clear link between the trend of greening and logistics. Drivers, which are considered motivators that lead to influence the sustainability and environmentally friendly logistics practices, originate from some external and internal factors. Various researchers have shown that there are drivers that lead to the adoption of sustainable logistics movements. These drivers have helped the companies to include social and environmental awareness into their logistics activities and other business aspects. Therefore, this forced firms to progress with new management tactics. Government regulations, customers, competitors, market pressures, improving market image, etc. define the green logistics drivers which help in the implementation of the practices in any organization. In this research, various drivers have been identified from the literature to get a clear understanding of the motivating factors which support the implementation of the proposed green logistics practices.

The various drivers have been explored for green logistics implementation in the manufacturing environment. Routroy's (2009) research showed that government initiatives, top management commitment, market image, more business, customer awareness, and environmental management system are the drivers of green logistics. The drivers of green business strategy are customer requirements, competitive pressures, and resource conservation opportunities (Pun et al., 2002). Chin et al. (1999) explained the many characteristics involved in the implementation of green practices in manufacturing. The various attributes involved in the implementation of GL practices include management outlook, organizational change, various social aspects, and technical aspects.

In addition to the drivers of Green Logistics discussed above, some obstacles hinder the integration of these environmentally friendly green logistics practices in the processes. Even though there are many drivers which exist while implementation, it is found few criticalities in implementing green logistics (Zaabi et al., 2013). The barriers pose a serious problem in implementation practices in the industries, so it becomes highly important to identify the barriers and analyze these barriers too. The analysis will help to understand the factors which act as hindrances towards greener elements in logistics. The various barriers identified through the critical literature review are the cost of implementation, lack of top management support, lack of customer awareness, fewer sustainability audits, and many others. Lack of technology and innovation in the logistics activities is considered the critical barriers in GL implementation as all other barriers are the result of a failure in technology and innovation (Rodriguez & Wiengarten, 2017). Based on the discussion above about practices, drivers, and barriers of green logistics and their effect on the economic as well as environmental performance, a research outline is presented in figure 1.5.

1.4 Overview of Indian Manufacturing Industry

Manufacturing is the backbone of any country and plays an important role in modern society, as everything from weaving textiles to steel production falls within this industry. The concept of manufacturing is based upon the idea of converting raw materials, into the useful products that are required and used by society. The Manufacturing Industry is divided into many ways depending upon the factors. Based on the raw materials used, the manufacturing industry is divided as below:

- *Agro-Based Industries*: Cotton, Wool, Jute, Sugar, Tea, Coffee, Silk, Textile, Rubber, etc.
- *Mineral Based Industries*: Iron and Steel, Aluminium, Cement, Oil & Gas, etc.

The economy at the national as well as the international level is majorly dependent on the Oil and Gas (O&G) industry. However, this sector has a very high negative impact on the atmosphere (Gardas et al., 2019). The Oil and Gas industry involves compound elements that vary from oil exploration sites to fuel stations. This industry has three verticals for logistics activities namely upward, middle, and downward. The upward vertical consists of survey & exploration, whereas the middle system is a distribution system that comprises pipelines and tankers transporting crude oil to refinery plants. The downward vertical is the last and stage, which includes the major logistics activities like marketing, wholesaling, as well as retailing (Inkpen and Moffett, 2011).

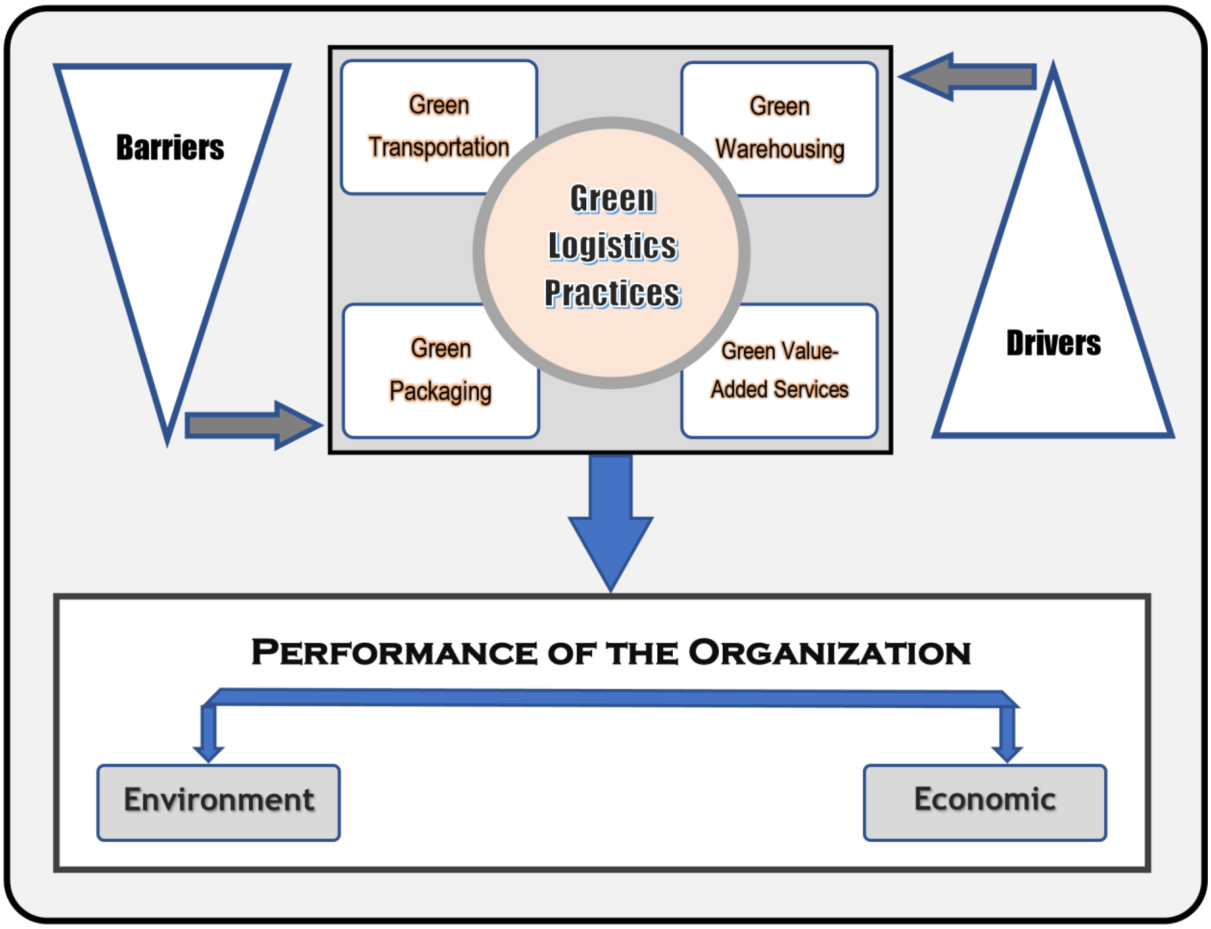

Figure 1.5 Research outline of Green Logistics (Source: Self)

The oil and gas industry is shown in fig. 1.6 depicts the flow as a major part of the global logistics system including global transportation, export and import services, inventory and its control, etc. Henceforth, this industry offers scope for a suitable model for achieving the suitability of environment-friendly activities in logistics. This is one of the rationale to consider this industry for green logistics practices implementation studies in the context of Indian manufacturing. Petroleum products are obtained from offshore or underground sites, and it is one of the most important primary nonrenewable resource across the world. (Hussain et al., 2013). Oil is very important as it produces wealth for the country.

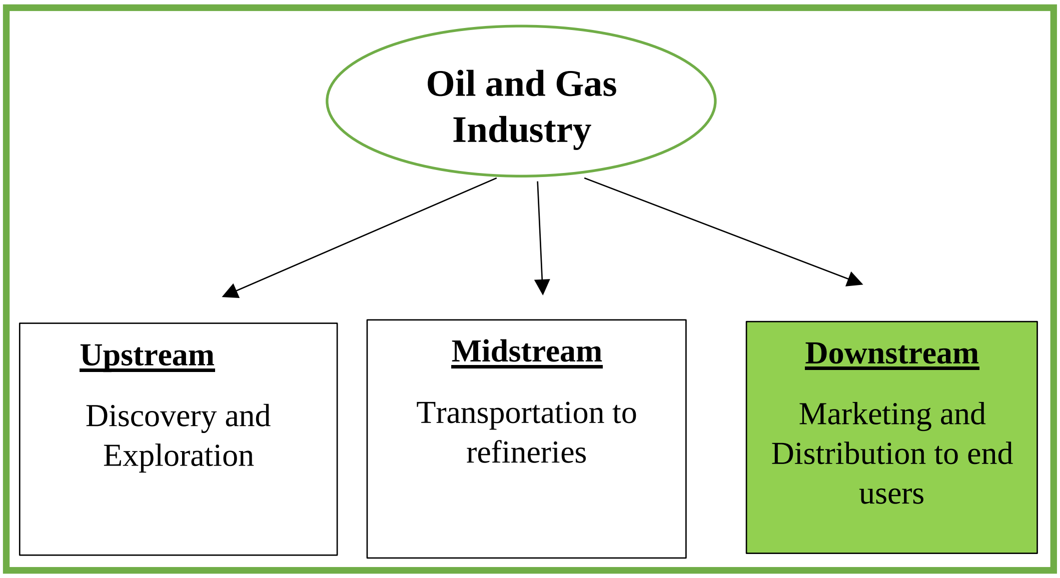

Figure 1.6 Flow of Oil and Gas Sector (Source: Self)

The supply and distribution of global these reserves, their consumption, and production are extremely unequal, given that nations with oil deposits are amongst the richest countries in the entire world (Yergin, 2011). It has been forecast that the world population would be somewhere around 9.0 billion by 2050 (UNPD, 2006). The population in India is also increasing at a very fast pace which has already reached a value of 130 Crore. This huge increase in population in India has put substantial pressure on the prevailing and available nonrenewable resources and thus influences changes in the climate. Further, the Oil and Gas industry is one of the most polluting industry in the world (Abubakar, 2014) and so does it is in India due to its logistics activities of the downward vertical. It is thus necessary to implement green practices in the Oil and Gas logistics activities which will help to solve the environmental problems. Therefore, the implementation of sustainable logistics practices in the logistics activities of the Oil and Gas industry of India will be beneficial towards resolving some of the environmental issues in the industry. The available research on Green logistics in this industry is limited, and factors that affect the adoption or implementation of the green logistics practices and their impact on the Environmental Performance and

Economic Performance have not been deeply analyzed. Few studies have highlighted the role of green, environment friendly, and sustainability and its emission reduction strategies of Greenhouse Gases (GHGs). Though, seldom research, such as those of was directed at exploring the factors, on the enterprise performance (Frynas, 2009: and García Rodríguez et al., 2013; Ahmad et al.,2016a).

1.5 Objectives of the research

The intensifying attention to the greener solutions has the main focus on logistics because it plays a very vital role, as it is one of the main pollution sources and resource usage. Logistics plays a major impact on climate change and is seen as an immediate threat to the environment. And this is the reason the shift has begun from logistics to green logistics And due to this trend the interest in Green Logistics has been increasing. The protection of the environment and the focus on reducing carbon emissions are already the priority of the developed countries. The major issues lie with the developing countries. To become a global competitor there is no other way than to go green in logistics activities (Aldakhil et al., 2018). Nowadays it has become more common for enterprises to remain competitive, a good balance of economic as well as environmental priorities needs to be achieved in their global operations (Cherrafi et al., 2016b). Therefore, determining how to promote environmental performance along with economic performance is presently one of the most significant issues being studied. The effective transition to this depends on many issues related to the economy, politics, society, law, and culture and thus requires radical changes in knowledge, organizations, technology, business strategies, and practices. As a result, the manufacturing industry is likely to face new challenges, especially in managing its processes and operations.

In India, the concept of Green Logistics is still in its initial phase and needs a lot of attention. The manufacturing industry knows the green logistics concept but still is not implementing it properly. There are only very few studies regarding the topic in the context of the Indian Manufacturing Industry. All the studies have been focused on either of the green logistics practices. There are no studies that collectively discuss all the activities of green logistics practices and their impact on the performances in the context of the Indian Oil and Gas Industry. However, within the limited reach of this study, the researcher could not find any single study of empirical nature which deals with different issues of Green Logistics in one place and that too in the context of downward logistics activities of the Oil and Gas industry in India. Moreover, most of the studies have considered either one or at the most two activities of Green Logistics. Some studies have discussed the impact of transportation on performance. But then these studies do not focus on all the performances like environmental and economic. There are a lot of gaps that need to be filled by conducting the research which gives a framework of the entire Green Logistics Practices on performances. The researchers of green logistics also believe that there is a gap in research examining the practices and performance issues of Green Logistics Practices within the Indian Manufacturing industry. The current research study aimed to fulfill these gaps through developing a green logistics performance-based framework with the help of numerous descriptive and inferential statistical studies on select Indian Manufacturing Industry (Oil and Gas). This will help the other manufacturing industry of a similar domain to adhere to various green practices which will help in managing their overall performances.

The scope of this study includes finding out the various Green Logistics Practices under the favorable drivers and non-favorable barriers. Also, the study was done to analyze the effect of these green logistics practices on the Environmental as well as Economic Performance of the logistics activities for the Indian Manufacturing

Industry (Oil and Gas). A framework has been drafted showing Green Logistics Practices that can be implemented to improve their performances by going green.

The logistics sector, in any country, is the backbone of national development and a major contributor to economic growth. The cost of logistics in India is approximately 14 percent of the Gross Domestic Product (GDP), as compared to 8 to 10 percent of the GDP for developed nations (Chapalkar, 2017; Sharma, 2018). In India, this cost has further increased in the past ten years. The main reasons for this high cost of transportation and logistics in India are the higher level of inefficiencies of the logistics system, such as higher turnaround time, lower average trucking speeds, lack of IT services, and high cost of administrative delays. These inefficiencies exist due to lack of proper basic infrastructure, non-conductive policy environment, lack of tracking and monitoring services, security, and extensive fragmentation of Industries. As suggested by Rao and Holt (2005), the firms can utilize the advantages of efficacy improvement and many other benefits like market shares and higher revenue margins by introducing the green concept in the logistics systems. To date, various qualitative methodologies have rarely been implemented in green logistics research to give clarity on these issues (Evangelista et al., 2010). However there are various logistics models in the literature, there is still a lack of research into real-life applications underpinned by case studies (Ubeda et al., 2011). The current research study validates a newly developed logistics model via real case studies of the Indian Manufacturing Industry. Therefore, this study could provide guidelines to the logistics activities of the select Indian manufacturing industry in implementing the green practices along with improvements in the environment and economy.

To address the problem discussed above and to cover the proposed scope, major objectives of the current study have been established and delineated below.

1) Justification of Green Logistics over non-Green Logistics in the context of the Indian Manufacturing Industry.

2) Identification and ranking of crucial barriers hindering the implementation of Green Logistics Practices in the context of the Indian Manufacturing Industry.

3) Identification and ranking of important drivers in select Indian Manufacturing Industry (Oil and Gas) for the implementation of Green Logistics Practices.

4) Identification and ranking of important Green Logistics Practices in select Indian Manufacturing Industry (Oil and Gas).

5) Analyzing Green Logistics Practices and Performance parameters after the implementation of Green Logistics Practices in select Indian Manufacturing Industry (Oil and Gas).

6) To develop a conceptual framework for the logistics activities of the Indian Manufacturing Industry (Oil and Gas) that will help the successful implementation of various Green Logistics Practices in the future.

1.6 Organization of Thesis

Chapter-1 is the introduction of the study, which focuses on the topic of the study. The background of the study explains what is the need for a shift from logistics to Green Logistics and how Indian logistics is presently affecting the environment. The research gaps motivate why this study is so significant followed by the research objectives of the study. Chapter 1 concludes with the outline of the thesis.

Chapter-2 comprises a literature review, which highlights the concept and evolution of Green Logistics. The chapter also discusses the main green logistics drivers, barriers, and important practices for the logistics activities of the manufacturing industry These practices were divided into major activities as Green Logistics Transportation Practices, Green Logistics Warehousing Practices, Green Logistics

Packaging Practices, and Green Logistics Value-added practices. Also, organizational performance parameters are discussed. The chapter concludes with the justification of research objectives by identifying literature gaps.

Chapter-3 is the research methodology chapter, which explains the research study design chosen, then followed by the research objectives and limitations. This chapter focuses on how the hypothesis is formed, and the design details of the questionnaire. Details about the data collection and analysis methods have also been discussed in this chapter.

Chapter-4 presents the justification of green logistics practices over the nonGreen Logistics practices using a mathematical technique. The justification provides various benefits of Green Logistics and thus, builds the foundations for further research on green logistics.

Chapter – 5 analyzes the connections among the barriers using the DEMATEL technique and thus finds out the most important barrier in the implementation of Green Logistics Practices in an Indian Manufacturing Industry.

Chapter-6 shows the empirical results and findings of the study. Data analysis was conducted using SPSS, ver.25. The various practices and drivers are prioritized based on the ranking from the mean values. This chapter ends with a conclusion.

Chapter-7 - From the statistical results, a framework was drafted for the logistics activities of the Indian Manufacturing industry (Oil & Gas). It helps the implementation of Green Logistics Practices as it shows Environmental and Economic performances. This chapter ends with a conclusion.

Chapter-8 presents the conclusions drawn from the study and recommendations for future research. The most important drivers and barriers are observed. The best practices in Green Logistics are suggested based on the performances. The effect of Green Logistics Practices on the performances has been statistically related. The summary of the findings of the green logistics framework is discussed.

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Chapter- 2

Literature Review

2.1 Introduction

A thorough literature review has been carried out to study the previous research efforts and directions associated with the focal area. The objective of the literature review is to identify the research gaps and showcase research motivations. First of all, the literature review presents a general description of Green Logistics. Further, practices of Green Logistics, which include Green Transportation, Green Warehousing, Green Packaging, and Green Value-added services, have been discussed in detail along with the various literature. Some specific drivers that can help in the implementation of these practices have also been identified, which works as enablers. Although there are several drivers but the implementation of these green practices is not so easy. There are several identified barriers that hinder the implementation of green practices and, therefore, would prevent achieving Environmental and Economic Performance. A detailed literature review has been done to determine all the major Green Logistics Drivers and Green Logistics Barriers to Green Logistics Practices. The literature review revealed that when these activities are being implemented as green practices, it might affect Economic and Environmental performance. The next section will give a comprehensive literature report about the overall research domain of Green Logistics in the Manufacturing Industry (Oil and Gas) and the practice and performance issues in the implementation of Green Logistics in the Indian Oil and Gas industry. The last section of this chapter discusses statistical modeling and Structural Equation Modelling(SEM). The flow of the chapter is illustrated in the following Figure 2.1.

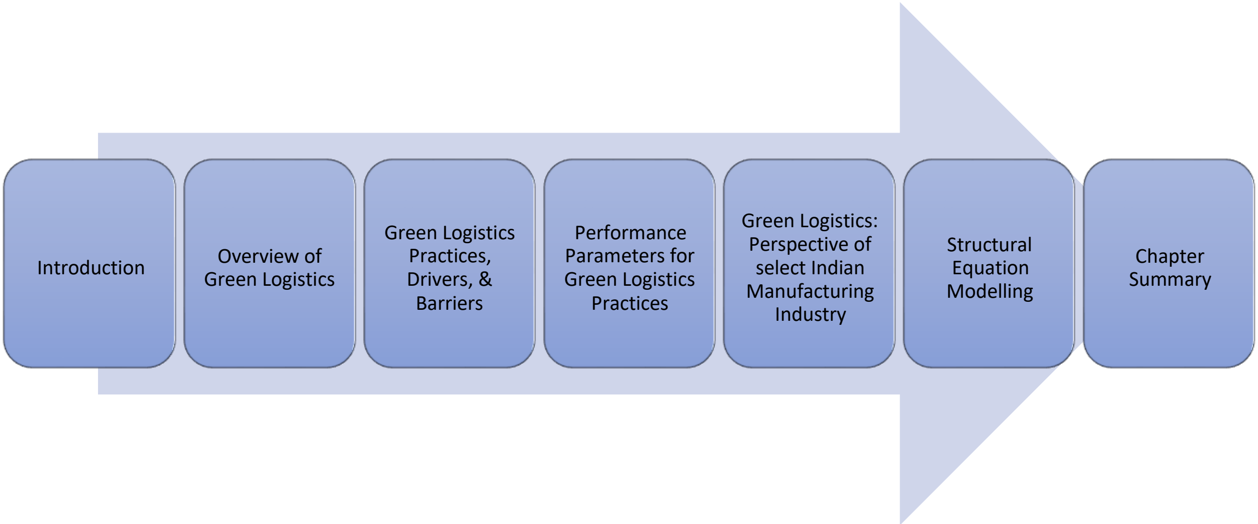

Figure 2.1 Chapter flow diagram

2.2 Overview of Green Logistics

Typically, logistics activities aim to achieve customer satisfaction with maximum profits and minimum costs. The term was initially used in many reports of manufacturing enterprises. But, now the term logistics is used in combination with green by generating a new term called Green Logistics. Due to their significance in today's highly competitive environment, Green Logistics concerns have sparked interest (Wu and Dunn,1995). It is also evident that the inclusion of environmental issues in the supply chain can influence various logistics decisions about the location, type of fuel used, raw material sourcing, route planning, etc. According to the literature, the social and economic value of Green Logistics was first recognized in 1990. (Srivastava, 2007). The inspiration for the change of logistics towards green logistics is the reason which motivates the study of Green Logistics. The various researchers, such as Murphy and Poist (2003), studied multiple motives for green logistics, barriers, drivers, and benefits of Green logistics behaviours in the research field. As per Sharma and Henriques (2005), Green Logistics is the capacity of the enterprise to manufacture and transfer products and services in a sustainable positive way along with the economic advantage and distribution of goods by considering environmental factors.

Lee & Klassen (2008) described Green Logistics as an enterprise's activity taking into account the issues related to the environment and integrating these activities into supply chain management. Measuring the environmental effect of various distribution methods and reducing energy consumption in logistics activities are among the green logistics activities (Sibihi & Eglese, 2009). If the comparisons are made in detail among the green logistics concepts between the US and the non-US companies, it was seen that they had the same opinions in green logistics management (Perotti et al., 2012). The administrators, individual managers, and experts have similar thoughts regarding logistics social responsibility values. They thus have significant impacts on the fulfilment of the environmental and social responsibility of logistics (Carter and Rogers., 2008). According to Zheng and Zhang (2010), Green Logistics was envisioned to guarantee that logistics activities are carried out correctly to minimize adverse impacts on the environment. The concept of Green Logistics has gained attention in the last few years.

Green Logistics contains various activities that lead to the ecological management of the movement of products and information between the starting point and endpoint of consumption, where the goal is to fulfil the customer demand (Mesjasz-Lech, 2011). Green Logistics are the logistics practices and policies that are carried to reduce the carbon footprint, minimizes freight energy, reduces transport, packaging, and waste management (Garcia Rodrigue et al., 2013). Therefore, many researchers have examined Green Logistics and its associated issues by conducting expert interviews and surveys with people employed in the logistics departments at different posts such as interviews with managers, and logistics providers (Hung Lau, 2011; Colicchia et al., 2013).

Green Logistics is a set of supply chain management practices that reduce the ecological carbon footprints during transportation, packaging, and distribution activities (Stolka and Kubicka., 2019). Green Logistics also helps to move towards sustainability in ecological, economic, and social terms (Lozano et al., 2012; Song et. a., 2017). As per the estimation, eight percent of the worldwide energy-associated carbon emissions are initiated from the freight of the logistics activities (Karaman et al., 2020). As the worldwide increase in global warming and deterioration in the environment, the use and adoption of green and low carbon logistics modes are in development widely across the globe (Li et al., 2020). The literature review has been conducted, as outlined in Figure 2.2 below:

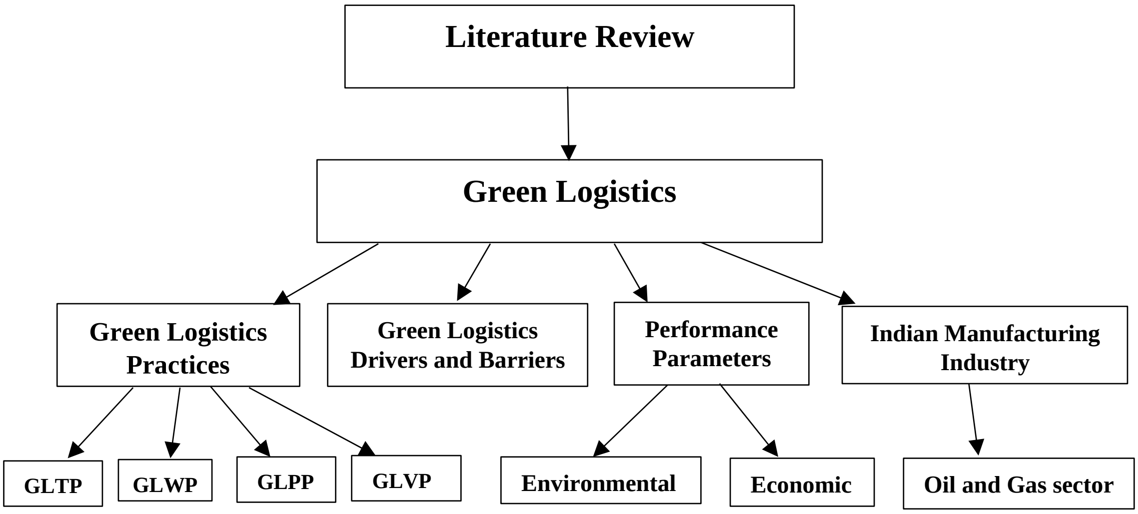

Figure 2.2 Outline of the literature review

2.3 Green Logistics Practices, Drivers, & Barriers

Green Logistics or sustainable logistics is concerned with reducing environmental and other adverse impacts associated with the movement of supplies. Various environmental practices such as transportation, warehousing, packaging, value-added services have been discussed by various authors in the past (Wu and Dunn, 1995; Carter and Dresner, 2001; Bowen et al., 2001; Zhu and Sarkis, 2004; Sheu et al., 2005; Ebinger et al., 2006; Singh, 2011; Singh et al., 2012). Green Logistics is the development of a strategy for the issues faced by the logistics activities such as increased logistics demands, environmental protection, and efficiency required in logistics services (Dekker et al., 2012; Luthra et al., 2014; Zaman and Shamsuddin, 2017; He et al., 2017; Rose et al., 2018).

Various activities of Green Logistics considered in this research have been selected based on the importance as suggested by the experts related to the select manufacturing industry through personal interactions and discussions. The majority of these activities included transportation, warehousing and distribution, packaging, and other value-added services. Martinez et al. (2009) have discussed the lack of knowledge and control of the status of the shipment vehicles in real-time conditions. Green Logistics management needs an exchange of information, coordination, and collaboration of teams to increase productivity and efficiency (Aldakhil et al., 2018). Table-2.1 shows the various activities of Green Logistics as per the literature review.

Table 2.1 Defining Green Logistics Practices

Green Transportation	It is an approach for managing delivery with the use of green vehicles that improve the environment, economic and social performance, e.g., use less fuel, backhauling, clean vehicles and natural green vehicles, etc.	Umar Sherif et al., 2021; Wang et al., 2020; Duric et al.,2019; Tian et al.,2019; Chang et al.,2018
Green Packaging	It is an approach of using packaging material that improves the environment, economic and social performance, e.g., use recyclable material, reuse materials, green packaging material, minimize waste and use of material and time to unpack, etc.	Wang et al., 2020; Moustafa et al., 2019; Chhabra et al., 2017; Zhang and Zhao et al., 2012
Green Warehousing and Distribution	It is an approach of optimizing energy for inventory/storage, reducing movement, energyefficient lighting system, utilize warehouse layout and inventory strategy, energy-efficient building, etc.	Carli et al.,2020; Bartolini et al.,2019; Li et al., Rudiger et al.,2016
Green Value-Added Services	It is an approach of developing strategic planning, control, and inclusion of value with utilization of the latest tools and technology for green logistics that improve the environment, economic, and social performance.	Liu et al., 2018; Sureeyatanapas et al, 2018; Mustapha et al.,2016;

Green Logistics practices highlight various activities that are followed to reduce the ecological problems of logistics, especially related to greenhouse emissions, and thus to attain sustainability among the environment and economy (Lai and Wong, 2012). The various Green Logistics Practices are discussed in the next section.

2.3.1 Green Logistics Practices

Green Logistics activities assist in the cost-benefit analysis and environmental considerations. It's not unusual to find that reduced carbon emissions can be achieved with just a small cost increase (Kim and Hen, 2011; Zhang and Zhao, 2012; Pazirandeh and Jafari, 2013). Given the manufacturing industry's contribution to India's economic development, a need for research has been established to encourage the Indian manufacturing industry to follow Green Logistics procedures in the greater interest of the global ecological system. Srivastava (2007) had discussed that the integration of environmental excellence practices with continuing operations in a supply chain is necessary for the present scenario. However, this integration increases complications in the chain and also responsible for the interest conflicts between economic and environmental requirements (Ebinger et al., 2006). Logistics in the industry, according to Abduaziz et al. (2015), included the integration of operations, storage, and distribution activities. They also suggested a simulation model for evaluating green logistics operations in the manufacturing industry, which would help managers and decision-makers gain a greater understanding of green logistics and its environmental impacts. Green Logistics in the Manufacturing sector focuses on lowering harmful greenhouse gas emissions and improving energy efficiency. Lu and Geng (2015) had introduced an industrial transition model and green manufacturing implementation to minimize harmful environmental pollution.

It is also clear that the majority of the Manufacturing Industry's resources are limited, and most of them are located far from the target markets. As a result, the Indian manufacturing Industry must follow economically controlled and environmentally friendly logistics activities to establish strategies for cost-effective environmental management. The Green Transportation Practices precisely refer to the suitable, safe, adequate, low-pollution, improved, and differentiated urban transportation system (Li et al., 2008). Various environmental conditions and practices have been suggested by various authors (Bowen et al., 2001; Zhu and Sarkis, 2004; Sheu et al., 2005; Zhang et al., 2020) and many of them have identified transportation as one of the important and visible as to be considered for the research. Green Transportation is generally said to have low-pollution vehicles, like dual-energy, and vehicles operating on renewable energy resources like natural gas, solar energy, hydrogen power, etc. It includes electrified vehicles such as tramcar, trolley bus, light rail, etc. According to Emissions (2020), the transportation sector accounted for 25% of total GHG (Green House Gases) emissions (Figure 2.3). Thus the implementation of Green Transportation Practices is most important in logistics as significant pollution is caused by transportation.

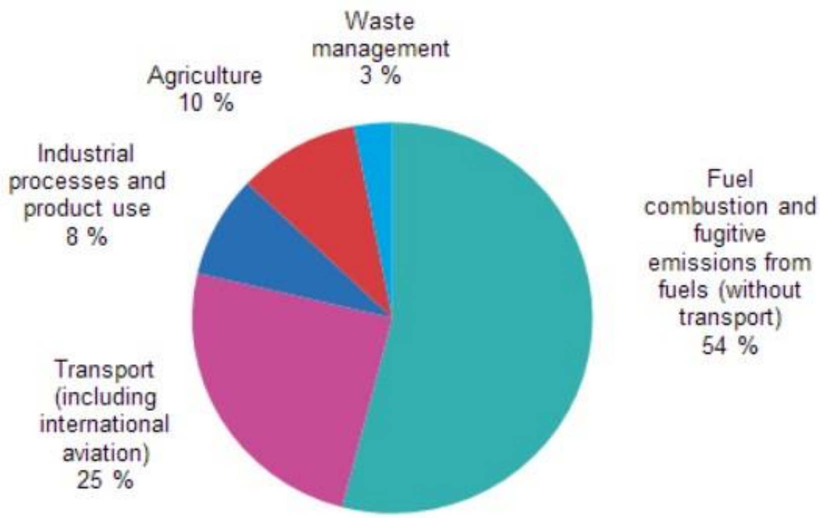

Figure 2.3 GHG Emissions by sector in EU-28, 2020 (Source: Emissions, 2020)

Authors such as Bauer et al. (2010) and Goel (2010), in their study, have discussed various environmental issues concerned with the modeling of transportation along with the selections of routes to increase the performance of delivery. These transportation models can certainly be modified to consider various green parameters such as CO2 emissions, usage of energy, waste, and losses, etc. In a real-life study performed by Janic (2011), an effort was made to evaluate the environmental effects of creating a multimodal transport node out of an airport by linking the airport to the rail transport network. Similarly, Geerlings and Van Duin (2011) had presented a transportation study of emissions and distances in a container terminal.

Authors have analyzed road transport operations given economic and ecological aspects and also evaluated the shifting scenario from road transport to rail transport to improve the energy efficiency (Vanek and Morlok, 2000; D'Agosto and Ribeiro, 2004). Multi-objective (maximum profit and minimum emission) mathematical models were proposed by Li et al. (2008) for the optimization of distributor locations by considering the cost of transportation and carbon emissions during transportation. Piecyk and McKinnon (2010) had considered fivefactor types viz. structural factors, commercial factors, operational factors, external factors, and functional factors that affect carbon intensity of fuel and found the most significant factors for carbon emissions in road transport. Based on the above literature, significant activities of Green

Transportation Practices have been identified and listed in Table 2.2.

Table 2.2 Green Transportation Practices

Sl. No.	Green Transportation Practices	Description	References
1.	Standardization of the Trucks	Standardization of the trucks means all heavy-duty trucks use the same engine, transmission, and tires. Standardization of truck sizes is essential to improve efficiency and reduce losses. Thus, it ultimately improves the environment by more inter-utilization of parts.	Pascaul et al., 2019; Bhardwaj ,2016; Yong Z, et al., 2014;
2.	Clean Vehicles	Clean vehicles mean to push for electric vehicles, biofuels that are sustainably grown, and lower carbon emission. The alternate and clean technologies are deployed to achieve emission reductions to a large extent	Li et al.,2019; Meirlo et al., 2017; Theill et al.,2011
3.	Wireless Technologies	Many wireless technologies have developed in the last few years to meet the growing needs of wireless communications in transportation. These evolving technologies will efficiently impact the operation of transportation of logistics	Taniguchi et al., 2020; Zhang et al., 2020; Mondragon et al., 2012

4.	Backhauling	Truck backhauling leads to the reduction of empty truckmiles by having drivers haul loads on the back trips. This is economical and environmental friendly as well.	Dukkanci et al., 2018; Sawik et al., 2017; Juan et al., 2014; Ubeda et al., 2013
5.	Scheduling	‘ Vehicle Scheduling is directly linked to fixed cost and labor cost, thus it is an essential phase in the public transportation planning process. It is preferable to reduce the number of vehicles used and maintenance costs, thus reducing resource waste.	Sureeyatanapas et al., 2018; Ubeda et al., 2013; Hassold and Ceder, 2014
6.	Optimization	Transportation routes are defined to optimize the cost of inbound or outbound deliveries. ‘Optimization’ of routes, as well as the load distribution, is crucial to achieving economic and ecological efficiency in logistics.	Jiang et al., 2019; Zhang et al., 2016; Theill et.,2011
7.	Freight Consolidation	Freight consolidation is the process of merging several packages or partial loads into a single trip for a common destination. This enables businesses to use fewer loads and deliver orders more easily and affordably. Load consolidation has several other benefits related to the environment.	Huang et al., 2020; Anand et al., 2019; Baykasoglu and Kaplanoglu, 2011
8.	System Monitoring Devices	System monitoring devices offer creative services related to various modes of transportation and management, enabling consumers to be more educated while also enhancing the environment.	Yang et al., 2018; Tsang et al., 2017

Numerous researches have been presented on the sustainability and environmental concerns in firms to mitigate risks and restore the firm's competitive condition (Rao and Holt, 2005; Dey et al. 2011). The various green industrial buildings and various innovative handling methods are generally linked with green warehousing. Therefore it is significant to study green warehousing practices of logistics as it helps in bringing a positive effect on the environment, society, and economy (Samari et al., 2013). Also, as the pressure and environmental concerns are increasing due to carbon footprint, the need for Green Warehousing Practices within the logistics industry is of leading priority. It is a vital element in the logistics system after transportation (Fichtinger et al., 2015).

Furthermore, researchers have approved that the practice of Green Warehousing is crucial as it leads to the safety and comfort of workers in warehouse environments. Iakovou et al. (2010) had presented an empirical model to analyse the economic and environmental consequences of placing a portion of production activities near serving markets in a significant paper. Palanivelu and Dhawan (2011) had also presented a pioneering study that addressed many green warehouses with low emissions. These warehouses can be designed by outfitting them with energy-saving equipment and solar panels. Much focus has been given to the above logistics practices for greening the environment. Table 2.3 lists warehousing activities from the literature.

Table 2.3 Green Warehousing Practices

Sl. No.	Green Warehousing Practices	Description	References
1	Reconditioning and reuse of Pallets	Pallets are the most generally used item for material handling in warehousing and are very crucial in logistics systems. Durable materials and is specially designed for multiple trips and extended life. This would ultimately help to achieve a better environment.	Koci, 2019; Tornese et al., 2019; Alonso et al., 2017;
2	Clean Material Handling	'Clean material handling' has been implemented by many companies to improve their environmental performances. This activity has been identified as an essential practice in the reduction of energy consumptions.	Alonso et al., 2017; Facchini, 2018; Davarzani and Norrman, 2015 Thiell et al., 2011
3	Innovative Handling	The deficit in carbon emission due to material handling activities can be obtained through policies such as using smart automatic pickers, energy-efficient material handling equipment, etc.	Carli et al., 2020; Bartolini et al., 2019; Facchini, 2018
4	Process Optimization	The energy can be saved through process optimization by order picking (approx. up to 55% of the total energy for warehousing can be saved).	Mao et al., 2019; Liu et al., 2018; Boenzi et al., 2016
5	Minimizing Inventories	The minimization of the inventory in the warehouse will both affect the storage space and materials handling activities within warehouses. The reduced stocks lead to less GHG emissions.	Li and Hai, 2019; Bowerson et al., 2013; Fichtinger et al., 2015
6	Low Carbon Storage	'Low carbon storage' refers to less carbon dioxide storage at point sources such as power plants. Sequestering carbon dioxide from the atmosphere and depositing it where it will not enter the atmosphere,	Bartolini, 2019; Boenzi et al., 2017; Freis et al., 2016; Thiell et al., 2011

Green Packaging is another important issue under the domain of Green Logistics that has been given importance in the literature. Green Packaging is sometimes also referred to as "ecological packaging," which is defined as environmentally friendly packaging that should be degradable and promote positive and sustainable activities. Green Packaging is said to be hurtless to the environment and also to human health. Thus, Green Packaging Practices are suitable ecological activities that should lead to reuse, recycle, and do not cause pollution in the environment during the life cycle of the product (Zhang and Zhao, 2012). In the literature, several attempts to minimize excess weight by decreasing packaging volume were also addressed (Palanivelu and Dhawan, 2011). The packaging was found to account for 23% of the overall waste weight. Reduced packaging also saves the environment since all packages must be shipped between retailers and waste processors.

Table 2.4 Green Packaging Practices

Sl. No.	Green Packaging Practices	Description	References
1.	Recycle, Reuse of Packaging	Recycling and reuse, i.e., green packaging put no harm to the environment or human health. Besides, reuse and recycle saves energy and reduce consumption and promotes sustainable development	Hao et al., 2019; Peng et al.,2020; Niero et al., 2017; Guang et al., 2011
2.	Ecological Material	Conventional methods of packaging have been related to environmental waste. Recently developed, bio-based packaging materials and other new materials can play a crucial role in sustainable development.	Niu and Xiao ,2020; He et al., 2017; Tumwesigye et al., 2016
3	ISO Suppliers	Indian enterprises have started adopting ISO-14001 as a measure for continuous improvements to achieve sustainability goals. These companies are also specifying the ISO certification as a minimum requirement in selecting suppliers for packaging materials	Johnstone et al., 2020; Sureeyatanapas et al., 2018; Nawrocka, 2009
4.	Environmental Messages on Packaging	The industry has initiated various new steps to communicate its sustainability efforts to its end-users. Different ways are being adopted, such as mentioning a message stating globally beneficial or locally beneficial.	Biondi et al., 2020; Nathaniel, 2016; Borin et al., 2011
5.	Restrict Excess Packaging	Minimizing excess filler materials and shrinking the overall packaging. Companies, nowadays, try to use as minimum material as possible. European and American countries have developed packaging reduction as the preferred strategy	Coelhoet et al., 2020; Biondi et al., 2020; Zhang and Zhao, 2012

Zhang and Zhao (2012), for example, had emphasized the government's role in the creation of new and creative green packaging materials. They also suggested standardizing the packaging materials with the active participation of the government and established institutions. All the popular Green Packaging activities are enlisted in Table 2.4.

The literature has also shown the importance of value-added practices in logistics activities, which reduces the negative impact on the environment. During the current development of green logistics activities, the focus on the management of relationships among customers and services has increased (Hertz and Alfredsson, 2003). Flexible and robust valueadded services that facilitate organizations that can improve the efficiency and environment

(Panayides and So, 2005). Hertz and Alfredsson (2003) have shown the importance of Green Value-added practices like potential skills, training, reports, and competencies for adding customer value. In this developing process, the logistics industry has a value-added part by providing Green Logistics, which would help their customers to produce greener products and services for customers (Wu and Dunn, 1995). The various types of environmental certifications are some of the value-added services which could be adopted by the manufacturing enterprises. This would provide customers with an ethical product, encouraging sustainable growth, enhancing the industry's reputation, improving relationships with stakeholders, and ultimately growing profits. Another value-added service, as discussed in the literature is publishing the Environmental footprints report by the enterprise. The manufacturing industry should understand that publishing these reports will help them and their employees to understand what harm various activities are putting on the environment. Thus training can be provided to the employees. The following are the major Green Logistics Value-added Practices discussed in the literature as shown in Table 2.5.

Table 2.5 Green Value-Added Practices

Sl. No.	Green Value-Added Services	Description	References
1.	Environmental Reports	Many studies in logistics research have concentrated explicitly on sustainability reporting to help to get the earliest information about carbon footprints, majorly, carbon emissions-related disclosures.	Karaman et al., 2020; Herold and Lee, 2017; Tacken et al.,2014; Thiell et al., 2011

2.	Staff Training	To help the workers and staff to get familiar with Green Logistics concepts, HR managers can launch initiatives such as staff training and awareness-raising programs.	Ren et al., 2019; Stolka, 2016; Yong, et al., 2014
3.	Long Term Environmental Objectives	Long-term environmental objectives are necessary to set for adequate environmental safety. These are also important as logistics companies are the primary cause of pollutants and wastes.	Zhang et al., 2020; Khan et al., 2017; Chen et al., 2018
4.	ISO Certified Company	Environmental management certifications such as BS7750 (1994), the EU eco-management and audit scheme (1993), and the international standard ISO14000 describe policies, procedures, and audit protocols for operations that produce waste or pollution.	Sureeyatanapas et al., 2018; Scur et al., 2017; Eltayeb et al., 2011
5.	Top Management involvement	Top-management involvement usually means having an increased focus on activities related to the environment. Top-management must understand the meaning of greening and must endorse these initiatives to provide necessary resources to the employees.	Karaman, 2020; Baah et al., 2020; Yen and Yen, 2012

2.3.2 Green Logistics Barriers and Drivers

The Manufacturing Industry is working diligently to implement green practices since the active implementation will gain a competitive advantage and help them move towards sustainability. (Zhu and Sarkis, 2004; Mathiyazhagan et al., 2014). But, the industry faces a lot of hindrances in implementing and adopting green logistics at their end. Many studies discuss the barriers of Green Logistics in the manufacturing industry (Lorek and Spangenberg, 2014; Blok et al., 2015; Kaur et al.,2019; Oliveira et al., 2018). Seuring and Muller (2008) had observed several barriers during the implementation of Green Logistics Practices from the perspective of environmental consideration. Studies by various researchers revealed that the general public has a lesser role in the development of sustainability practices. In similar lines, some researchers have proposed that low eco-literacy and a lack of awareness, experience, and environmental protection management could act as barriers. Therefore, unawareness or the lack of knowledge and information regarding the issue of sustainability is a significant barrier. Another potential barrier could be the lack of sharing of information that can contribute to more gaps in implementing Green Logistics Practices. The barriers pose a serious problem in the implementation of Green Logistics Practices in the industries. So it becomes highly important to identify the barriers and analyze these barriers.

The analysis helps the employers to understand the factors which act as hindrances towards greener elements in logistics. Summarizing the above arguments, a list of important barriers is presented in Table 2.6.

Table 2.6 Barriers in Implementing Green Logistics Practices

S.No.	Barriers	Description	References
1.	Low Rate of Investment	The rate of investment is the most crucial factor considered by the manufacturing industry in terms of profit. And the industry and enterprises do feel that the ROI is low in implementing green logistics practices	Perotti et al., 2015; Gumley, 2014; Ageron et al., 2012
2.	Less market demand for GL	The market demand for green logistics activities is still not very high and thus enterprises do not wish to implement these activities	Adams et al., 2017; Zhang et al., 2015; Mudgal et al., 2010
3.	Lack of Govt Support and Policies	The support of the Government in promoting and adopting green practices in logistics is still less in developing nations. However now this is changing slowly.	Wadud & Huda, 2017; Khan & Qianli, 2017; Rizos et al., 2016
4.	Lack of Top Management Support	The top management of any enterprise is mostly concerned with profits and thus does not support the green and environment-friendly practices which involve money.	Govindan et al., 2014; Khan et al., 2019; Khan and Qianli, 2017; Rizos et al., 2016
5.	Lack of Focus on Circular `Economy	The focus is yet not on the circular economy. As the enterprises and manufacturing industry need to enhance this focus which leads to green practices.	Li et al., 2020; Govindan et al., 2018; Li et al., 2015; Su et al., 2013
6.	Employees Resistance for Change	As a general practice, the employees in any organization are always resistant to change and so is the case in implementing various green activities in logistics.	Gaur and Mani, 2018; Govindan et al., 2018; Rizos et al., 2015; Zhu and Geng, 2013

7.	Lack of approach towards the use of renewable energy resources	The enterprises are still utilizing now renewable energy resources as they are easily available which hinders environment-friendly practices.	Govindan et al., 2018; Kamble et al., 2018; Hussain, 2017
8.	Lack of training and skilled Labor force	The implementation of green logistics practices needs to have a skilled workforce who knows how to implement such activities.	Benesova, 2017; McKinnon et al., 2016;; Yadav et al., 2014; Longoni et al., 2014;Liu and Bai, 2014
9.	Lack of Resources for Sustainable Process Change	The availability of such resources which are required for bringing sustainable change in the logistics activities is not easily available.	Khan and Qianli, 2017; Singh and Ordonez, 2016; Ghisellini et al., 2016; Lorek and Spangenberg, 2014;
10.	Lack of Investment and innovation for R&D	The green logistics practices need a lot of research work to be done however there is still a lack of investment.	Shahbazi et al., 2016; Ahmed et al., 2014; Govindan et al., 2014
11.	Lack of Approach for IT systems and advanced Technologies (AI, Bigdata, IoT, RFID, etc)	The logistics activities involved in the enterprises and manufacturing industry do not extensively use advanced IT technologies.	Rymaszewska and Gunasekaran, 2017; Khan and Qianli, 2017; Genovese et al., 2015; Luthra et al., 2014; Su et al., 2013
12.	Lack of Collaboration among Suppliers	The enterprises do not collaborate with the suppliers while buying the raw materials for packaging and other activities. This collaboration would help in implementing green and environmentally friendly practices.	Farooq et al., 2019; Fontana, 2018; Rymaszewska et al., 2017
13.	Complexity of Process Design to reuse and recycle	The implementation of the green practices in the logistics activities is hindered as the reuse and recycle designing is a complex process.	Haddud et al., 2017; Ghisellini et al., 2016; Tukker, 2015; Govindan et al., 2014
14.	Lack of sustainable Packaging	The lack of environmentfriendly material for packaging is a major hindrance in the green practices in packaging	Meherishi et al., 2019; Hussain, 2017; Govindan et al., 2014; Garcia-Arca et al.,2014
15.	Lack of Customer Awareness for Environment	The major obstacle in shifting towards green practices is the lack of customer awareness towards sustainability. Until the customers and end-users are aware of the green practices they won't be implemented easily.	Rehman et al., 2020; Lieder & Rashid, 2016; Gonget et al.,2019

16.	Lack of Effective Environmental measures.	There are yet no effective and proper environmental measures. The absence of these measures does not promote the implementation of green practices.	Ghazilla et al., 2015; Li et al., 2015; Govindan et al., 2014

However, some factors influence the effective implementation of Green Logistics Practices in the Manufacturing Industry. These factors promote the implementation of Green Logistics Practices in the industry. And, thus improve the performance of the industry in terms of economy and environment (Min et al., 2001). These factors are known as drivers or stimuli that provoke organizations to implement Green Logistics Practices. Previous studies in the literature identified several drivers that have a prominent effect on driving organizations. Therefore, in the present competitive scenario, drivers of Green Logistics have significant importance and require serious research attention (Bhattacharjee, 2015). Based on the literature, a list of relevant and crucial drivers is presented along with citations in Table 2.7.

Table 2.7 Drivers in Implementing Green Logistics Practices

S. No	Green Logistics Drivers	Description	References
1	Decrease in Availability of Fossil Fuels and their High Costs.	The logistics companies have forecasted that the availability of the existing nonrenewable energy resources will decrease more in the future. Thus, the prices will be high. So the shift towards better cleaner and greener sources of energy are desired and act as drivers.	Sureeyatanapas et al., 2018; He et al., 2017; Zeng et al., 2014; Eyefortransport, 2007
2	Complying with Government	The companies follow the policies and regulations regarding the environment. So this acts as a driving force for the companies to adopt and implement green practices.	Jovanovic et al., 2020 Govindan and Bouzon,2018; Mckinnon et al., 2015
3	Decreasing Fuel Bills	This acts as a significant driver, as it ultimately leads to a reduction in total costs of operations in any organization. Therefore, management gets motivated to adopt new practices.	Mensah et al., 2020; Ayyildiz et al., 2017; Pagell et al., 2010
4	Differentiating with Competitors	This provides an edge over the other competitors. Some companies always urge to keep an edge over competitors by doing something different, which drives them to implement these green initiatives.	Sureeyatanapss et al., 2020; Kim, 2010

5	Collaborating with Customers	The industries collaborate with customers' requirements for green services and thus works to achieve ecological activities involved in logistics	Centobelli et al.,2017; Liimatainen et al., 2015; Mosers et al., 2015;
6	Complying with Internal Regulations	If the internal regulations, are directed in accordance with the green initiatives, would encourage the adoption of these practices.	Jovanovic et al., 2020; Agarwal et al., 2018; Dornfield et al, 2013
7	Improving Public Relations	People choose industries that care about societal and environmental performance. So improving public relations is a motivating factor for the firms.	Govindan et al., 2020; Mckinnon et al., 2015; Evangelista, 2014
8	Marketing Pressures	Nowadays, the market trend also plays an important role. The industries see the trend and change to various environmental activities in logistics.	Lam et al., 2019; Dangelico et al., 2017; Pun et al.,.2013
9	Increasing Supply Chain Efficiency	The overall efficiency is increased by implementing green practices in logistics. So to improve the overall efficiency, logistics plays an important role.	Meager et al., 2020; Paulsen et al., 2017; Zhang et al., 2014; Evangelista, 2014
10	Part of Corporate Social Responsibility	Corporate social responsibility (CSR) has become vital for industries to satisfy the increasing societal potentials for environmentally and socially responsible operations. As a significant part of CSR, green logistics practices are implemented by the manufacturing industries	Uyar et al., 2020; Shou et al., 2020; Chu et al., 2019; Zhang et al., 2014
11	Pressure by Environmental Advocacy Groups	As the environmental deterioration is increasing, various environmental groups and activists are supporting environmentally friendly activities.	Karaman et al. 2020; Liu et al., 2018; Stolka, 2014

2.4 Performance Parameters for Green Logistics Practices

Authors had presented numerous researches on the sustainability and environmental concerns in the manufacturing sectors to mitigate risks and restore the firm's competitive state (Rao and Holt,2005; Dey et al.,2011). Authors such as Vachon and Klassen (2006) and Ates et al. (2012) had examined ecological investment decisions and partnership behavior with suppliers about logistics to prove that the Environmental Performance of the Manufacturing Industry has an impact on the green performance. When implementing the triple-bottom-line approach, it is important to strike a balance between environmental sustainability, economic growth, and quality of life. It's also true that the Manufacturing Industry can't bear the high acceptance costs of integrating Green Logistics Practices into their operations.

Modern methods of prioritizing consumer needs based on the least negative environmental effect are now being developed by the manufacturing industry (Niesten and Lozano, 2015). This will also include several stakeholders, as well as the community, to enhance the organization's long-term viability (Lozano, 2012a). Much research has been done to justify the environmental performance by implementing Green Logistics Practices. A study about the Environmental Performance of the system (CO_2 emissions) due to various decisions such as locations of distribution centers, transportation, and warehouse operations decisions has been presented by Mallidis et al. (2010). All the crucial environmental performance parameters have been summarized, explained, and listed in table 2.8.

Table 2.8 Environmental Performance Parameters

Sl. No	Environmental Performance Parameters	Description	References
1	Fuel Efficiency	The green logistics practices continue to reduce the amount of fuel utilized in the logistics activities as optimization, scheduling, etc. have been done.	Karaman et al., 2020; Lu et al., 2019; Arya et al., 2011
3	Carbon Footprint Reduction	Manufacturing Industry is now implementing green practices in their operations like green transportation, green purchasing, green warehousing, green value-added services to reduce the carbon emissions from all the logistics activities.	Lambotte et al., 2020; Khan et al., 2019; Chhabra et al.,2017; Govindan et al., 2016
4	Energy Saving	Energy Saving is the result of energy efficiency, which is defined as the ratio of the output of performance or energy to the input of energy. This has been identified that green practices like consolidation, standardization, information flow, and optimization lead to energy saving.	Khan et al., 2019; Aldakhil et al., 2018; Zaman & Shamsuddin, 2017; Huget et al., 2017
4.	Less Disasters	Some industries have already taken the priority to implement green logistics, especially when the results lead to better pollution climate change, fewer natural disasters.	Khan et al., 2019; Yu et al., 2018; Guiffrida et al., 2011

Profit is the primary objective of the Manufacturing industry and every other organization on the planet. The industry can save a large amount of money by incorporating various Green Logistics principles. A well-designed green system will result in waste reduction, lower transportation costs, lower energy costs, and decreased material consumption, all of which increase profit, which is a significant motivator for the industry to make changes. Furthermore, improved customer loyalty, a better market position, new market prospects, and a competitive edge could be achieved (Agan et al, 2013). In the literature, there are numerous examples of effective Green Logistics implementation. Ubeda et al. (2011) had presented one such report, which successfully demonstrated that Green Logistics Practices can be applied without compromising an enterprise's efficiency. The performance is not only related to the environment but also Economic Performance. The Economic Performance has suggested the benefits in profits achieved due to the greening of the logistics activities. To summarize, some of the significant Economic Performance Parameters are listed in Table 2.9.

Table 2.9 Economic Performance Parameters

Sl. No	Economic Performance Parameters	Description	References
1	Decrease in Energy Consumption Cost	Green Logistics practices use environmentally soundvalues and methods of logistics, which leads to the conservation of energy and resources. Thus, it reduces the energy consumption cost and improves firm performance.	Khan et al., 2020; Agyabeng-Mensah et al., 2020; Chhabra et al., 2017
2	Decrease in Fuel Cost due to Optimized Routes	The various changes in the activities of the logistics movement, such as consolidation, reducing the number of trips by scheduling and optimizing. This would lead to a decrement in fuel costs.	Agyabeng-Mensah et al., 2020; He et al., 2017; Zsigrova et al., 2013
3	Decrease in Cost of Waste Disposal	The logistics activities, which work in sync with the environment, always emphasize on reuse and recycle of the parts and products. Thus, the cost of doing waste disposal reduces to an extent. Waste has to be managed rather than disposed of in the context of sustainable development.	Aryampa et al., 2021; Baah et al., 2021; Chhabra et al., 2017; Zhu, et al., 2012
4	More Business due to Brand Image Improvement	The manufacturing industry that puts a greater focus on green logistics is more likely to gain more business and produce better environmental outcomes. Customers and customers who prefer environmentally friendly practices are affected by the brand image.	Tumpa et al., 2019; Chen et al., 2012
5	Reduction in VTT Costs	The value of travel time is referred to as the expense of travel time. It covers the costs to companies of time spent commuting by their staff and cars, as well as the costs to customers of personal (unpaid) travel time.	Zhong et al., 2020; Wang et al., 2018; Gajanandand and Narendran, 2013
6	Decrease in Vehicle Costs as better life of vehicles	Drivers must know best practices for transportation and geo-referencing to check the state of their truck at regular intervals and ultimately to set goals and performance parameters. Advanced technology also helps in achieving better vehicle performance.	Rodrique et al., 2020; Sureeyatanapas et al., 2018; Kara et al.,2017; Honorato, M., 2016

Few cases are found in the literature which show the successful implementation of green logistics. Still, a lot of manufacturing industry especially in developing countries are hesitant to implement Green Logistics Practices due to the investment involved. Much research work has to be done to show the effects of Green Logistics practices on Environmental Performance and Economic Performance.

2.5 Green Logistics: Perspective of Select Indian Manufacturing Industry

In India, the Manufacturing Industry has been a high growth sector, and recent years have shown tremendous rise and have given global recognition to the economy. By the year 2022, India would become the fifth largest manufacturing country in the world. The government is all set to attain a 25 percent GDP share and 100 million jobs in the manufacturing sector in 2020 (IBEF, 2018). In our country, among the eight core industries, the Oil and Gas Industry is one of them and has a significant role in making decisions of the economy. The economic growth of the country is closely related to the demands of energy; therefore, the Oil and Gas industry is projected to grow more, which makes this quite favorable for investments. This industry serves as the backbone for many other industrial areas. Although, it holds a significant threat to the environment and harms different levels, including air, water, and soil on our planet (Aggarwal and Bhattacharjee,2017). As per the research, the most prevalent and dangerous consequence of oil and gas industry logistics activities is pollution. Pollution is related to all activities throughout all stages of the Oil and Gas industry (Chermisinoff, 2016). In India, during the finale of Transporters Meet, the Minister of Road Transport and Highways, Shri Nitin Gadkari had said that transport and logistics should move towards Green Logistics to reduce pollution as the government is planning for strict pollution norms. He also said that certain changes are inevitable to be done in the logistics activities for the Oil and Gas sector. The changes suggested by him include the adoption of LPG as a future fuel, the use of electric vehicles for freight, etc. The event was organized by hindu businessline, along with Indian Oil Corporation Limited

(IOCL) and Mahindra Automobile Limited (Bureau, 2020). Therefore the shift towards Green Logistics along with sustainable development has become the most ethical and necessary obligation towards society and the country**.** And, as the Oil and Gas industry has a considerably harmful effect on the environment as well as on society, it needs to be studied carefully to reduce pollution (Mariano, 2017; Gardas, 2015; Abubakar, 2014)

Logistics is the vital linkage between the Oil and Gas Manufacturing industry and the distributor. Most of the logistics operations utilize the road as the mode of transportation. This mode is preferred as it is flexible, and through this mode, the supply can also be sent to the remote areas of the country (Mariano, 2017). In India, oil consumption has expanded at a CAGR (Compound Annual Growth Rate) of 3.3 percent during the years 2008 to 2016 and has reached 4.0 percent in 2016. India would become the world's third-largest oil consumer, the first and second being the US and China, respectively, by 2025. The total number of retail petrol outlets in India is around 56,190 as of March 2016. Out of these, approximately 25,000 are of Indian Oil Corporation Ltd, 13,000 each are of Bharat Petroleum and Hindustan Petroleum Ltd (Arockiaraj, 2017). The major part of the supply chain of the oil and gas industry involves logistics activities. Greening these logistics activities may require the discussion and analysis of various crucial issues in the sector.

The logistics for the Oil and Gas sector consists of elements that extend from oil exploration to fuel stations. The logistics activities of this industry have three significant streams - upward stream, middle stream, and downward stream. The upward stream involves the exploration-related activities, whereas the middle stream is the movement and distribution through pipelines and tankers, which transport crude oil to refineries. The downward stream, which is the last stage, includes activities that do refining, marketing, wholesaling, and retailing (Inkpen and Moffett, 2011). The downward stream logistics or sometimes called secondary logistics includes choosing storage depots for each market, type of carriers, type of warehouses, type of packaging, range, and capacities of tank trucks, and planning and scheduling. The logistics of the Oil and Gas sector are the main linkage partners which take products in their custody before handing them to the retail stations. Therefore the need for ecological improvement in logistics activities by switching over to Green Logistics will be based on their views and implementation (Mariano, 2017; Joshi et al., 2016; Ahmad et al.,2016).

Besides the above, in literature, the emphasis has been given on improving the upward stream and middle stream only. However, downward stream logistics issues have always been ignored. Having discussed earlier in this section, the size of Oil and Gas logistics in India, the pollution caused by these activities requires considerable attention in today's scenario. Besides having a massive scale of logistics activities in this industry due to a large number of retail outlets, still very few green logistics-based research studies are found in the literature. This could be highlighted as a possible research gap in the domain of Green Logistics studies.

2.6 Structural Equation Modelling (SEM)

Structural Equation Modelling is an effective statistical method that seeks to analyze the relationship between multiple variables by the measurement and structural models ((Hair et al., 2013; Vinodh and Joy, 2012). The measurement model establishes the relationships between observed and unobserved variables (Byrne, 2010). It shows how the principle is interpreted by the measured variables (Hair et al., 2013). SEM is a mathematical method for evaluating and estimating causal relationships using a mixture of statistical data and qualitative causal assumptions. Structural Equation Models (SEM) are ideal for both theory testing and theory creation since they allow for both confirmatory and exploratory modeling. A hypothesis is typically the starting point for confirmatory modeling, which is then described in a causal model. The model's principles must then be operationalized to evaluate the relationships between the concepts in the model. To assess how well the model matches the data, it is checked against the collected measurement data. The model's causal assumptions often have falsifiable effects that can be checked against the evidence. Researchers may use SEM to answer a series of similar research questions in a single, systematic, and detailed study. This approach is focused on simultaneously modeling the relationships between several independent and dependent constructs. Structural equation modeling is used to test the model developed including moderation and mediation. The fit of the model against the data collected using the survey questionnaires is tested for conformity using the fit metrics described in this section. The details of how this methodology is used have been explained later.

2.7 Chapter Summary

The chapter carried out a detailed literature review to find out the previous studies, analyses, and researches done by various scholars at national and international levels around the globe. The different terminology involved in the study has been defined and discussed in detail to give a clear understanding of Green Logistics and the proposed research.

At the outset, the concept and need for Green Logistics have been discussed in detail, Based on the literature review, there are various justifications of why Green Logistics needs to be implemented in the Indian Manufacturing industry. Various Green Logistics Practices involved in logistics have also been discussed by different authors in the literature review. Further, these green logistics activities, also termed Green Logistics Practices, are reviewed separately in detail. Various researchers have given their views on the different logistics practices activities and the items involved under these practices. Green Logistics Practices, i.e., Green Transportation, Green Warehousing, Green Packaging, and Green Value-added practices, have various subactivities called ‘items’ under these practices. These items under each practice have been identified in the literature review in detail. These identified items have been discussed with the experts, after which, the main items of each Green Logistics Practices have been tabulated in various tables along with the description and references. These tables give a clear idea about different items to be studied and focussed on while doing the detailed analysis in chapter 6 in the research.

Subsequently, the various factors which act as driving force in the implementation of green logistics practices and the elements which act as hindrance are studied through the literature. Factors that help in the implementation of the Green Logistics Practices are called green logistics drivers, and the factors which hinder are called Green Logistics Barriers. The scholars and researchers have identified various drivers and barriers for different types of industries and applied them to national and international level studies.

Lastly, in this chapter, the various performance parameters pertaining to the Manufacturing Industry are identified from the past and recent literature and tabulated, showing descriptions and references. Different studies indicate that the performance of any organization is judged by analyzing Economic Performance. However, when Green Logistics Practices are studied, then Environmental Performance also becomes essential. Various authors have described these performances and how green practices affect them. The green logistics from the perspective of the select Indian manufacturing industry is also discussed. The literature also showed the need for the implementation of Green Logistics in the downward stream of logistics activities of the Oil and Gas industry as the downward stream involves major logistics activities and thus causing a lot of carbon emissions.

The research efforts are motivated by the identified research gaps from the literature, and subsequent chapters of this thesis will address many of such issues. One of the important questions that emerged from the literature review is the need for a unified framework for Green Logistics-enabled environmental and economic performance improvement in the select Manufacturing Industry that would allow practitioners to understand the behavior of Green Logistics in a more intuitive manner.

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Chapter- 3

Research Methodology

3.1 Introduction

The systematic approach, which includes generalization and the preparation of the theory, is termed research. As such, the term research is the systematic method consisting of the problem definition, hypothesis formulation, data collection, analyzing the facts, and then giving certain conclusions by either giving solutions of the concerned problem or by some generalizations through specific theoretical formulation. The term research methodology indicates a method that systematically resolves a research problem. It is aimed to give the plan of research. Researchers always study and research to advance the quality of their findings in their concerned area by using appropriate and related research methods. In this study, the literature review presented in the previous chapter highlighted the need to study green logistics practices, drivers, barriers, and performance parameters. This chapter focuses on the research methodology used in this thesis to study green logistics and performance-related issues in the select Indian Manufacturing context. The research methodology includes many procedures and methods required to undertake research, including the preparation of a survey questionnaire, data collection techniques, data analysis methods. However, it's not just about conducting the study it should also be proved purposeful by checking the reliability, validity, and social acceptability. The remaining of the chapter, initially, describes research objectives and a list of hypotheses along with the explanation. Further sections of this chapter will present standard research methodology topics such as research design, the methodology used throughout the thesis, notes on data reliability and validation, and ethical considerations. The chapter will end with a summary. The complete flow of the chapter is shown in Figure 3.1.

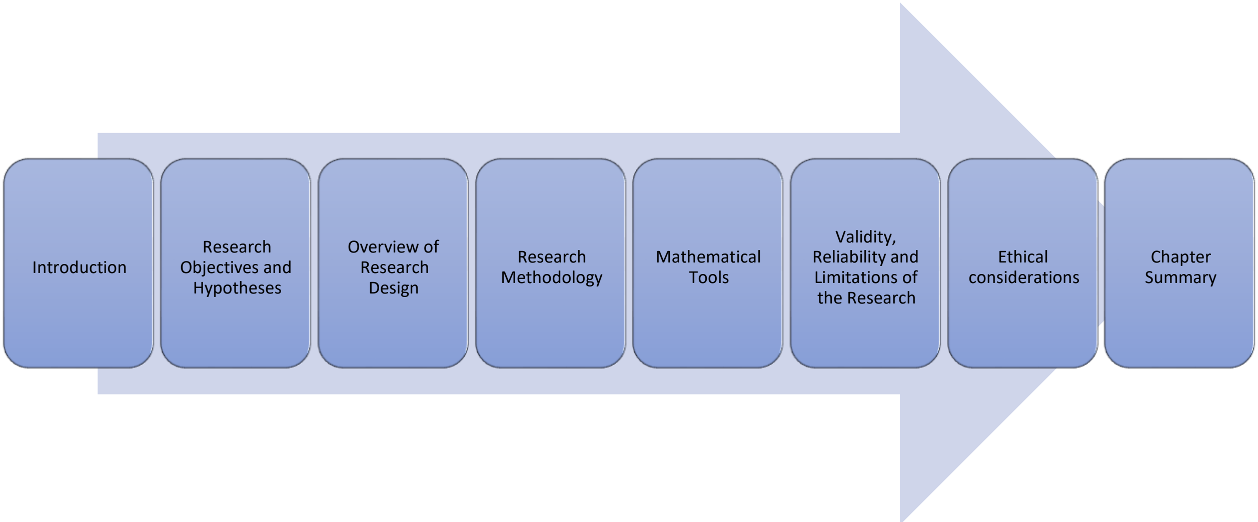

Figure 3.1 Chapter flow diagram

3.2 Research Objectives and Hypotheses

Based on the extracts from the literature review, it is clear that Green Logistics is a current area of research. There are many theoretical as well as empirical studies related to drivers of Green Logistics, barriers of Green Logistics, Green Logistics Practices, and performance parameters of Green Logistics. The drivers, barriers, and practices of Green Logistics have been applied to various manufacturing sectors and from the perspective of different countries. Though, within the limited reach, any single study of empirical nature which deals with all the issues of Green Logistics in one place and that too in the context of the downward logistics of the Oil and Gas industry in India was not found. Moreover, most of the studies have considered either one or at the most two green logistics practices majorly transportation activities of the logistics. This scenario directs a scope to study the subject further. So, the current research work seems to be a suitable topic to work on, the results and findings of which may add to the existing information and knowledge for both academicians as well as practitioners.

To address the research issues and gaps raised through a comprehensive and systematic literature review, presented in chapter 2 of this thesis precisely defined research objectives have been formulated. These objectives have been further used to identify the research hypotheses for research design and analysis purposes. Research objectives are illustrated below:

1) Justification of green logistics over non-green logistics in the context of the Indian Manufacturing Industry.
2) Identification and ranking of crucial barriers hindering the implementation of Green Logistics Practices in the context of the Indian Manufacturing Industry.
3) Identification and ranking of important drivers in select Indian Manufacturing Industry (Oil and Gas) for the implementation of Green Logistics Practices.
4) Identification and ranking of important Green Logistics Practices in select Indian Manufacturing Industry (Oil and Gas).
5) Analyzing Green Logistics Practices and performance parameters after the implementation of green logistics practices in select Indian Manufacturing Industry (Oil and Gas).

6) To develop a conceptual framework for the logistics activities of the Indian Manufacturing Industry(Oil and Gas) that will help the successful implementation of Green Logistics Practices in the future.

Now, the formulation of research hypotheses will be done to explore the relationships among green logistics practices (Green Transportation, Green Warehousing, Green Packaging, and Green Value-Added Services) and Green logistics performance parameters (Environmental performance and Economic performance).

Here, the hypotheses and conceptual framework of the proposed model is delineated as below:

Green Logistics Practices and Environmental Performance

Hypothesis-1 (H1) :

on Environmental Performance

Green Logistics Warehousing Practices has a significant impact

Hypothesis-2 (H2) :

on Environmental Performance

Green Logistics Packaging Practices has a significant impact on

Hypothesis-3 (H3) :

Environmental Performance

Green Logistics Value-Added Services Practices has a significant

Hypothesis-4 (H4) :

Green Logistics Transportation Practices has a significant impact impact

on Environmental Performance

Green Logistics Practices and Economic Performance

Green Logistics Transportation Practices has a significant impact

Hypothesis-5 (H5) :
on Economic Performance

Hypothesis-6 (H6) : Green Logistics Warehousing Practices has a significant impact on Economic Performance

Hypothesis-7 (H7) : Green Logistics Packaging Practices has a significant impact on Economic Performance

Hypothesis-8 (H8) : Green Logistics Value-Added Services Practices has a significant impact on Economic Performance

Mediation Relationship

Hypothesis-9 (H9) : Environmental Performance mediates the relationship between Green Logistics Transportation Practices and Economic Performance

Hypothesis-10 (H10) : Environmental Performance mediates the relationship between Green Logistics Warehousing Practices and Economic Performance

Hypothesis-11 (H11) : Environmental Performance mediates the relationship between Green Logistics Packaging Practices and Economic Performance

Hypothesis-12 (H12) : Environmental Performance mediates the relationship between Green Logistics Value-Added Services Practices and Economic Performance

Moderation Relationship

Hypothesis-13 (H13) : Government and Environment Policies moderate the relationship between Green Logistics Transportation Practices and Environmental Performance

Hypothesis-14 (H14) : Government and Environment Policies moderate the relationship between Green Logistics Warehousing Practices and Environmental Performance

Hypothesis-15 (H15) : Government and Environment Policies moderate the relationship between Green Logistics Packaging Practices and Environmental Performance

Hypothesis-16 (H16) : Government and Environment Policies moderate the relationship between Green Logistics Value-Added Practices and Environmental Performance

Hypothesis-17 (H17) : Government and Environment Policies moderate the relationship between Green Logistics Transportation Practices and Economic Performance

Hypothesis-18 (H18) : Government and Environment Policies moderate the relationship between Green Logistics Warehousing Practices and Economic Performance

Hypothesis-19 (H19) : Government and Environment Policies moderate the relationship between Green Logistics Packaging Practices and Economic Performance

Hypothesis-20 (H20) : Government and Environment Policies moderate the relationship between Green Logistics Value-Added Practices and Economic Performance

The proposed conceptual framework (Figure 3.2) shows that the effects of Green Logistics Practices on Environmental Performance and Economic Performance. The first four hypotheses H1 to H4 show the effect of Green Logistics Practices on Environmental Performance. The next four hypotheses H5 to H8 show the effect of Green Logistics Practices on Economic Performance. The framework also shows the effect of Green Logistics Practices on Economic Performance which is mediated by Environmental Performance. The next four hypotheses from H9 to H12 are dedicated to mediation. The mediator variable for this research study is Environmental Performance.

Apart from the above, the framework also highlights a variable, Government and Environment Policies (GEP), moderating among the Green Logistics Practices and Economic Performance as well as Environmental Performance.

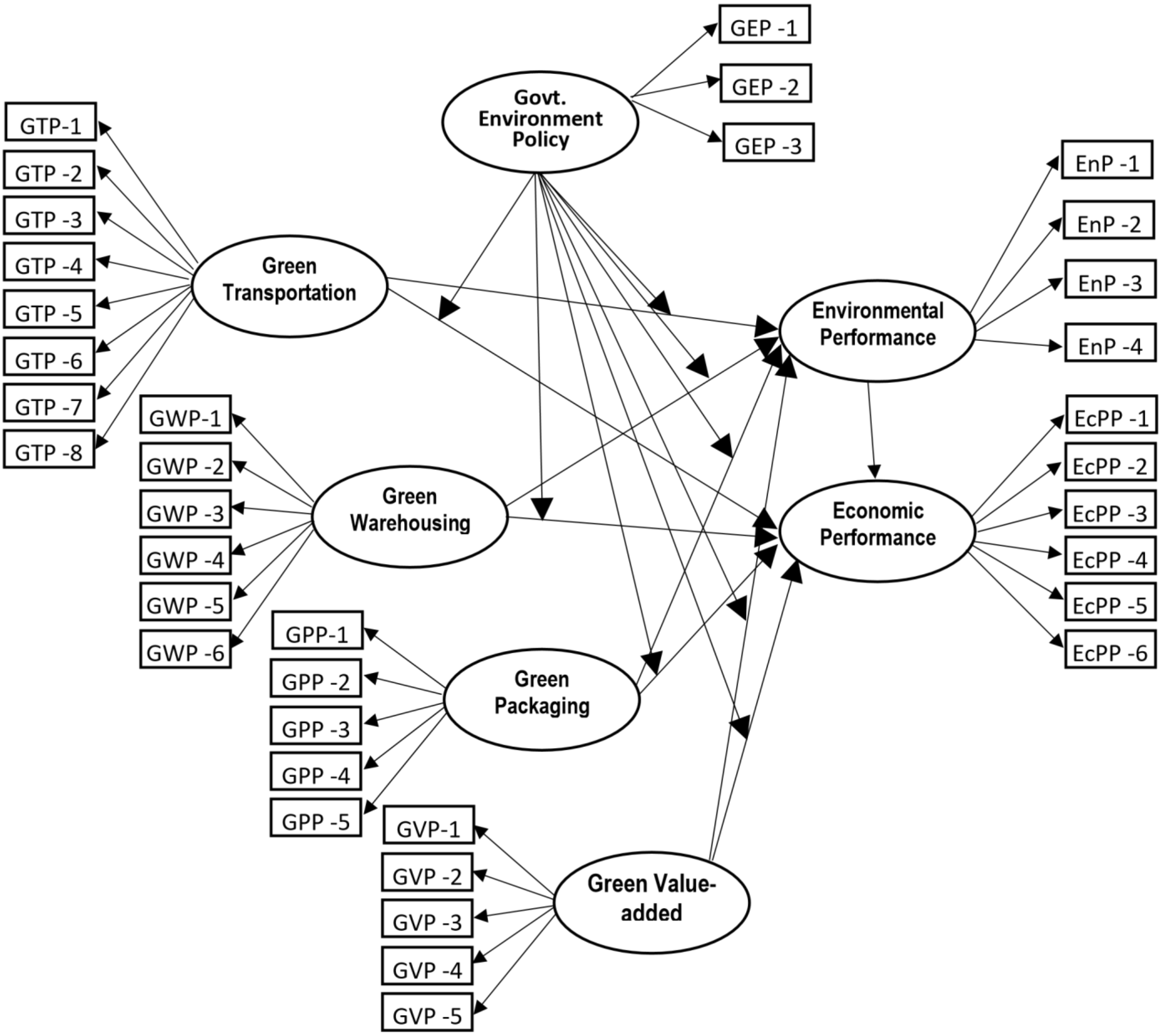

Figure 3.2 Proposed Conceptual Framework (Source: Self)

The moderator consists of the three Green Logistics drivers namely Complying with Government (GLD2), Complying with Internal Regulations (GLD5), and Pressure by Environmental Groups (GLD11). These three drivers are clubbed into one construct namely Government and Environment Policies, which acts as the moderator for the framework. The hypotheses H13 to H20 are the moderation analysis hypotheses. Now, the next section will explain the research design in detail. The primary role of the research design is to create a framework for the proposed research to test the above hypotheses and eventually fulfil the research objectives using exploratory, descriptive and inferential analysis.

3.3 Overview of Research Design

Research design has been defined in the past by many researchers and scholars from different perspectives. Research design is defined as the plan and structure of examination so considered to obtain findings to research questions. It is the complete scheme of the research. The research design consists of a summary that includes what is achieved from writing hypotheses and their inferences to the final analysis of data. A structure is defined as the framework or shape, showing the relationship among variables in the study. Thus, a research design shows both the structure of the research and the plan of investigation used for analyzing relations of the study problem (Blumberg et al., 2008). During the research, the technique and construction of an inquiry or the study chosen by the researcher for doing data collection and analysis are also called a research design.

The purpose of a research design is to confirm that the evidence obtained allows scholars to address the research problem as unmistakably as possible. Without focussing on these design issues earlier, the findings can be weak and unpersuasive and, ultimately, will fail to solve the overall research problem. Research design is planned based on available time and given activities, which depends on several research questions. It is a frame used to find out the relation between the chosen variables. It helps in finalizing the methods to be used during the research and thus supports the researchers.

3.3.1 Types of Research Design

There could be three categories of research designs based on their characteristics, viz., descriptive type of research design, exploratory research design, and explanatory research design. These types of research designs have been discussed briefly in Table 3.1 below:

Table 3.1 Comparing Research Design types

Descriptive research Design	**Exploratory Research Design**	**Explanatory Research Design**
Descriptive research is described as research that defines features of items, people, clusters, organizations, or surroundings; It tries to show the idea of a given situation (Saunders *et al.,* 2012)	Exploratory research is done by getting in-depth information about the study. It is beneficial when the nature of the problem is not explicit, and thus it's open to change. The techniques that can be used to conduct it include, interviews with people in the relevant field, and focus on group discussions (Saunders *et al.*, 2012).	Explanatory research validates causal relationships among variables. The main advantage of this research is to investigate a specific problem to show the relationships among the variables under study (Saunders *et al.*, 2012).

The research methodology followed in our work is the combination of all three types and is called Combination Research Design. The first stage of the study consists of exploratory research design in the concept of green logistics and explored it systematically with the support of Literature Review (by way of various sources like national and international journals, sources from the internet, research reports, magazines, etc.). This helped to get in-depth knowledge and understanding of green logistics and various parameters and factors associated with it in the case of the select Indian manufacturing industry. The exploratory research has been done to form the hypotheses throughout the study and review the literature. The descriptive analysis is used to determine the level at which logistics officials working for the oil and gas industry have information about different green practices in their logistics activities.

This, therefore, helped in collecting the desired amount of data required to carry out our research work. In the last stage, explanatory research is carried to find out the relations between the dependent variables and the independent variables according to the hypotheses formulated in the first stage. In this stage, structured equation modeling has been done which explains the relationship between the dimensions of green logistics practices and performance parameters with moderation and mediation analysis in the context of the oil and gas industry.

It thus fulfils the other objectives of the study. As all the three research designs (exploratory, descriptive, and explanatory) have their usage and requirements, the use of Combination Research Design becomes necessary for our work.

3.4 Research Methodology

The process used in research always follows a distinct sequence of steps mostly in sequential order, and thus, there are well-defined steps for every research. (Opoku et al., 2016). This section will explain these steps (design of research, sampling design, research methods, data collection, data interpretation, and analysis) in detail.

3.4.1 Development of Research Design

There are three types of research methods, namely, Qualitative, Quantitative, and Mixed methods (Creswell, 2009). In this research, a Quantitative Research approach has been undertaken. The questionnaire survey has been taken as the research tool. For doing quantitative analysis, the survey method is very efficient and is mainly used by researchers (Opoku et al., 2016). In the survey method, the structure of the descriptive research designs can be easily formulated and thus helps to evaluate the required parameters by framing questions (Samouel & Page, 2011). Therefore, for the research work, a well-defined questionnaire has been framed, which acts as a primary research instrument. The questionnaire survey was implemented using the offline mode. This survey uses numeric data in the form of scales and close-ended questions. In the current study, a self-administered questionnaire is converted into a lime survey, which was physically given to the logistics managers attached to the Oil and Gas industry in India. They, further, distributed it to the respondents personally. A lime survey is a very user-friendly tool that stores data that can easily be converted into the input format of the statistical software package, i.e., SPSS version- 25.0 (Saunders et al., 2012).

Furthermore, quantitative research design can be classified as experimental designs and non-experimental designs (DeVos et al., 2011). However, for our study, a non-experimental type of research design has been followed which includes surveys (questionnaires) to collect the information. Now, the next section will through some light on the sampling design of our research study.

3.4.2 Sampling Design Formulation

The next step in research methodology is sampling design formulation, which includes various stages that support the proper selection of the sample. In this research study, the data collection is done by using questionnaire forms filled by different logistics companies working for the oil and gas industry in India as responses. This process of data collection was done in two parts. The questionnaire was initially designed and modified a little later after consultation by six experts of the domain. Then, a detailed questionnaire survey has been conducted for the target population and has been distributed through personal networking. There are different stages to select a sample successfully (Zikmund et al.,2010), namely defining the target population, selecting a sampling frame, planning the procedure, and determining sample size. The target population is defined as the people, records, or events that provide all the necessary information required to generate answers for the given questions (Cooper and Schindler, 2011). In the case of our study, the target population is the managers and officials at different levels of the logistics companies located in India. The next is the sampling frame, which is defined as the list of the population from where the samples are drawn (Zikmund et al., 2010). In this study, the list of logistics companies was provided by the Deputy General Manager (DGM) of the Oil and Gas industry (enclosed in appendices). Out of the 380 questionnaires sent to the officials, 278 responded, and only 262 respondents completed the entire survey. A sample unit is defined as a single or group of elements with a focus on the selection in the sample (Zikmund et al., 2010). In this study, sample units are a group of elements that are selected. This included the 380 logistics-related officials of the Oil and Gas Industry identified during the survey process. The next section will discuss the data collection process.

3.4.3 Research Instrument, Survey Design, Structure, and Data Collection

In this section, the explanation of the research instruments, methods, and data collection procedure will be discussed. In various studies, questions with '*What*' are used for exploratory studies, and the questions enquiring with '*How*' are used for explanatory studies. In this research, we aim to develop an analysis-based green logistics framework. Hence, questions starting with '*What*' and '*How*' have been framed in this work for explanatory and exploratory information. Table 3.2 briefed several types of research question coverage that can be answered by different research instruments and methods.

Table 3.2 Question Coverage and Various Instruments

Data Collection Instruments	Question Coverage
Case Study	How, Why, How, many
Survey	Who, Where, How Much, What
Experiment	How, Why
History	How, Why, How Many
Archival Analysis	Where Who, What, How Much

So far as the data collection is concerned, there are various techniques available based on characteristics in the case of the quantitative type of research. Some of the popular quantitative data collection methods are 'structured observations,' 'structured interviews,' 'questionnaire forms,' 'scales and indexes, etc. However, if the interviews or the observation is unstructured, then they will be part of qualitative data collection. Literature Review understands the research problem and thus helps to get information, related data, and details for carrying out the research. For this study, the detailed literature about various features and facets of green logistics is available in the form of multiple primary and secondary data. This has been described in detail in Chapter 2. With the Literature review method, exploratory research is done, which helps to gather all the information about the crucial parameters of green logistics under consideration. The main activities of green logistics, along with their sub-items, are identified, namely green transportation, green warehousing, green packaging, and green value-added services. The main green logistics barriers and drivers were also determined using the literature review method. The various performance parameters were also found and listed in the table in the literature review chapter 2.

Survey Questionnaire investigates and explains the relationships among the variables to be studied. For our research, a thorough survey was conducted by providing the questionnaire to the participants involved in logistics activities of the oil and gas industry with a self-completion approach. Thus, the data is collected using a structured questionnaire. It is a methodically developed instrument for measuring essential characteristics of people, companies, organizations, and other phenomena (Hair et al., 2011).

Self-administered surveys can be categorized into two types, viz., paper surveys, and electronic surveys. In the current study, paper surveys have been found the most appropriate, suiting our needs. The reasons behind its suitability are as below:

- The main advantage of these types of '*survey*' is that it characteristically gathers much higher response rates than their electronic counterparts (Nutty, 2008).
- It is believed that paper surveys are more anonymous than online surveys, due to which it will have fewer chances of bias, and respondents will be more anonymous (Dillman, 2007).
- Also, printed surveys have formatting, which looks the same for all respondents. Thus the environment is similar for all respondents.

The research instrument (Appendix-1) – consisted of a structured disguised questionnaire which was prepared based on the literature survey. The objectives of the study were kept in mind and also the coverage of the secondary data analysis. The closed-ended questions with multiple options were used. The main disadvantage of paper surveys is that they require higher resources. But in this case, as the logistics officials were working for the Oil and Gas industry, so could be contacted easily and filled with a higher response rate. While designing the layout of the questionnaire survey, some crucial points should be considered as shown in

Table 3.3.

Table 3.3 Design Considerations of Questionnaire Survey

Visual Aspect of the Form	The first point in survey design is that it must be easy, clear, and must provide the respondent with a user-friendly platform. In this research, we have made the form as user-friendly and straightforward as possible.
Survey Guidelines	Survey guidelines should be stated clearly at every step, along with the instructions.
Completion Time of Survey	The time should be specified in advance, and therefore, before starting the survey, the respondent can free himself for that much duration. Mostly, the average time is about 20 minutes.
Types of Questions	Both types of questions that are open-ended questions and close-ended questions can be asked, and no personal questions should be a part of the survey.
Sequences of questions	The sequence is very important in the survey questionnaire. In our study, first, the general questions are asked and then questions related to the concerned factors have been asked.

The questionnaire had been formed in such a manner that respondents had fully understood the questions and the requirements of data collection as per the research study. The questionnaire had been divided into three sections, which consisted of different types of questions indicating items. The first section of the Questionnaire had several questions related to the basic information of the respondent's logistics company. The second section of the questionnaire consisted of questions related to green logistics drivers, to get the viewpoint of the respondents about drivers. The third section of the questionnaire for data collection consisted of various green logistics practices and their impact on the performance parameters.

3.4.4 Data Interpretation and Analysis

The questionnaire surveys were filled and the answers were tabulated using data management packages such as Microsoft Excel, 2017. After classifying the data, the responses to the survey were examined for finding the essential green logistics practices and drivers that could be adopted. After conducting the data analysis, this step had introduced the empirical results and research findings coming out after thorough discussions and using appropriate Statistical Tools which involved using SPSS ver 25.0 for Exploratory Factor Analysis and AMOS ver26.0 for Confirmatory Factor Analysis and Structured Equation Modelling. A detailed study about the empirical results, research findings, and related discussion have been performed in Chapter 6 and Chapter 7 of this thesis**.**

3.5 Mathematical Tools

In the previous sections, data collection, descriptive and statistical analysis, and related topics have been discussed. Whereas, this complete close-ended data is analyzed for the research findings based on a statistical study of the data using the software package SPSS ver25.0 and AMOS ver26.0. The research study in the first objective analyses the ways using AHP by which the Indian Manufacturing industry can accomplish positive environmental effects by merely changing their logistics operations and systems. The second objective establishes connections among the barriers using the DEMATEL technique and thus finds out the most crucial barrier in the implementation of green logistics. Therefore, these tools need to be discussed below:

3.5.1 Analytical Hierarchical Process

Saaty's (1996) analytic hierarchy approach is a strong multicriteria decision-making tool that has been used in several fields including economics, politics, and engineering. The AHP method allows each additional alternative to be assigned a value reflecting the preference degree for a given alternative. Centered on a hierarchical structure, certain values can be used to define and choose alternatives. It can be shown that AHP is the most commonly used tool for software evaluation. They've even been used to pick manufacturers and vendors. AHP has been combined with other techniques in recent approaches. The approach begins by arranging a decision-making problem in the form of an upside-down tree, with the primary target at the top. At the second stage, partial goals that reach the primary target are imposed. Every partial second-level objective can be decomposed into third-level goals, and each set at each level meets the target of the level to which it is subordinate. In this text, these partial goals are regarded as requirements. At a lower level, the alternatives are identified and then compared pairwise in terms of their contribution to achieving each of the lower level's goals or criteria. At the fundamental scale, pairwise comparisons are performed using the method defined by Saaty.

3.5.2 Decision Making Trial and Evaluation Laboratory (DEMATEL)

Decision-Making Trial and Evaluation Laboratory(DEMATEL) is a method for developing and analyzing a structural model for evaluating causal relationships among complex criteria. It's a common and useful tool for determining cause and effect relationships among criteria, ranking important criteria on the same dimension for longterm strategic decision-making, and defining improvement scopes. Between 1972 and 1976, the Geneva Research Center of the Battelle Memorial Institute of Geneva created the DEMATEL technique (Gabus and Fontela, 1972). DEMATEL's basic idea is a digraph theory, which helps one to examine the system's cause and effect by separating and relating the problems (Falatoonitoosi, 2013). Visualization is used to solve problems in this process. Also, the suggested method defines the powerful weights of criteria by taking into account the hierarchy of criteria based on the 2-tuple DEMATEL technique's performance.

3.6 Validity, Reliability and Limitations of the Research

It is always necessary to highlight and evaluate the validity and reliability of the research after following a particular Research Methodology.

3.6.1 Research Validity

There are five types of research validity methods in any research being conducted, viz., Internal Validity, Content Validity, Criterion-related Validity, Construct Validity, and External Validity (Saunders et al., 2012). Table 3.4 shows the tabular comparison among different validation categories. In this research study, Internal Validity, Content Validity, and Construct Validity are being fulfilled.

Table 3.4 Comparing Validation Categories

Internal Validity	It highlights casual relations among variables. In the questionnaire, this validity is the ability to know and measure what is desired.
Content Validity	It refers to the degree to which some measurement-related questions are written in the questionnaire and thus provide information for investigative research. In our study, the questionnaire is drafted based on a literature review and associated methods.
Criterion Validity	It refers to those research questions which provide exact and truthful predictions.
Construct Validity	It is for those research, which uses suitable measures of variables. Also, it determines that whether the performance of the test highlights the set of related variables.
External Validity	It is related to the whether research findings of the showed study can be generalized or not. Also, it determines if the findings of the research can be applied even if the groups are changed

3.6.2 Reliability

The reliability of a research study is observed when the data collection methods and various analytical measures used by the researcher, provide consistent and reliable results every time. This trend should continue in recurrence even if the test is performed by some other researcher or performed at a different time under dissimilar situations (Saunders et al., 2012). Therefore, if a test does produce the same results recurrently when performed in the same environment, it can be said that reliability is achieved. In this study, all three research methods, namely exploratory, descriptive, and explanatory have been used. Thus, to

examine the reliability of the results, some continuation work like result discussions & findings is necessary, which is explained in detail in chapter
7.

3.6.3 Limitations of the Study

Green Logistics is a much-discussed field in India, but the manufacturing industry has still not implemented the concept in actual activities of the logistics. This research study is done only for the select Indian Manufacturing industry, and it could be done for a similar type of other manufacturing sectors. The detailed discussion regarding the limitations of the study shall be presented in Chapter 8, after submitting the complete work.

3.7 Ethical Considerations

Ethical considerations are said to be the ethics of science, which are concerned with what is wrong and what is right during the conduct of research (Mouton, 2001). Also, the relationship with friends, colleagues, workers, and surrounding conditions give rise to moral behavior values and ethical considerations. The concepts and meanings of ethics are different in consideration among various people as we all have different perceptions to look at things, or our nature and moral standards are different.

In this study, participants or respondents did not undergo any emotional or physical hurt or stress. The timings of the survey are carefully selected, and the survey took just 15-20 minutes of the respondent's time. The survey form is quite simple and easy to handle. The participation of the respondents in the survey is voluntary, and none of them is forced in any manner. A 'Brief Information Sheet is framed for carrying out the Survey,' and a 'Consent Form' is also provided to the participants. This information sheet contains all the required details precisely. It was provided to all interested candidates so that he/she could choose whether they want to participate in the survey or not.

3.8 Chapter Summary

This chapter thoroughly discussed the research methodology used in this research work. The chapter begins with the research objectives and hypotheses for the research work, and after that, various types of research designs are discussed. The six objectives were formulated for the complete research study. Based on these research objectives, twenty hypotheses were delineated to fulfill the research gaps. The research design chosen is the combined research design as per our objectives. Then the Research Methodology used in this work is presented, which gives a clear picture of how the work will be analyzed in the next chapter. The 5 points Likert survey questionnaire was designed based on the literature review and modified with the help of experts from the Oil and Gas industry. The questionnaire was used as the research instrument in the study. It investigated the relationship between green logistics practices and green logistics performances. The validity and reliability of the research work are also discussed, which is very important for any research validation. Ethical consideration is also essential for any research work and thus briefed lastly in this chapter.

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Chapter- 4

Justification of Green Logistics over non-Green Logistics

4.1 Introduction

This chapter justifies Green Logistics over non-Green Logistics in the Indian manufacturing industry. It has already been discussed in the literature that when the manufacturing industry adopts Green Logistics, it will achieve many benefits in different aspects. In addition to the main objectives of achieving organizational targets, the Manufacturing industry may increase productivity and attain a range of other longterm benefits by incorporating greening initiatives in logistics activities. By integrating the green concept into logistics systems, the manufacturing industry will benefit from improved productivity as well as other benefits such as increased market share and profit margins (Rao and Holt, 2005). Non-Green Logistics (NGL) is defined as the traditional logistics system that involves planning, implementation, and controlling the flow and storage of raw material, in-process goods, finished goods, and the related information from the starting point to the endpoint. Green logistics (GL) also has the same objective as non-green logistics (NGL) to minimize the effect of these activities on the environment. The manufacturing industry has a crucial role in the Indian economy therefore, it is justified to compare the benefits of Green Logistics and nonGreen Logistics in this sector. In the Indian context, it is typical to find that the manufacturing industry is normally located far away from their target markets. As a result, they must adopt economically controlled and environmentally competitive logistics activities to develop strategies for cost-effective environmental management. This chapter presents the justification to evaluate the benefits of Green Logistics critically and justifying the adaptation using the Analytical Hierarchy Process in the

Indian Manufacturing Industry. The chapter flow is shown in figure 4.1. The next section describes the selection of benefits of green logistics based on the literature.

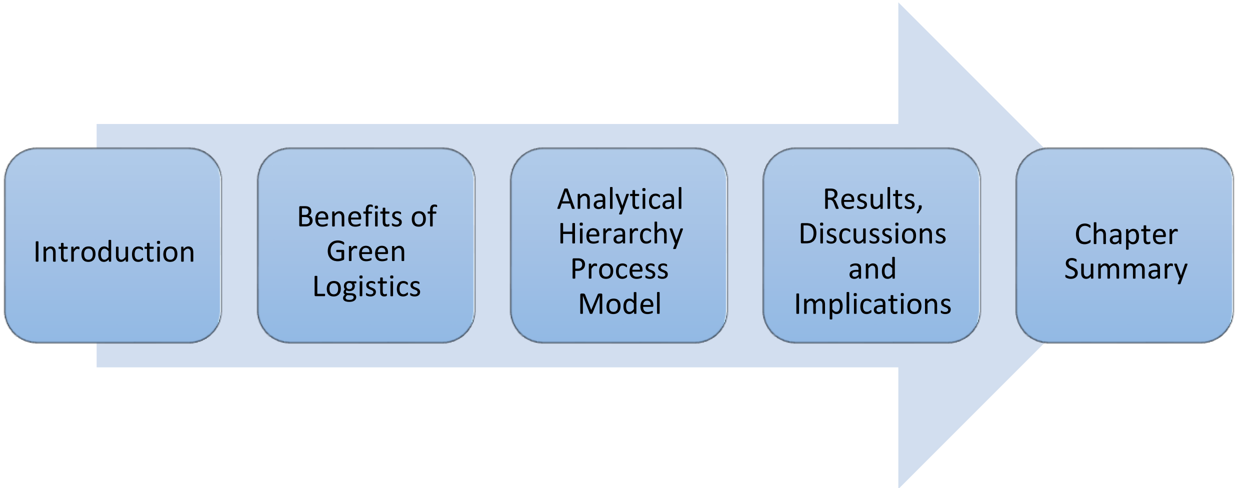

Figure 4.1 Chapter flow diagram

4.2 Benefits of Green Logistics

Since the manufacturing industry is so important to the Indian economy, it's fair to compare the advantages of green and non-green logistics in this market. In the Indian context, it is typical to find that most manufacturing industry always has fewer resources. As a result, manufacturing organizations must adopt economically controlled and environmentally competitive logistics activities to develop strategies for costeffective environmental management. The Indian manufacturing industry engages in large-scale processing, storage, and transportation of a variety of goods, posing major environmental challenges. Today's top environmental issue is global warming, which is often related to large-scale greenhouse gas emissions from factories. In this respect, various decision techniques, such as the Analytical Hierarchy Process (AHP) are, therefore, an important method.

Given the role of the manufacturing industry in the development of the Indian economy, research is required to encourage these businesses to follow Green Logistics procedures in the interest of the global environmental system. The study is done to justify the adaptation of green logistics concepts in manufacturing enterprises based on different benefits. The major benefits of Green Logistics over non-Green Logistics have been recognized from the literature review and the various experts of the manufacturing sector. These are the protection of the ecological environment (Wang et al., 2020; Guirong and Zongjian, 2012), reduction of CO2 emissions (Wang et al., 2020; Xue et al., 2019; Rizet et al., 2012), quality improvement (Zhang et al., 2020; Li et al., 2019), energy-saving (Zhang et al., 2020; Sureeyatanpas et al., 2018; Conding et al., 2013), reduction in distances (Zaman et al., 2016; Ubeda et al., 2011) and managing waste disposal (Eduardo et al., 2019; Apaydın and Gonullu, 2011) as shown in Table 4.1.

Table 4.1 Benefits of Green Logistics

Benefits of Green Logistics (GL)	**Abbreviation**	**References**
Protection of the ecological environment	PEE	Wang et al., 2020; Eduardo et al., 2019; Zhang and Zhao, 2012
Reduction of Carbon Emissions	RCE	Wang et al., 2020; Xue et al., 2019; Rizet et al., 2012
Quality Improvement	QI	Zhang et al., 2020; Stellingwerf et al., 2020; Li et al., 2019
Energy saving	ES	Zhang et al., 2020; Sureeyatanpas et al., 2018
Reduction in Distance	RD	Zaman et al., 2016; Ubeda et al., 2011
Managing Waste Disposal	MWD	Eduardo et al., 2019; Apaydın and Gonullu, 2011

There can be two alternatives available for the management to choose from, and these are green logistics (GL) and non-green logistics (NGL). In Green Logistics, the manufacturing industry follows and implements the various ecological concepts and environmental measures while deciding the logistics operations across the supply chain. In contrast, in non-Green Logistics, decisions are made to achieve traditional techniques without considering green factors. Justification of Green Logistics has been based on benefits resulting from it. The next section will present the implementation of the

Analytical Hierarchical Process (AHP) to evaluate the benefits of Green Logistics critically and to justify the adaptation in the Indian Manufacturing Industry.

4.3 Analytical Hierarchical Process (AHP) modeling

In this, the Analytic Hierarchy Process (AHP) to justify the concept of Green Logistics in the Indian manufacturing industry. AHP is a widespread technique developed by Saaty (1980) to solve multi decisions, complex, multi-factor, and nonstructured real-life problems. This facilitated the researchers to realize the research objectives more efficiently by obtaining benefits from all the methods collectively. The following five-phase procedure has been observed in this chapter:

1. Define and structure the problem
2. Build the AHP model
3. Collect primary data from the expert interviews 4. Determine the normalized priority weights of all factors
5. Find the solution to the defined problem.

4.3.1 Phase 1 - Define and structure the problem

The first phase in this research involves defining and structuring the complete problem domain, along with the selection of main parameters in the area of green logistics. These parameters have been selected based on the literature reviewed in the area of green logistics. Based on the parameters chosen and the literature, the goal or aim of the AHP model is defined. The main aim is to justify the strategic application of green logistics over non-green logistics in the global industrial scenario.

4.3.2 Phase 2 - Build the AHP model

This process entails creating the AHP model, which includes goals, key factors, and outcomes. This study aimed to explain the use of Green Logistics over non-Green Logistics. As shown in figure 4.2, the goal has been put at the top of the hierarchy. Six major benefits are listed and put on the second level of the hierarchy: protection of the environmental conservation (PEE), reduction of carbon emissions (RCE), quality improvement (QI), energy-saving (ES), distance reduction (RD), and waste management (MWD). Green Logistics (GL) and Non-Green Logistics (NGL) are the two alternatives to the problem at the third level. The diagram of the AHP model is shown in Figure 4.2.

4.3.3 Phase -3 Collect and measure primary data

Once the hierarchy model for AHP has been developed, the next step is to measure and collect primary data. This was done by choosing nine experts and assigning the pairwise comparison to the AHP hierarchy's key factors. These experts were drawn from a range of manufacturing industries. A few of the experts were shop floor supervisors, and some were distribution managers in the manufacturing industry. The panel of experts also included a group of people who worked as consultants regarding environmental issues. Researchers have also empaneled a small group of experts with a strength of fewer than ten members for data collection in AHP, according to the literature. (Sultan et al.,2016; Bayazit and Karpak, 2013).

To allocate comparative scores to the pairwise comparison between key factors, Saaty (1994) established a nine-point scale for AHP (Table 4.2). The experts were asked to give each comparison a relative score on Thomas Saaty’s nine-point scale, and the process was replicated at all levels of hierarchy.

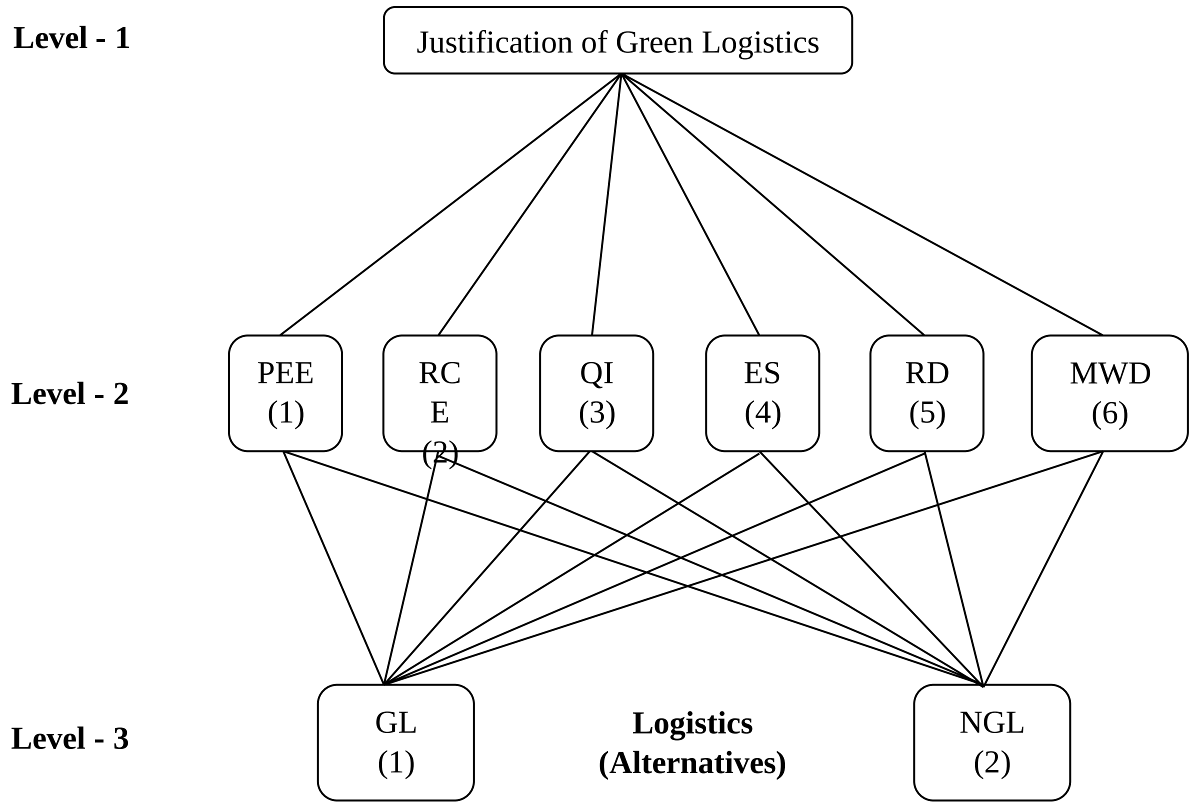

Figure 4.2 The AHP Model

The team of experts consisted of people from the manufacturing industry and academia. A questionnaire was developed to collect primary data from experts, which included all major variables, and was used to gain pairwise comparative opinion from the experts. Under the condition of no consensus, importance would be given to the decision which had a majority.

4.3.4 Phase – 4 Determine the normalized priority weights

This phase defines the comparative significance of six major factors that have been described earlier. Based on the experts' opinion during the data collection in the previous phase, pairwise comparison judgment matrices have been prepared. Now, to determine the normalized weight, the following procedure has been followed:

1. Formulation of pairwise comparison matrices:

In this step, pairwise comparison matrixes are constructed for each of the lowerlevel attributes. The higher-level element is the governing element for the lower-level element. Comparison is made between the lower-level elements of each other. This is done based on their impact on the governing factor above it. This offers a square matrix of decisions. The pairwise comparison is made in terms of the supremacy of an element over another element to convey judgments as integers. If element 1 is higher than element 2 then the whole integer is entered in row 1 of column 2 and the integer is entered in row 2 of column 1. If the matching elements are the same, the value 1 is assigned to both positions. Table 4.2 shows the pairwise comparison matrix for the level 2 criterion. There are n(n-1)/2 judgments available for the development of a set of matrices.

2. Validation of results: calculation for the degree of consistency

In AHP, the responders used to indicate inconsistencies in their answers. It is therefore important to determine the consistency level of the approximate vector used to test the consistency of the pairwise comparison. Saaty (1994) has provided an appropriate consistency ratio (CR) for different matrices depending on the size of the matrix. For example, a 3 x 3 matrix has a CR value of 0.05, a 4 x 4 matrix has a CR value of 0.08, and for large matrices, the CR value is 0.1. The results will be considered valid if the consistency level falls into the acceptable range. Consistency is determined using Eigenvalues after making all the comparisons and entering the data. For doing this column of numbers is normalized by dividing each entry by the sum of total entries then the sum of each row of the normalized value is calculated and the average is calculated. Eventually, the priority vector(PV) is obtained. The next is to find out the Consistency ratio.

Table 4.2 Average random index values (Saaty, 1980)

N	1	2	3	4	5	6
RCI	0	0	0.58	0.90	1.12	1.24

Depending upon the value of CR, judgments are considered consistent. If the consistency ratio is less than 10%, the judgment is considered consistent, and if the consistency ratio is more than 10%, then the judgment quality should be enhanced.

4.3.5 Phase – 5 Find the solution to the problem

The final step is to find a way to justify green logistics factors. This is achieved after the normalised priority weights have been calculated. For each of the GL and NGL, a set of global priority weights was obtained by multiplying the local weights of the lower factors with the weights of all the higher parent factors and then applying all the multiplied products to the alternatives.

The above illustrated AHP modeling procedure was followed to conceptualize the decision-making model with the help of industry experts. The next section will summarize the results of the model and provide some insights and discussion relevant to the practical implementation of green logistics in the Indian Manufacturing Industry.

4.4 Results, Discussion, and Implications

Six major factors are taken into consideration during the formulation of the hierarchy model of AHP. The formulated AHP model, as shown in figure 4.1 is used for justification of green logistics over non-green logistics in the Indian manufacturing industry. After the AHP model, which determined the normalized weight, the pairwise comparison judgment matrices are constructed. The formulation of criteria pairwise comparison matrix was done for all the major six benefits viz., protection of the ecological environment (PEE), reduction of carbon emissions (RCE), quality improvement (QI), energy-saving (ES), reduction in distances (RD), managing waste disposal (MWD) (Table 4.3). Consistency ratio (CR) is an important parameter while using AHP and is calculated for verifying the degree of consistency in the pairwise comparison matrix. For other levels also the same method is followed for the calculation of PV and CR. The results are shown in Table 4.4. From the table of results, it is obtained that for all six factors, GL has more PV in comparison to NGL. The validity and consistency of the decision also exist as the value of the CR is less than 0.1 for all factors. The local weights of attributes for alternatives are shown in Table no. 4.5. The global weights of the six major benefits for GL are shown in Table 4.6. For the calculation of global weights, the individual weights of the main factors and subfactors are to be found. These individual weights are equal to the PV value of the corresponding normalized table. In similar lines, global weights for two alternatives can also be calculated as illustrated below:

Global weights of green logistics (GL) = Level 2 weights x GL weight Global weights of non-green logistics (NGL) = Level 2 weights x NGL weight Total Global Weight = Sum of the global weight of the respective column.

The literature review revealed six major benefits of green logistics over nongreen logistics. Out of all the benefits, the highest global weight is energy saving (0.27339). Logistics in any manufacturing enterprise requires and utilizes energy thus logistics should be optimized in such a way that during various phases of the process, energy efficiency is of major concern. By implementing greener practices in logistics, energy supply, and consumption can be saved. It should be done seriously by any manufacturing industry not only for the environment but for the present and future societies and mankind. The second highest global weight is the reduction in carbon emission (0.2242). Inflated carbon footprint is a major problem with the globalization of logistics activity. Hence, it is needed to effectively and efficiently design the logistics, which should be eco-friendly to improve environmental performance. When green logistics is incorporated, the carbon emissions will reduce, which is quite beneficial for the organization as well as for the environment. The third highest is for the protection of the ecological environment (0.2132). Due to the increased demand, the resources available are depleting very fast. Single usage of the packaging product in logistics reduces product life. The ill effect is consuming a large number of resources together with the threat on the ecological environment. So, by developing and practicing GL, it leads to the protection of the ecological environment, which is a major benefit and major requirement. The fourth major benefit is managing waste disposal (0.076). Waste disposal is a major issue of concern both by the organization and by the government. A lot of human resources, money, and other resources are to be incorporated to manage the disposed waste. Green Logistics helps in managing waste disposal by utilizing green methods, which will ultimately save the resources involved in waste disposal. The next benefit of Green Logistics as per the global desirability index is the reduction in the distance (0.0506). The activity of transport is an important aspect of logistics. By developing delivery rescheduling and backhauling methods in green logistics, the distance of transportation is reduced, which leads to greater fuel efficiency and less environmental impact. The last benefit discussed in the literature review is a quality improvement (0.0251). The manufacturing industry should have an improvement in the quality of the product manufactured. In green logistics, quality improvement is possible by practicing various proactive environmental strategies that involve the use of innovative and better technologies. Quality initiatives should be intended to fulfill manufacturing enterprises' goals along with achieving sustainable development, which includes environmental, social, and economic issues.

Table 4.7 displays the Global Desirability Index for Green Logistics and Non-Green

Logistics. The Green Logistics Global Desirability Index is higher than the non-Green Logistics Index. This research has shown that the introduction of Green Logistics is justified for the Indian manufacturing sector.

Table 4.3 Criteria pairwise comparison matrix (level 2)

	PEE	RCE	QI	ES	RD	MWD	PV.
PEE	1	3	5	0.25	6	2	0.248825
RCE	0.333	1	4	2	5	4	0.252244
QI	0.2	0.25	1	0.166	0.333	0.5	0.037748
ES	4	0.5	6	1	4	5	0.312447
RD	0.166	0.2	3	0.25	1	0.25	0.056925
MWD	0.5	0.25	2	0.2	4	1	0.09181

Table 4.4 Pairwise comparison judgment matrices

Alternative analysis for PEE			
	GL	*NGL*	*PV.*
GL	1.00	6.00	0.86
NGL	0.17	1.00	0.14
Total	1.17	7.00	
Alternative analysis for RCE			
	GL	*NGL*	*PV.*
GL	1.00	8.00	0.89
NGL	0.13	1.00	0.11
Total	1.13	9.00	
Alternative analysis for QI			
	GL	*NGL*	*PV.*
GL	1.00	2.00	0.67
NGL	0.50	1.00	0.33
Total	1.50	3.00	
Alternative analysis for ES			
	GL	*NGL*	*PV.*
GL	1.00	7.00	0.88

NGL	0.14	1.00	0.13
Total	1.14	8.00	
Alternative analysis for RD			
	GL	*NGL*	*PV.*
GL	1.00	8.00	0.89
NGL	0.13	1.00	0.11
Total	1.13	9.00	
Alternative analysis for MWD			
	GL	*NGL*	*PV.*
GL	1.00	5.00	0.83
NGL	0.20	1.00	0.17
Total	1.20	6.00	

Table 4.5 Weights of Attributes for Alternatives

Sl. No.	**Attributes**	**Level 2 Weights (PV) From Table 1**	**GL Weight (PV) (From Each Analysis)**	**NGL Weight (PV) (From Each Alternative)**
1	PEE	0.248825088	0.86	0.14
2	RCE	0.252243993	0.89	0.11
3	QI	0.037748447	0.67	0.33
4	ES	0.312446697	0.88	0.13
5	RD	0.056925416	0.89	0.11
6	MWD	0.091810359	0.83	0.17

Table 4.6 Desirability Index of Alternatives Global Weight

Sl. No.	**Attributes**	**GL global Wt.**	**NGL global Wt.**
1	PEE	0.213278647	0.035546441
2	RCE	0.224216883	0.02802711
3	QI	0.025165631	0.012582816
4	ES	0.27339086	0.039055837
5	RD	0.050600369	0.006325046
6	MWD	0.076508633	0.015301727
Total Global Weight		0.863161023	0.136838977

Table 4.7 Global Desirability index of alternatives

1	Global desirability index of Green Logistic	0.863161
2	Global desirability index of Non-Green Logistic	0.136839

4.5 Chapter Summary

The practice of green issues in the 21st century is a major social and business concern. Government regulation, fluctuating market demand, lack of sufficient resources, the development of international certification standards are just some of the reasons for their relevance. Green Logistics activities will achieve both economic and environmental objectives. In such an age of environmentalism, Green Logistics manufacturing firms will profit. The benefits would eventually lead to better results, increased market shares, and higher profits. In this chapter, the theoretical hierarchy process is used to explain the major benefits extracted from the literature review of green logistics in the manufacturing sector. After the benefits were extracted, the study had been carried out and it was found that, out of the six main benefits of Green Logistics, energy savings had the highest degree of global desirability(0.039). It had been accompanied by a reduction in carbon emissions, environmental conservation, waste disposal management, distance reduction, and energy saving. These results would have a significant impact on encouraging the manufacturing industry to adopt green logistics to boost its performance in terms of energy production and usage, carbon footprint reduction, environmental sustainability, etc. The findings of this research will allow potential researchers to prioritize different variables according to their benefits and to provide a holistic approach to Green Logistics in the Indian manufacturing industry.

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Chapter- 5

Modelling of Green Logistics Barriers

5.1 Introduction

In today's situation, it is becoming challenging to manage the antagonistic effects of the non-sustainable manufacturing activities involved in logistics. It has also been justified that significant improvement in logistics activities involved in the manufacturing industry across the global economy will happen by adopting green practices. The flow of logistics should also achieve the satisfaction of the customers as well as the organizational goals, along to reduce the effect of these activities on the environment (Rodrigue et al., 2001). Green Logistics helps the manufacturing industry to reduce unnecessary utilization of resources, reduce waste, and thus help in environmental and social expectations for ecological preservation (Lai and Wong, 2012). The industries are working diligently to implement green practices since the active implementation will gain a competitive advantage and help them move towards sustainability. (Zhu and Sarkis, 2004; Mathiyazhagan et al., 2014). But, the manufacturing industry faces a lot of barriers in implementing and adopting green logistics at their end. Many studies discuss the barriers of green logistics in the manufacturing industry that pose a severe problem in the implementation of green logistics practices. (Blok et al., 2015; Kaur et al., 2018; Oliveira et al., 2018). Thus it becomes highly essential to identify the barriers in the Indian manufacturing industry and analyze these barriers. Once the barriers are identified, an investigation is done to find out the dependence of each barrier over another. This is done with the help of the managers and academicians working in the areas of green logistics. Decision making trial and evaluation laboratory (DEMATEL), along with MATLAB, is used for the analysis of the barriers, and once the technique is applied, the result will show the most significant barrier. It is suggested that the manufacturing industry practitioners and policymakers must take measures in overcoming these barriers to the successful adoption of green logistics.

This chapter analyzes how barriers can affect green logistics practices in the Indian Manufacturing industry using DEMATEL. The chapter flow diagram is shown in Figure 5.1.

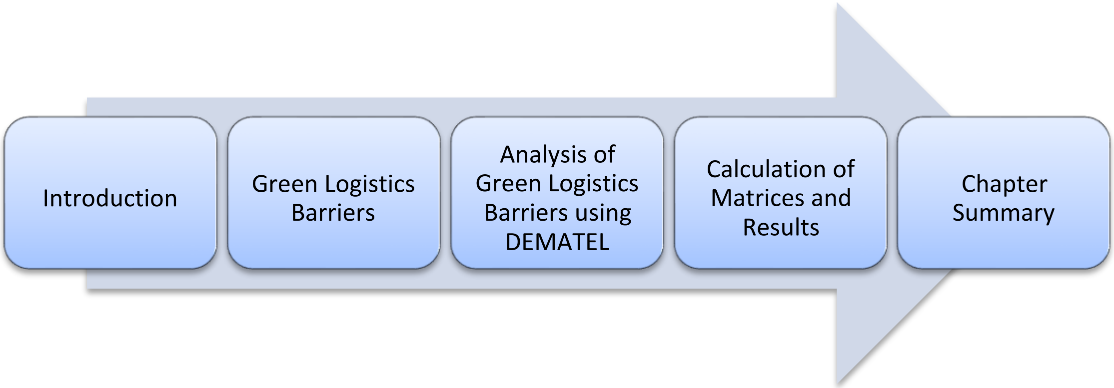

Figure 5.1 The chapter flow diagram

However, the next section will describe the manufacturing industry-specific barriers, listed in the study earlier.

5.2 Green Logistics Barriers

The barriers create problems in the implementation of green logistics practices in the industries. Thus, it becomes highly important to identify the barriers and analyze these barriers. The analysis helps the employers to understand the factors which act as hindrances towards greener elements in logistics. The implementation of green logistics practices in the manufacturing industry is becoming vital from the environmental aspect and thus the hindrances need to be removed. Therefore, the analysis of the barriers in the manufacturing industry is done. In this study, the Green Logistics Barriers were identified through literature review and from the help of people who are experts in this area. The team of experts consisted of sixteen people in total from academia and the manufacturing industry. The list of crucial barriers chosen for the study has already been discussed in chapter 2 of the study.

5.3 Analysis of Green Logistics Barriers using DEMATEL

Decision making trial and evaluation laboratory (DEMATEL) technique (Gabus and Fontela, 1972; Torbacki, 2017) is used for the analysis of barriers for the implementation of green logistics in the case company. The technique has already been explained in detail in chapter 3, illustrating the research methodology used in the thesis. The method is used to identify the relationship between various identified important barriers. The technique is used along with MATLAB version 2017 to find the correlation. The following steps have been conducted in the study:

Step-1 Direct Relationship Matrix - At first four scales determine the interdependence of relationships between different factors according to the experts' opinion. The value ranges from 1 to 4 and based on this scale, a direct relationship matrix is formed. First of all, each respondent was asked to evaluate the direct influence between any two factors by an integer score from 0-4 representing as 0 = no influence 1 = low influence 2 = medium influence 3 = high influence 4 = very high influence. To incorporate all opinions from H respondents, the average matrix $\boldsymbol{A} = [aij]$ has been constructed as follows:

$$\mathbf{A} = [aij] = \mathbf{1}\ H \sum xij\ H\ k$$

Step-2 Normalized Direct Relationship Matrix - The second step was to normalize the values obtained from the first table. Normalize initial direct relation matrix $\boldsymbol{D}$ by

$$\boldsymbol{D} = m \times \boldsymbol{A},$$

Each element in matrix *D* falls between zero and one. Since the sum of each row *i* of the matrix *A*, represented the total direct effect that the factor *i* gives to other factors. Likewise, since the sum of each column *j* of the matrix *A*, is the total direct effect received by the factor *j*, and thus have the largest total direct effect received for all factors.

Step-3 Total Relationship Matrix – This step involved the calculation of the total relationship matrix. The power of the normalized initial direct-relation matrix D, D^m, which is called m-indirect influence, is used to represent the effect of length m or the effect propagated after m - 1 intermediate. The total influence or total relation can be obtained by summing up D, D^2, D^3,... The original DEMATEL assumes that D^m would converge to zero matrix.

Step-4 Total Relationship Matrix with D & R – In this step, one factor which affects another factor was calculated, using the Total relationship matrix. The size of the matrix is important for this. Also, D and R were calculated. D is the sum of rows, and R is the sum of columns. The calculation of the sum of columns and sum of rows is important as in the next step the ranking of the factors was based on the values of Sum of rows and sum of columns.

Step-5 Cause and effect table and Diagram – In this final step, the values of D-R and D+R are calculated. D-R is the kind of relation between criteria. This is the cause group if its value is negative and the effect group if its value is positive. D+R is the degree of the relation of each criterion with others. The value of D+ R decides the ranking of the factors. The highest value of D+ R is categorized as the most important factor out of all the factors based on the relation of each criterion.

5.4 Calculation of Matrices and Results

Decision making trial and evaluation laboratory technique (DEMATEL) is a mathematical method that can be easily applied using a popular software package called MATLAB. For this study, the 2017b version of the package has been used. Table 5.1 shows the direct relationship matrix based on the selected barriers and their interdependence values.

Table 5.1 Direct Relationship Matrix

Barriers	. Less ROI	. No economics of scale for GL	. Lack of access to govt. subsidies and incentives	. Non -interest of Top level Mgt towards GLP	. Less internal sustainability audits	. Reluctance to switch to green practices	. Lack of investment in R&D	. Lack of effective env. Measures	. Lack of Resources to Switch	. Lack of Training Courses	. Lack of env. Awareness	. Complexity of design to re -use and recycle	. Lack of Technological information reg GLP implementation	. Lack of sustainability certification	. Lack of Integration of IT systems	. Lack of customer awareness towards GLP
1. Less ROI	0/35	3/35	1/35	3/35	3/35	4/35	3/35	1/35	1/35	3/35	1/35	1/35	1/35	1/35	2/35	1/35
2. No economics of scale for GL	1/35	0/35	1/35	2/35	2/35	3/35	4/35	1/35	1/35	2/35	1/35	1/35	1/35	1/35	2/35	1/35
3. Lack of access to govt. subsidies and incentives	1/35	2/35	0/35	1/35	1/35	3/35	3/35	2/35	1/35	1/35	2/35	1/35	2/35	2/35	1/35	2/35
4. Non-interest of Top level Mgt towards GLP	3/35	2/35	3/35	0/35	4/35	1/35	4/35	1/35	2/35	3/35	2/35	1/35	1/35	2/35	3/35	3/35
5. Less internal sustainability audits	2/35	1/35	2/35	3/35	0/35	1/35	1/35	3/35	1/35	1/35	2/35	1/35	1/35	1/35	1/35	1/35
6. Reluctance to switch to green practices	4/35	1/35	3/35	1/35	2/35	0/35	2/35	1/35	1/35	2/35	1/35	1/35	2/35	1/35	2/35	3/35
7. Lack of investment in R&D	1/35	2/35	2/35	2/35	2/35	3/35	0/35	1/35	2/35	2/35	1/35	1/35	1/35	1/35	3/35	3/35
8. Lack of effective env. Measures	1/35	1/35	1/35	4/35	3/35	3/35	1/35	0/35	1/35	1/35	3/35	1/35	1/35	3/35	1/35	1/35
9. Lack of Resources to Switch	1/35	1/35	1/35	3/35	1/35	2/35	1/35	1/35	0/35	1/35	2/35	1/35	1/35	1/35	3/35	3/35
10. Lack of Training Courses	2/35	1/35	1/35	2/35	1/35	1/35	1/35	1/35	1/35	0/35	1/35	2/35	4/35	1/35	1/35	1/35
11. Lack of env. Awareness	1/35	1/35	4/35	3/35	3/35	4/35	3/35	3/35	1/35	2/35	0/35	1/35	2/35	3/35	2/35	1/35
12. Complexity of design to re-use and recycle	1/35	2/35	1/35	3/35	1/35	3/35	1/35	1/35	1/35	1/35	1/35	0/35	1/35	1/35	1/35	2/35
13. Lack of Technological information reg GLP implementation	2/35	1/35	2/35	2/35	1/35	3/35	1/35	1/35	2/35	2/35	2/35	3/35	0/35	1/35	3/35	3/35
14. Lack of sustainability certification	1/35	2/35	3/35	3/35	3/35	4/35	2/35	3/35	1/35	2/35	3/35	1/35	2/35	0/35	1/35	1/35
15. Lack of Integration of IT systems	3/35	2/35	2/35	1/35	1/35	2/35	1/35	1/35	1/35	1/35	1/35	2/35	2/35	1/35	0/35	2/35
16. Lack of customer awareness towards GLP	1/35	2/35	1/35	1/35	1/35	1/35	2/35	1/35	2/35	1/35	1/35	2/35	3/35	1/35	4/35	0/35

Once the interdependence among various barriers was obtained, it was then normalized. Now, Table 5.2 shows the normalization table. After the normalization was done, the total relationship matrix is calculated.

Table 5.2 Normalized Direct Relationship Matrix

Barriers	. Less ROI	. No economics of scale for GL	. Lack of access to govt. subsidies and incentives	. Non -interest of Top level Mgt towards GLP 4	. Less internal sustainability audits	. Reluctance to switch to green practices	. Lack of investment in R&D	. Lack of effective env. Measures	. Lack of Resources to Switch	. Lack of Training Courses	. Lack of env. Aware ness	. Complexity of design to re -use and recycle	. Lack of Technological information reg GLP implementation	. Lack of sustainability certification	. Lack of Integration of IT systems	16. Lack of customer awareness towards GLP
1. Less ROI	0.0000	0.0857	0.0285	0.0857	0.0857	0.1142	0.0857	0.0285	0.0285	0.0857	0.0285	0.0285	0.0285	0.0285	0.0571	0.0285
2. No economics of scale for GL	0.0285	0.0000	0.0285	0.0571	0.0571	0.0857	0.1142	0.0285	0.0285	0.0571	0.0285	0.0285	0.0285	0.0285	0.0571	0.0285
3. Lack of access to govt. subsidies and incentives	0.0285	0.0571	0.0000	0.0285	0.0285	0.0857	0.0857	0.0571	0.0285	0.0285	0.0571	0.0285	0.0571	0.0571	0.0285	0.0571
4. Non-interest of Top level Mgt towards GLP	0.0857	0.0571	0.0857	0.0000	0.1142	0.0285	0.1142	0.0285	0.0571	0.0857	0.0571	0.0285	0.0285	0.0571	0.0857	0.0857
5. Less internal sustainability audits	0.0571	0.0285	0.0571	0.0857	0.0000	0.0285	0.0285	0.0857	0.0285	0.0285	0.0571	0.0285	0.0285	0.0285	0.0285	0.0285
6. Reluctance to switch to green practices	0.1142	0.0285	0.0857	0.0285	0.0571	0.0000	0.0571	0.0285	0.0285	0.0571	0.0285	0.0285	0.0571	0.0285	0.0571	0.0857
7. Lack of investment in R&D	0.0285	0.0571	0.0571	0.0571	0.0571	0.0857	0.0000	0.0285	0.0571	0.0571	0.0285	0.0285	0.0285	0.0285	0.0857	0.0857
8. Lack of effective env. Measures	0.0285	0.0285	0.0285	0.1142	0.0857	0.0857	0.0285	0.0000	0.0285	0.0285	0.0857	0.0285	0.0285	0.0857	0.0285	0.0285
9. Lack of Resources to Switch	0.0285	0.0285	0.0285	0.0857	0.0285	0.0571	0.0285	0.0285	0.0000	0.0285	0.0571	0.0285	0.0285	0.0285	0.0857	0.0857
10. Lack of Training Courses	0.0571	0.0285	0.0285	0.0571	0.0285	0.0285	0.0285	0.0285	0.0285	0.0000	0.0285	0.0571	0.1142	0.0285	0.0285	0.0285
11. Lack of env. Awareness	0.0285	0.0285	0.1142	0.0857	0.0857	0.1142	0.0857	0.0857	0.0285	0.0571	0.0000	0.0285	0.0571	0.0857	0.0571	0.0285
12. Complexity of design to re-use and recycle	0.0285	0.0571	0.0285	0.0857	0.0285	0.0857	0.0285	0.0285	0.0285	0.0285	0.0285	0.0000	0.0285	0.0285	0.0285	0.0571
13. Lack of Technological information reg GLP implementation	0.0571	0.0285	0.0571	0.0571	0.0285	0.0857	0.0285	0.0285	0.0571	0.0571	0.0571	0.0857	0.0000	0.0285	0.0857	0.0857
14. Lack of sustainability certification	0.0285	0.0571	0.0857	0.0857	0.0857	0.1142	0.0571	0.0857	0.0285	0.0571	0.0857	0.0285	0.0571	0.0000	0.0285	0.0285
15. Lack of Integration of IT systems	0.0857	0.0571	0.0571	0.0285	0.0285	0.0571	0.0285	0.0285	0.0285	0.0285	0.0285	0.0571	0.0571	0.0285	0.0000	0.0571
16. Lack of customer awareness towards GLP	0.0285	0.0571	0.0285	0.0285	0.0285	0.0285	0.0571	0.0285	0.0571	0.0285	0.0285	0.0571	0.0857	0.0285	0.1142	0.0000

Table 5.3 shows the total relationship matrix with values of D (sum of rows) and R (sum of columns). After the calculation of values of D (sum of rows) and R (Sum of columns) was done, the D+ R and D-R columns were calculated.

Table 5.3 Total Relationship Matrix with D and R

Barriers	. Less ROI	. No economics of scale for GL	. Lack of access to govt. subsidies and incentives	. Non -interest of Top level Mgt towards GLP	. Less internal sustainability audits	. Reluctance to switch to green practices	. Lack of investment in R&D	. Lack of effective env. Measures	. Lack of Resources to Switch	. Lack of Training Courses	. Lack of env. Awareness	. Complexity of design to re -use and recycle	. Lack of Technological information reg GLP implementation	14. Lack of sustainability certification	. Lack of Integration of IT systems	. Lack of customer awareness towards GLP	D (Sum of Rows)
1. Less ROI	0.1662	0.2262	0.2016	0.2718	0.2567	0.3202	0.2658	0.1578	0.1458	0.2366	0.1668	0.1491	0.1811	0.1514	0.2374	0.2024	0.0000
2. No economics of scale for GL	0.1652	0.1224	0.1736	0.2141	0.2006	0.2609	0.259	0.1363	0.1273	0.1837	0.1441	0.1294	0.1556	0.1313	0.2087	0.1758	2.7880
3. Lack of access to govt. subsidies and incentives	0.1693	0.1829	0.1551	0.1994	0.1839	0.2771	0.2432	0.1712	0.1329	0.1645	0.1801	0.1358	0.1896	0.1667	0.192	0.2087	2.9524
4. Non-interest of Top level Mgt towards GLP	0.2687	0.2305	0.2839	0.2306	0.3127	0.2877	0.3241	0.1867	0.1948	0.2623	0.2216	0.1731	0.2114	0.2026	0.2986	0.2839	3.9732
5. Less internal sustainability audits	0.1814	0.1449	0.1933	0.2386	0.1456	0.2041	0.1776	0.1873	0.1216	0.1519	0.1705	0.1232	0.1475	0.1333	0.1727	0.1644	2.6579
6. Reluctance to switch to green practices	0.2552	0.1675	0.2374	0.2066	0.2146	0.2048	0.2252	0.149	0.138	0.1977	0.1577	0.1432	0.1983	0.1431	0.2261	0.2403	3.1047
7. Lack of investment in R&D	0.1789	0.1893	0.2123	0.2285	0.2123	0.2773	0.1689	0.1473	0.1633	0.1942	0.1566	0.1416	0.1715	0.1421	0.2518	0.2416	3.0775
8. Lack of effective env. Measures	0.1837	0.1657	0.2006	0.2934	0.255	0.2877	0.2064	0.1311	0.1395	0.177	0.2193	0.1409	0.1719	0.2044	0.2004	0.1917	3.1687
9. Lack of Resources to Switch	0.1617	0.1484	0.1709	0.2354	0.1714	0.2296	0.1793	0.1341	0.0975	0.1534	0.1688	0.1287	0.1543	0.1313	0.2341	0.2234	2.7223
10. Lack of Training Courses	0.1751	0.1377	0.1565	0.2004	0.1582	0.1937	0.1642	0.1243	0.1176	0.1171	0.1343	0.1493	0.2204	0.1212	0.1671	0.1599	2.4970
11. Lack of env. Awareness	0.222	0.2013	0.3168	0.3108	0.2919	0.3673	0.299	0.2412	0.168	0.2373	0.1734	0.1716	0.2364	0.234	0.2685	0.2358	3.9753
12. Complexity of design to re-use and recycle	0.1511	0.1641	0.1583	0.2231	0.1609	0.2414	0.169	0.1244	0.1169	0.1447	0.1328	0.0909	0.1421	0.1218	0.1677	0.1859	2.4951
13. Lack of Technological information reg GLP implementation	0.2162	0.1751	0.2253	0.2446	0.199	0.2969	0.2096	0.1563	0.1716	0.2061	0.1925	0.2042	0.1549	0.1523	0.2646	0.2547	3.3239
14. Lack of sustainability certification	0.2117	0.2165	0.2805	0.3004	0.2824	0.3535	0.264	0.2329	0.1603	0.2287	0.2436	0.1637	0.2263	0.147	0.2321	0.2235	3.7671
15. Lack of Integration of IT systems	0.2089	0.1737	0.1899	0.1826	0.1669	0.2324	0.1768	0.1312	0.122	0.1521	0.1394	0.1531	0.1762	0.1272	0.1477	0.1927	2.6728
16. Lack of customer awareness towards GLP	0.1607	0.1753	0.1681	0.186	0.167	0.2092	0.2014	0.1329	0.1522	0.1527	0.1428	0.1586	0.2055	0.129	0.2598	0.1455	2.7467

R (Sum of Columns)	3.0760	2.8215	3.3241	3.7663	3.3791	4.2438	3.5335	2.5440	2.2693	2.9600	2.7443	2.3564	2.9430	2.4387	3.5293	3.3302	

The values of D+R and D-R obtained, as shown in Table 5.4. Barrier numbers 1, 4, 8, 9, 11, 12, 13, and 14 were in the cause group, which have positive values of DR. From this table cause and effect, the diagram is obtained as in Figure 5.2. The results show the cause and effect groups. Also, barrier number 4, i.e., Noninterest of Top-level management, came out to be the most important barrier with the highest positive value of D+ R as 7.739.

Table 5.4 Cause and Effect Table

Barriers	D	R	D-R	D+R	Remarks
1	3.33690	3.0760	0.26090	6.41290	
2	2.78800	2.8215	-0.03350	5.60950	
3	2.95240	3.3241	-0.37170	6.27650	
4	3.97320	3.7663	0.20690	**7.73950**	Highest
5	2.65790	3.3791	-0.72120	6.03700	
6	3.10470	4.2438	-1.13910	7.34850	
7	3.07750	3.5335	-0.45600	6.61100	
8	3.16870	2.5440	0.62470	5.71270	
9	2.72230	2.2693	0.45300	4.99160	
10	2.49700	2.9600	-0.46300	5.45700	
11	3.97530	2.7443	1.23100	6.71960	
12	2.49510	2.3564	0.13870	**4.85150**	Smallest
13	3.32390	2.9430	0.38090	6.26690	
14	3.76710	2.4387	1.32840	6.20580	
15	2.67280	3.5293	-0.85650	6.20210	
16	2.74670	3.3302	-0.58350	6.07690	

The lowest value of D+R is for barrier number 12, i.e., Complexity of design to reuse and redesign, which comes out to be 4.851.

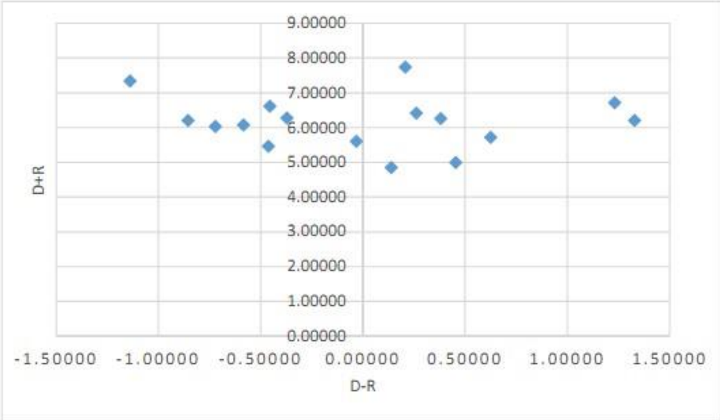

Figure 5.2 Cause and Effect Diagram

5.5 Chapter Summary

In an era of environmentalism, manufacturing enterprises with green logistics practices will easily survive in the global market. The knowledge of the barriers and then their analysis will help the manufacturing industry to work on the removal or reduction of such barriers and thus achieve sustainability. This chapter has established connections among the barriers using the DEMATEL technique and thus finds out the most important barrier for the implementation of Green logistics. A group of experts from industry and academia was referred for giving the dependence of one barrier over another and DEMATEL methodology. MATLAB has been used to develop the relative relationship among the identified barriers. The results are supportive in recognizing the significant barriers, identifying the barriers under the dependent and independent category, finding the most critical barrier, and thus helping the policymakers to understand which barriers hinder the implementation of green logistics practices. Out of all the barriers, the most important barrier comes out to barrier - 4, which is '*Noninterest of Top-level management towards GLP*'. It has been seen in the industries that where the Top-level management takes an interest in the implementation of green logistics practices becomes very easy. The least important barrier which implements green logistics practices difficult is a barrier - 11, i.e., '*the complexity of design to reuse and recycle*.'

The results generated will help the industries to remove the major barriers to the implementation of GLP in the manufacturing industry. This will help the company owners, policymakers, and even the government. The barriers which affect the most should be focused on and worked upon by the practitioners in the industry. In the future, this relationship model using DEMATEL can be used to develop a platform for the adoption of green logistics by reducing the important barriers.

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Chapter- 6

Descriptive Analysis of Green Logistics Drivers and Practices

6.1 Introduction

The main research objective of the existing study is to develop a framework for Green Logistics Practices that might help the Oil and Gas industry in India in improving their economic as well as environmental performance. This objective can be achieved by finding out important Green Logistics Practices from the perspective of various logistics officials working for the Indian Manufacturing Industry (Oil and Gas). Another objective of this study is to identify the important drivers that support or enable the implementation of these Green Logistics Practices. As already discussed in Chapter 3, the research data has been collected utilizing a questionnaire survey (lime type). The research instrument (Appendix-1) consists of the structured designed questionnaire which was prepared based on the literature survey. The goals of the research were kept in mind as well as the coverage of the secondary data analysis. An effort was made to cover all variables related to the influence and the respondents were asked to show their level of involvement. Closed-ended questions with various options have been used. The survey is divided into three sections. Section One examines basic information like the level in the company, turnover of the company, no. of employees, total no. of vehicles in the company. Section Two, questions were included to gather the important green logistics drivers in the logistics activities and thus to obtain the moderator construct i.e. Government and Environmental policies. Section Three includes questions on key Green Logistics Practices and results for downstream logistics activities. All items for the above-listed constructs were calculated using a 5point Likert scale ranging from 1 to 5. The data collected was compiled and translated into an Excel spreadsheet (Microsoft Office 2019) and exported and interpreted using the software package SPSS (Statistics Package for Social Sciences) version 25.0. This research presents the exploratory, descriptive and inferential analysis. The exploratory research has been utilized to find out background knowledge about the area of research (i.e., green logistics) and thus, enabled the formulation of hypotheses for fulfilling the research objectives. These hypotheses are delineated in chapter 3. In this research, the Statistical Package for the Social Sciences (SPSS) version 25.0 has been utilized for the statistical analysis of the data. Mean and Standard Deviation has been computed to rank the important Green Logistics Drivers, and Practices of the Indian Manufacturing Industry (Oil and Gas).

The flow of this chapter is described in Figure 6.1. The next section 6.2 consists of the basic information of the respondents.

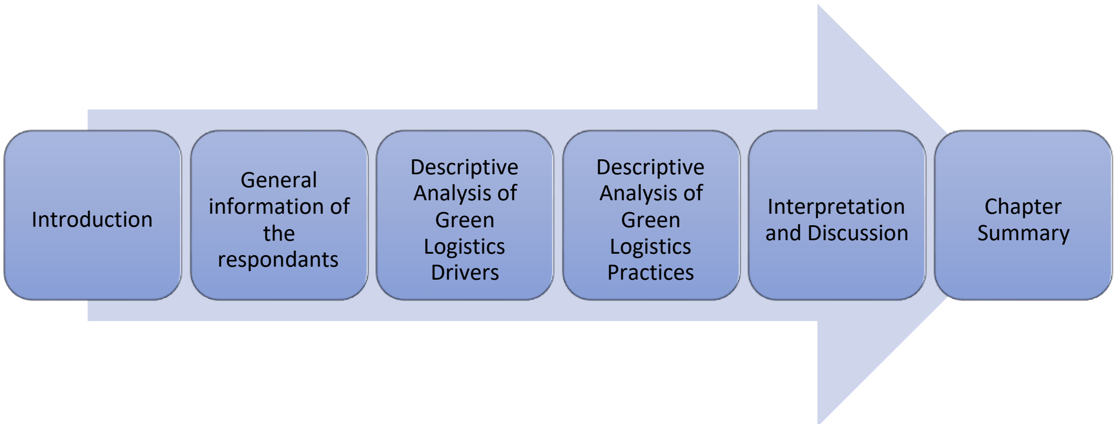


Figure 6.1 The chapter flow diagram

Further section 6.3 provides a statistical research study (descriptive) of Green Logistics Drivers and Green Logistics Practices based on the empirical evidence obtained through questionnaires. Inferential statistical analysis of the data is given in section 6.4. However, the thorough discussion and conclusion/chapter overview are given in sections 6.5 and 6.6, respectively.

6.2 General information of the respondents

The respondents were asked questions of general knowledge in Section A of the questionnaire. They were asked to indicate their position in the company, the turnover of the company each year, the number of employees in the company, the number of vehicles, the warehouses in square meters. The questionnaire also consisted of a participant information sheet, where the respondents indicated that they had agreed and agreed to the terms and conditions of the questionnaire. (See Appendix-1 of the Participant Information Sheet and Questionnaire).

The first question in the questionnaire asked the respondents to indicate their position. They had to choose from three choices, namely lower-level management, middle-level management, and top-level management. Table 6.1 shows the frequency and percentage of respondents who completed the questionnaire.

Table 6.1 Frequency and percentage of the position of the respondents

	Frequency	Percentage
Lower-level management	24	9.16%
Middle-level management	176	67.17%
Top-level management	62	23.66%
Total	262	100.0

It is clear from fig. 6.2 that the significant responses were from middle and toplevel management as 67.17% and 23.66%, respectively. It justifies the study's creditability as lower-level management, which is not much aware and involved in environmental practices, had a low response rate of 9.16%.

Question 2 of the questionnaire asked the respondents to indicate the company turnover per annum as indicated in Table 6.2. Fig. 6.2 below illustrates that 7.63% of the companies' turnover per annum was less than INR 5cr, 61.07% of the companies' turnover per annum was between INR 5cr. and INR 20cr, 29.00% was between INR 20cr. – INR 30cr and 2.30% of the companies' turnover per annum was above INR 30cr.

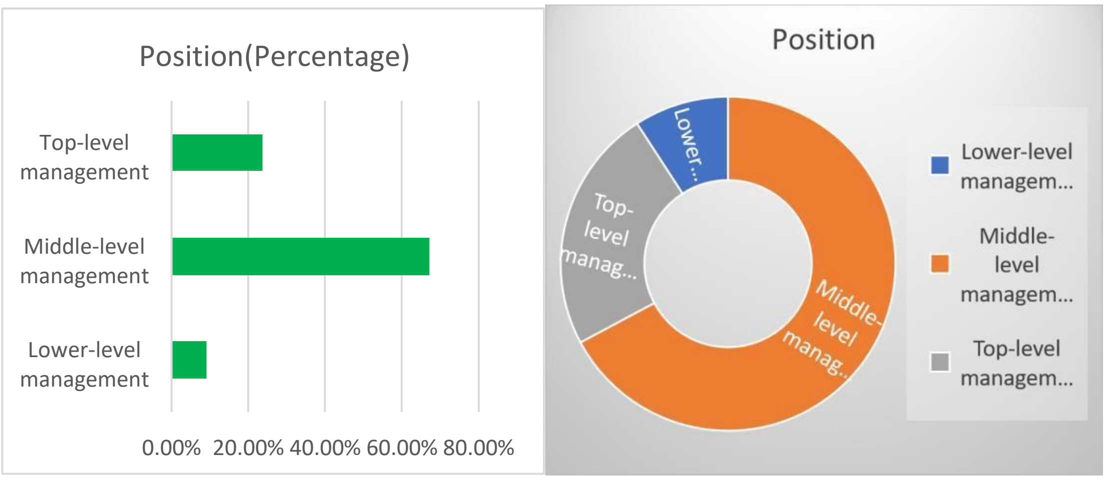


Figure 6.2 Frequency and Percentage of the position of the respondents

Table 6.2 Frequency and percentage of the company turnover per annum

	Frequency	Percent
Less than INR 5cr.	20	7.63%
Between INR 5cr. – INR 20cr.	160	61.07%
Between INR 20cr. – INR 30cr.	76	29.00%
More than 30cr.	6	2.30%
Total	262	100.0

The next question of the questionnaire enquired the respondents to indicate the number of employees in the company. Table 6.3 shows the results.

Table 6.3 Frequency and percentage of the number of employees in the company

Number of employees	Frequency	Percentage
Less than 50	25	9.54%
Between 51 – 100	189	72.13%
Between 101 – 200	34	12.96%
More than 200	14	5.33%

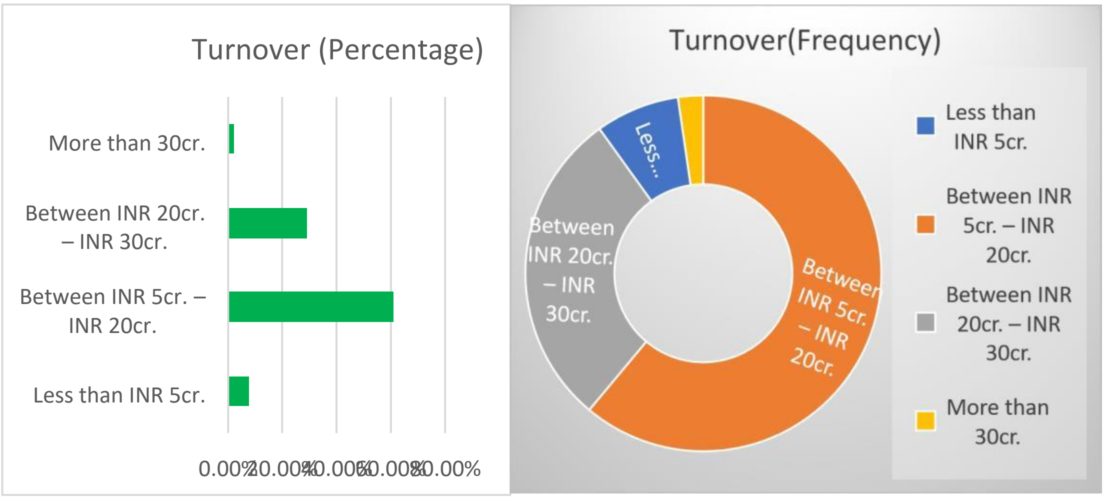


Figure 6.3 Frequency and percentage of the company turnover per annum

The values in Figure 6.4 indicates that 9.54% of the companies had less than 50 employees, 72.13% had between 51 and 100 employees and 12.93% had between 101 and 200 employees. Only 5.33% of the companies had more than 200 employees.

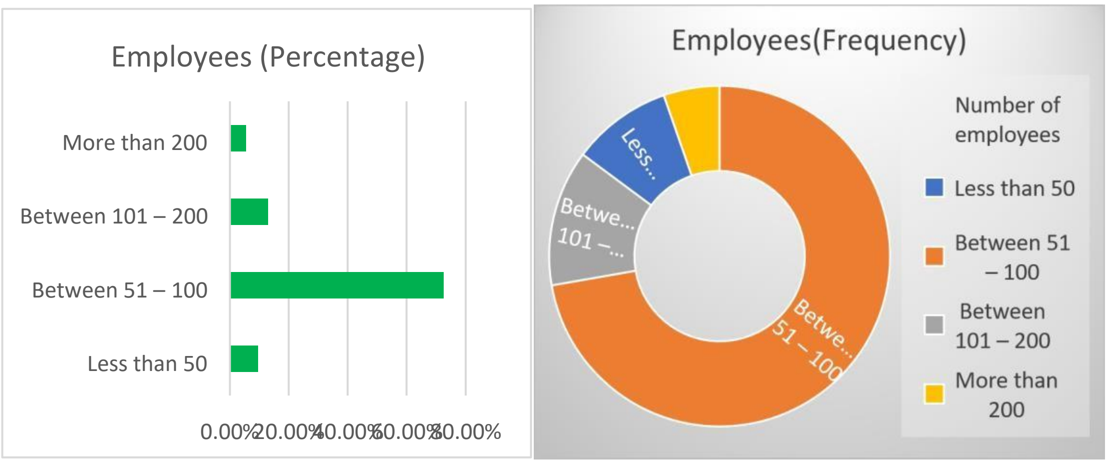


Figure 6.4 Frequency and percentage of employees in the company

Question 4 of the questionnaire needed the respondents to mark the no. vehicles in the company. Table 6.4 shows the frequency and percentage of the vehicles.

Table 6.4 Frequency and percentage of the number of vehicles in the company

Number of vehicles	Frequency	Percentage
Less than 10	17	6.48%
Between 11- 50	144	54.96%
Between 51 – 100	76	29.00%
More than 100	25	9.54%
Total	262	100.0%

As per Figure 6.5, it is clear that 6.48% of companies had either less than 10 trucks. While 54.96% of companies had between 11 and 50 trucks, 29.00% of the companies owned between 51 and 100 trucks and only 9.54% of the respondents had more than 100 trucks.

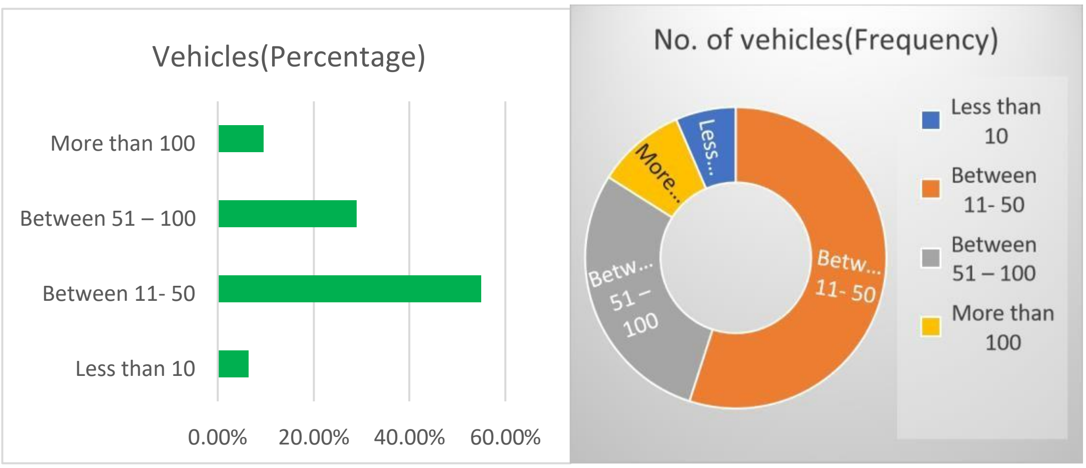


Figure 6.5 Frequency and percentage of the number of vehicles in the company

As per the outcomes of the questions in section A of the questionnaire, the highest category frequency (in %) of each question is briefed below to show the profile of most respondents.

67.17% of middle-level managers completed filled the questionnaire.

61.07% of the companies had a turnover between INR 5 cr. – INR 20cr.

72.13% of the companies employed 51 - 100 employees.

54.96% of the companies owned between 11 – 50 vehicles.

6.3 Descriptive Analysis of Green Logistics Drivers

The third objective of the research is to recognize the important drivers of Green Logistics and then rank them based on importance. This is done by descriptive analysis in which the mean and standard deviation is calculated using SPSS for the drivers. The driver with the highest mean is ranked first, and the driver has the lowest mean is ranked last. This will help the oil and gas industry to prioritize the important drivers in green logistics.

Table 6.5 represents the mean value, standard deviation, and rank for each driver that enables the respondents to identify the important drivers. Figure 6.6 represents the radar graph of the mean values of Green Logistics Drivers.

Table 6.5 Mean values for the Important Green Logistics drivers

Items	Drivers of Green Logistics	Mean	S.D.	Rank
GLD1	Decrease in Availability of Fossil Fuels	4.03	0.68	9
GLD2	***Complying with Government***	***4.19***	***0.65***	***1***
GLD3	Decreasing fuel bills	4.16	0.64	3
GLD4	Differentiating with competitors	4.17	0.57	2
GLD5	Collaborating with the customers	3.99	0.62	10
GLD6	Complying with internal regulations	4.05	0.52	8
GLD7	Improving Public relations	4.17	0.73	2
GLD8	Marketing Pressures	4.12	0.56	5
GLD9	Increasing Supply chain efficiency	4.14	0.57	4
GLD10	Corporate Social Responsibility	4.10	0.56	7
GLD11	Pressure from Environmental groups	4.11	0.60	6

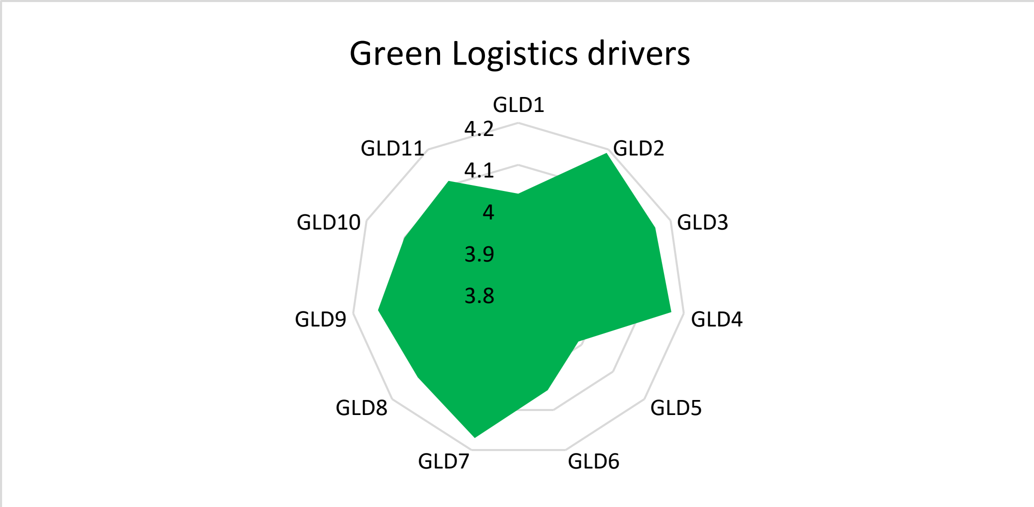


Figure 6.6 Radar Graph for the mean values of Green Logistics drivers

Respondents ranked *Complying with Government (GLD2)* as the most important driver in implementing the Green Logistics Practices with a mean value of 4.19 and a standard deviation of 0.65. This is supposed to be the main inducement for the manufacturing industry to implement Green Logistics Practices. Other important drivers are as below:

- *Differentiating with customers (GLD4) and Improving Public Relations (GLD7)* ranked as the second most important driver having a mean value of *4.17* and a standard deviation of *0.57* and *0.73*, respectively.

- *Collaborating with the customers (GLD5) ranked as the least important driver, with a mean value of 3.99 and a standard deviation of 0.62.*

6.4 Descriptive Analysis of Green Logistics Practices

Section C of the survey asked the respondents for identifying the most important green logistics practices (Green Transportation, Green Warehousing, Green Packaging, and Green Value-Added Services) and also their level of significance in evaluating the performance parameters (Environmental performance, and economic performance).

The mean value for each practice is the value that shows the importance of that practice for Green Logistics implementation.

Mean & Standard Deduction (SD) for Green Transportation: Transportation is the most important activity of any Logistics System of any sector as the products/parts need to be transported from the source to the destination and thus to end customers. Green Logistics Transportation practices include activities like backhauling, standardization, optimization, use of wireless technologies, etc. There are eight critical activities considered in this study and thus analyzed to know the rank based on importance in Table 6.6 and radar graph in Figure 6.7.

Table 6.6 Mean values for Green Logistics Transportation Practices

Items	Practices of Green Transportation	Mean	Standard Deviation	Rank
GLPT1	***Standardization***	***3.50***	***1.14***	***1***
GLPT2	Clean Vehicles	3.46	1.17	2
GLPT3	Wireless Technologies	2.97	1.40	7
GLPT4	Backhauling	3.41	1.16	3
GLPT5	Scheduling	3.40	1.15	4
GLPT6	Optimization	3.39	1.17	5
GLPT7	Freight Consolidation	3.09	1.28	6
GLPT8	System monitoring Devices	3.40	1.15	4

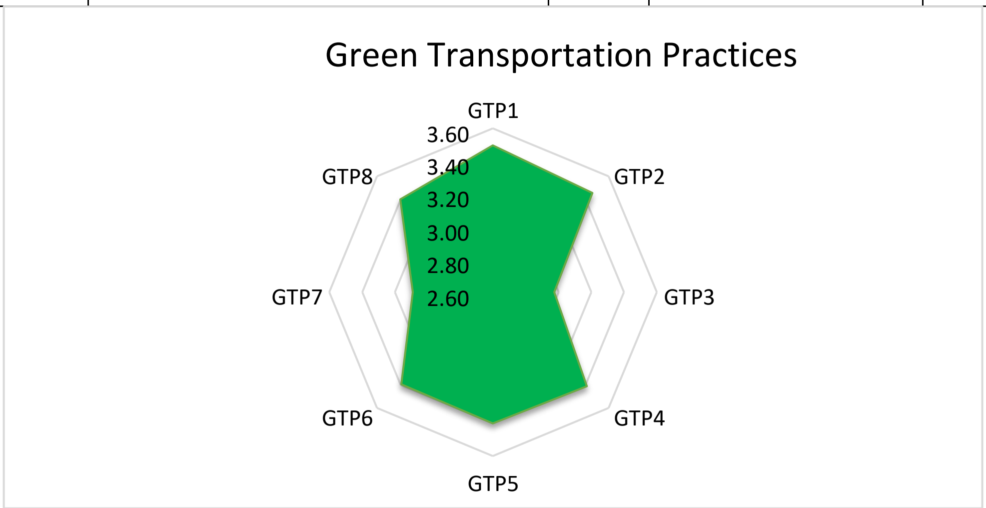


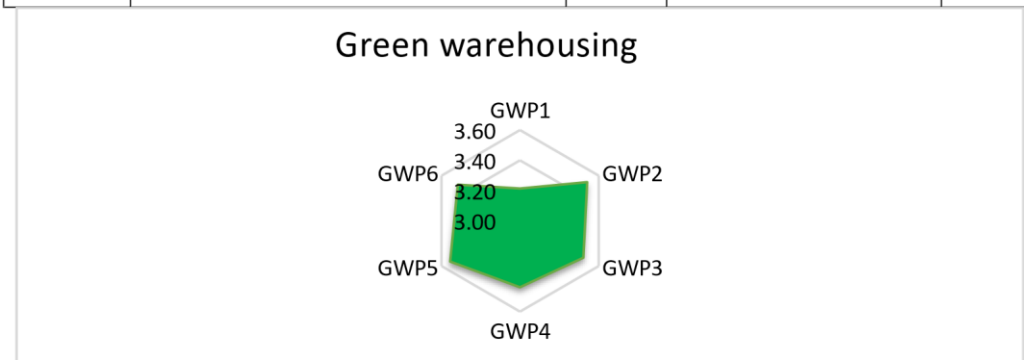
Figure 6.7 Radar Graph for the mean values of Green Transportation Practices

The respondents rated *Standardization* as the most important Transportation practice for Green Logistics with a mean value of *3.50* and a standard deviation of *1.141*. Trucks are standardized, thus the same trucks can be used to transfer multiple products. The standardization helps in overcoming the challenge of empty truck returns and also reduces inefficiencies associated with energy & fuel consumption and greenhouse emissions.

Mean & Standard Deduction (SD) for Green Warehousing: Green warehousing is an important activity of the logistics system. There are various tools and handling devices that will help in reducing CO_2 emissions and energy consumption. The study is done to rank the important warehousing practices in the oil and gas sector distribution. There are eight critical parameters considered in this study and thus analyzed based on importance. The results are presented below in Table 6.7 and the radar graph in Figure 6.8.

Table 6.7 Mean values for Green Logistics Warehousing Practices

Items				
GLPW1	Reconditioning of pallets	3.21	1.316	5
GLPW2	Clean Material handling	3.51	1.127	2
GLPW3	Innovative handling	3.48	1.098	3
GLPW4	Process Optimization	3.44	1.098	4
GLPW5	***Low Carbon Storage***	***3.53***	***1.049***	***1***
GLPW6	Minimizing inventories	3.48	1.092	3



Practices of Green Warehousing Mean Standard Deviation Rank

Figure 6.8 Radar Graph for the mean values of Green Warehousing Practices

The respondents rated *Low Carbon Storage* as the most important Warehousing practice for green logistics with a mean value of *3.53* and a standard deviation of *1.049*. This green warehousing practice leads to the reduction of carbon emissions as the storage is recommended to be low carbon. The storage is preferred to have low carbon and thus reducing all that equipment and inventory in the warehouse which leads to more carbon dioxide utilization. Therefore, this practice will help the warehouses in the reduction of carbon footprint

Mean & Standard Deduction (SD) for Green Packaging: Packaging is a very crucial activity of logistics in any manufacturing industry. The safety of the product is dependent on effective packaging. Although packaging also generates a large amount of waste in the environment. So the various green logistics packaging practices include the reusable material/ minimum use of packaging material, environmental messages on the packs There are five important parameters to analyze the green packaging practices shown in Table 6.8 and the radar graph in Figure 6.9.

Table 6.8 Mean values for Green Logistics Packaging Practices

Items	Practices of Green Packaging	Mean	Standard Deviation	Rank
GLPP1	***Ecological Material***	***3.21***	***1.11***	***1***
GLPP2	Recycle Reuse of Packaging	3.06	1.32	5
GLPP3	ISO suppliers	3.17	1.05	2
GLPP4	Environmental Messages	3.12	1.08	3
GLPP5	Restrict Excess Packaging	3.09	1.15	4

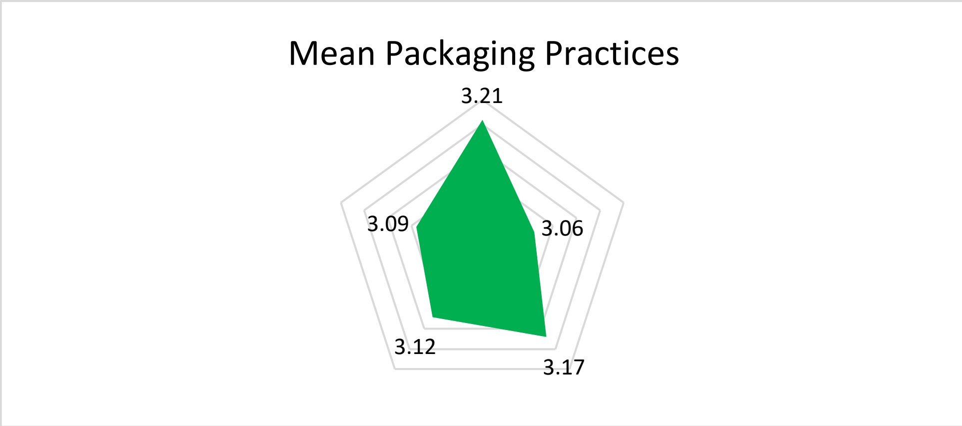


Figure 6.9 Radar Graph for the mean values of Green Packaging Practices

The respondents have ranked *Ecological Material* as the most important Packaging practice for green logistics with a mean value of *3.21* and a standard deviation of *1.11*.

Mean & Standard Deduction (SD) for Green Value-Added Practices: There are various important activities of logistics that come under the domain of Value-added services. These are not direct logistics activities, but they are associated activities that, if carried out, will improve the green effect of logistics. The various activities include Staff Training, Long Term Environmental Objectives, Top management support, etc. There are five important activities shown in Table 6.9 and Figure 6.10.

Table 6.9 Mean values for Green Logistics Value-Added Practices

Items	Practices of Green Value-added Services	Mean	Standard Deviation	Rank
GLPVE1	***Environmental Reports***	***3.10***	***1.11***	***1***
GLPVE2	Staff Training	2.94	1.26	5
GLPVE3	Long-term Environmental Objectives	2.97	1.16	4
GLPVE4	ISO Certified Company	3.08	1.13	2
GLPVE5	Top Management Support	3.06	1.09	3

The respondents rated *Environmental Reports* as the most important Valueadded Practices for Green Logistics with a mean value of *3.10* and a standard deviation of *1.11*.

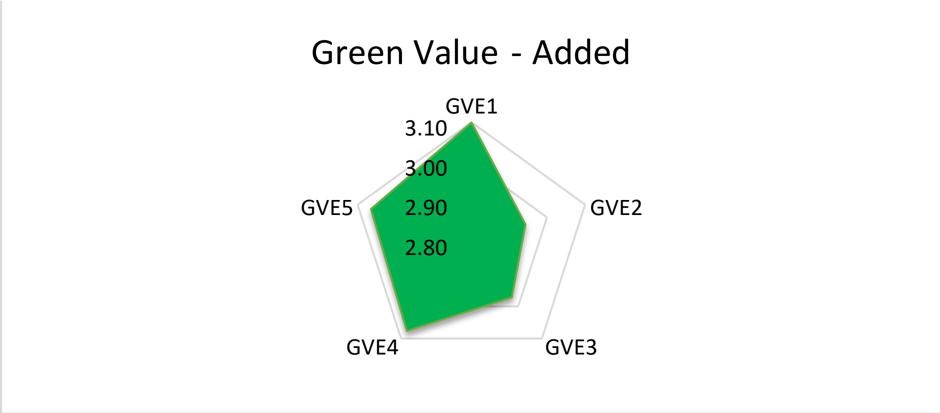


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Figure 6.10 Radar Graph for the mean values of Green Value-added Practices

6.5 Interpretation and Discussion

The Green Logistics framework consists of drivers and practices and parameters. The data analysis conducted above has computed various essential parameters. The descriptive data analysis for the drivers analyzed all the Green Logistics Drivers and ranked them accordingly. As seen in Table 6.5, the driver *'GLD2 - Complying with the Government*' is listed as the most important driver. This means that the logistics activities of the Oil and Gas industry have regulations related to green practices that act as the highest motivator. This would encourage the Administrators and Policymakers of the Government to make rules which would favor Green Logistics Practices. The least ranked driver in Table 6.5 is *'GLD5 - Collaborating with the Customers*'. This means the collaboration with the customers does not act as a high motivator and that ranked least by the respondents.

Green Logistics Practices (Transportation): Table 6.7 shows the ranking of Green

Transportation Practices, and as per the analysis, *'GLPT1 - Standardization'* is ranked as the most important practice of green logistics. Trucks are standardized, so the same trucks can be used to transfer multiple products. This standardization practice in transportation helps in overcoming the challenge of empty truck returns and reduces inefficiencies associated with energy & fuel consumption and greenhouse emissions. Thus, the Oil and Gas industry must focus more on standardization in the future.

Green Logistic Practices (Warehousing): Table 6.8 shows '*GLPW5 – Low Carbon Storage* as the highest-ranked warehousing practice. The current and latest research also shows a lot of work is done in this area. This practice leads to the reduction of carbon emissions as the storage is recommended to be low carbon. It helps the warehouses of the oil and gas industry in the reduction of carbon footprint.

Green Logistics Practices (Packaging): Table 6.9 shows that '*GLPP - 1 Ecological Material*' is the highest-ranked packaging practice. The respondents feel that these sustainable materials are very important and should be encouraged. This green practice in packaging has certain advantages like carbon footprint reduction and as the material is biodegradable so less waste material is produced. The use of ecological material also improves the brand image of the company as the customers and government promote the companies which use ecological material for packaging.

Green Logistics Practices (Value-added Services): Table 6.10 shows the ranking of value-added services in logistics activities. The topmost is '*GLPVE - 1 Environmental Reports*. The environmental reports at a particular interval of time in the year just like the financial reports would promote active and voluntary disclosure of environmental information. This would improve their reputation for their environmental efforts.

6.6 Chapter Summary

This chapter discussed the data analysis findings and results based on the responses gathered with the help of the questionnaire. Initially, the data set is prepared using SPSS ver.25. These results and findings provide deep insights into the Indian manufacturing industry(Oil and Gas) giving the basic information of the various respondents working for logistics activities in the Oil and Gas Industry. The findings ranked the Green Logistics Drivers as well as the various Green Logistics Practices. The most significant drivers and practices for the green logistics activities of the downward logistics are analyzed from the questionnaire responses. These findings will also be very useful for future researchers working in the area of Green Logistics and also would provide useful information for framing the policies regarding this industry for logistics activities. The most important driver and the most important practices should be given more weightage by the industry in the future. The next chapter in this thesis will present the statistical analysis of the practices and performances along with the mediation and the moderator which will, in turn, provide and validate the framework for the study.

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Chapter 7

Structural Equation Modelling of Green Logistics framework

7.1 Introduction

The chapter presents the Structural Equation Modelling (SEM) of the Green Logistics practices and performance using mediation and moderation analysis, followed by a summary of the same. The chapter is structured in such a way that first, the exploratory factor analysis is performed, then the convergent and the discriminant validity across the constructs are determined based on confirmatory factor analysis, and then hypotheses testing is done using structural equation modelling for the Green Logistics framework. A chapter flow diagram has been shown in Figure 7.1.

An examination of the mediation carried out using macros that tested whether Environmental Performance mediated the relationship among the practices of Green Logistics and Economic Performance as indicated and discussed below.

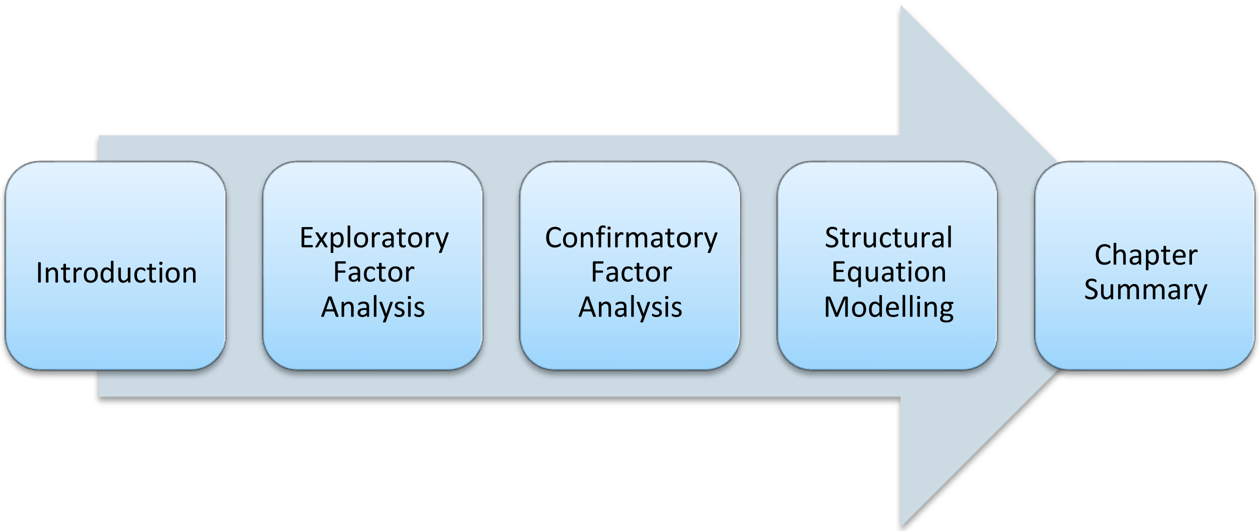

Figure 7.1 Chapter flow diagram

The Government and Environment policies as discussed in chapter 3, serve as a moderator between the Green Logistics Practices and Environmental Performance as well as between Green Logistics Practices and Economic Performance and have been examined, the results of which are shown below. The moderation and mediation analysis was carried out using SEM analyses, and these findings are also tabulated, checked, and discussed. The Structural Equations Modeling (SEM) methodology is used in this section for testing the hypotheses referred to in Table 7.1.

Table 7.1- Hypotheses related to Research model

Green Logistics Practices and Environmental Performance

Hypothesis-1 (H1) :
impact on Environmental Performance
Green Logistics Warehousing Practices has a significant
Hypothesis-2 (H2) :
impact on Environmental Performance
Green Logistics Packaging Practices has a significant
Hypothesis-3 (H3) :
impact on Environmental Performance
Green Logistics Value-Added Services Practices has a
Hypothesis-4 (H4) :
Green Logistics Transportation Practices has a significant

significant impact on Environmental Performance

Green Logistics Practices and Economic Performance

Green Logistics Transportation Practices has a significant
Hypothesis-5 (H5) :
impact on Economic Performance

Hypothesis-6 (H6)	: Green Logistics Warehousing Practices has a significant impact on Economic Performance
Hypothesis-7 (H7)	: Green Logistics Packaging Practices has a significant impact on Economic Performance

Hypothesis-8 (H8)	:	Green Logistics Value-Added Services Practices has a significant impact on Economic Performance

Mediation Relationship

Hypothesis-9 (H9)	:	Environmental Performance mediates the relationship between Green Logistics Transportation Practices and Economic Performance
Hypothesis-10 (H10)	:	Environmental Performance mediates the relationship between Green Logistics Warehousing Practices and Economic Performance
Hypothesis-11 (H11)	:	Environmental Performance mediates the relationship between Green Logistics Packaging Practices and Economic Performance
Hypothesis-12 (H12)	:	Environmental Performance mediates the relationship between Green Logistics Value-Added Services Practices and Economic Performance

Moderation Relationship

Hypothesis-13 (H13)	:	Government and Environment Policies moderate the relationship between Green Logistics Transportation Practices and Environmental Performance
Hypothesis-14 (H14)	:	Government and Environment Policies moderate the relationship between Green Logistics Warehousing Practices and Environmental Performance
Hypothesis-15 (H15)	:	Government and Environment Policies moderate the relationship between Green Logistics Packaging Practices and Environmental Performance
Hypothesis-16 (H16)	:	Government and Environment Policies moderate the relationship between Green Logistics Value-Added Practices and Environmental Performance
Hypothesis-17 (H17)	:	Government and Environment Policies moderate the relationship between Green Logistics Transportation Practices and Economic Performance
Hypothesis-18 (H18)	:	Government and Environment Policies moderate the relationship between Green Logistics Warehousing Practices and Economic Performance
Hypothesis-19 (H19)	:	Government and Environment Policies moderate the relationship between Green Logistics Packaging Practices and Economic Performance
Hypothesis-20 (H20)	:	Government and Environment Policies moderate the relationship between Green Logistics Value-Added Practices and Economic Performance

A list of notations of items used in various constructs is also presented in the Table 7.2.

The conceptual model of Figure 7.2 shows the relationship between green logistics practices and performances. After the development of the conceptual model, the next step is to validate the conceptual model by performing a variety of statistical tests, accompanied by the validation of the model by the testing of hypotheses. Evaluation and validation must be carried out systematically and statistically so that the results of the study can be used by prospective researchers and scholars at a later date. The evaluation is to decide if the process as a whole will generate results that meet the required requirements.

Validation is used to evaluate if the analysis, as implemented, will generate results that meet the expected requirements/specifications with adequate capability.

Table 7.2 Notations used for Items in various constructs

Name of Constructs	Name of Items	Notations Used
Green Logistics Transportation Practices	Standardization of the trucks	GTP1
	Clean Vehicles	GTP2
	Wireless Technologies	GTP3
	Backhauling	GTP4
	Scheduling	GTP5
	Optimization	GTP6
	Freight Consolidation	GTP7
	System Monitoring Devices	GTP8
Green Logistics Warehouses Practice	Reconditioning and reuse of pallets	GWP1
	Clean Material Handling	GWP2
	Innovative Handling	GWP3
	Process Optimization	GWP4
	Minimizing Inventories	GWP5
	Low Carbon Storage	GWP6
Green Logistics Packaging Practice	Recycle,Reuse of Packaging	GPP1
	Ecological Material	GPP2
	ISO Suppliers	GPP3
	Environmental Messages on Packaging	GPP4
	Restrict Excess Packaging	GPP5
Green Logistics Value-added Practice	Environmental Reports	GVP1
	Staff Training	GVP2
	Long Term Environmental Objectives	GVP3
	ISO Certification	GVP4
	Top Management involvement	GVP5
Environmental Performance	Fuel Efficiency	EP1
	Carbon Footprint Reduction	EP2
	Energy Saving	EP3

	Less Disasters	EP4
Economic Performance	Decrease in Energy Consumption Cost	EcP1
	Decrease in Fuel cost due to Optimized routes	EcP2
	Decrease in Cost of Waste Disposal	EcP3
	More Business Due to Brand Improvement	EcP4
	Reduction in VTT cost	EcP5
	Decrease in vehicle costs as better life of vehicles	EcP6
Government and Environmental Policies	Complying with Environment	GEP1
	Complying with Internal Regulations	GEP2
	Policies by Environmental Groups	GEP3

The method must be challenged for validation by means of verified measurement systems. The model has to be validated, analyzed, and tested for the framed hypotheses. For this reason, Exploratory Factor Analysis shall be carried out in the section 7.2., Confirmatory Factor Analysis is carried out in section 7.3 and, evaluation and confirmation of the SEM research hypothesis using AMOS are carried out in section 7.4.

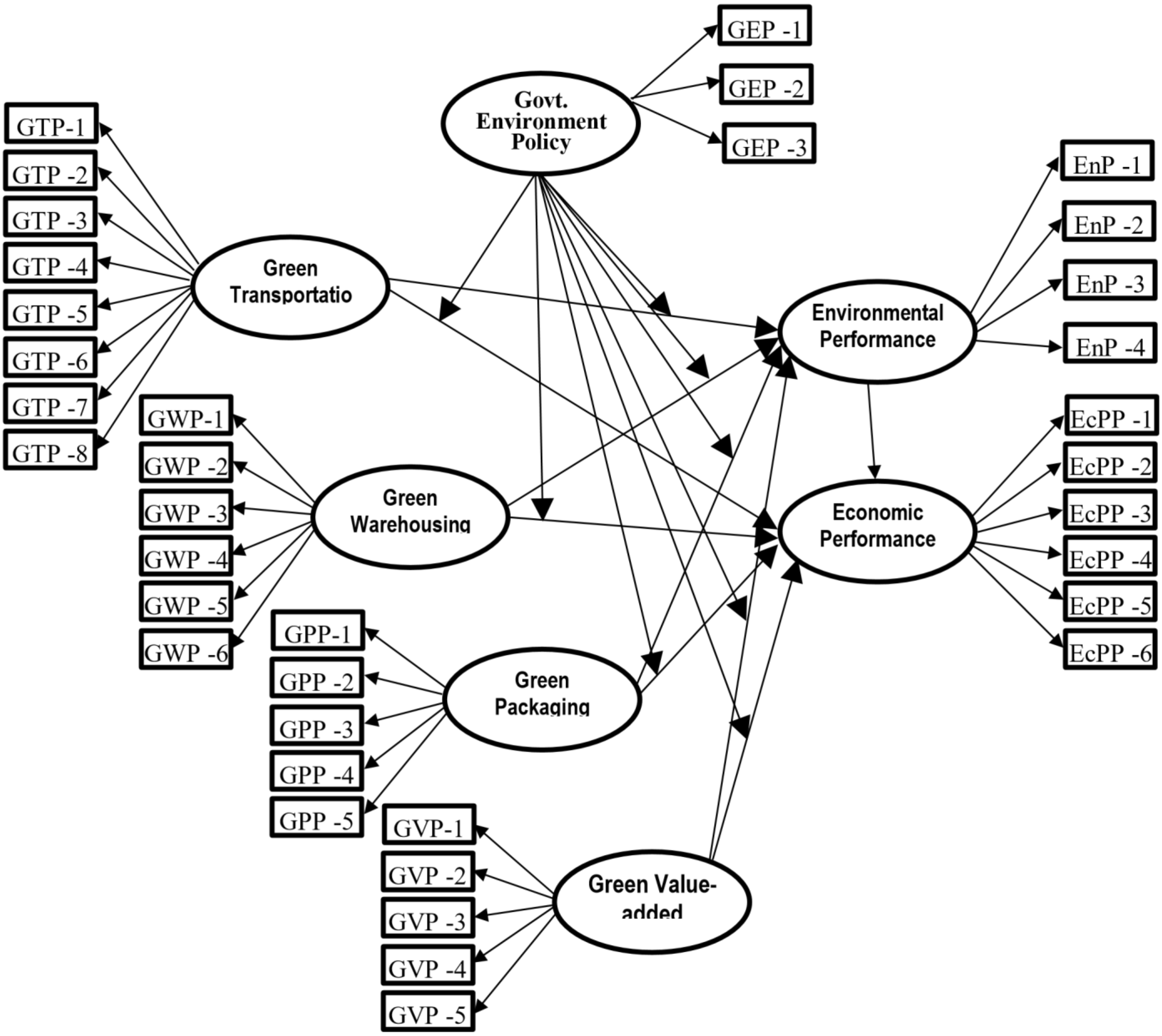

Figure 7.2 Proposed Conceptual Framework for SEM analysis (Source: Self) 7.2

Exploratory Factor Analysis for Green Logistics framework

Exploratory Factor Analysis is a multivariate method that addresses questions related to the evaluation of the probability of a few latent variables accounting for several variables. It is a statistical approach that reduces data to a small set of variables and explores the underlying hypothetical structure of the phenomenon. Thus it is used to evaluate the relationship structure between the variable and the respondent.

Exploratory Factor Analysis (EFA) is a classic formal measurement model that is used when both measured and latent variables are thought to be determined at the interval level. The feature of the EFA is that the variables observed are first standardized (zero mean and standard deviation of 1). The EFA is performed on a matrix of correlations between objects. An Exploratory Factor Analysis (EFA) (Moore and Benbasat 1991; Hinkin 1998) was performed to correct the measurements. An exploratory analytic factor model was used for the extraction and analysis of the factors. Factor analysis is a statistical method for determining a minimum number of unobservable common factors by observing the covariance between a series of variables observed (Malhotra, 2011). An exploratory factor analysis was carried out to evaluate the data components that could be related to each other and then to test the construct validity of each component against the sub-items of the scale. The principal component analysis (PCA) of the orthogonal rotation (varimax) study was conducted. Various tests are performed which include the Reliability Test, the KMO and Barlett test, and the Factor Loading by doing Factor Analysis:

7.2.1 Reliability test using Cronbach's Alpha

The issue of reliability ascends when the scales are extended to include the field of prediction. Cronbach's alpha (Cronbach, 1951) is one of the popular as well as reliable statistics used today. The internal consistency which is the average correlation of items in the survey instrument is gauged by Cronbach's Alpha which determines its reliability. The value of the Alpha varies from zero to one as it is the ratio of the two variances. However as it depends on the measurement process used, alpha calculations can any value less than or equal to 1, even negative values, but only positive values make sense. Higher alpha values are much more desirable in the analysis. Generally, as a rule of thumb, alpha needs to have a reliability of 0.70 or higher (obtained on a significant sample) before using an instrument. Cronbach's Alpha will normally increase as the interrelationships between test items increase and is often considered to be an internal accuracy estimate of the reliability of the factors. Since the correlations between test items are maximized when all items measure the same construct, Cronbach's Alpha is commonly presumed to show the degree to which a group of items measures a single one-dimensional latent construct. The widely accepted thumb rule for defining internal consistency using Cronbach's Alpha is shown in Table 7.3.

Table 7.3 Internal Consistency of Cronbach's Alpha (Cronbach, 1951)

Cronbach's Alpha	**Internal consistency**
$\alpha \geq 0.9$	Excellent
$0.7 \leq \alpha < 0.9$	Good
$0.6 \leq \alpha < 0.7$	Acceptable
$0.5 \leq \alpha < 0.6$	Poor
$\alpha < 0.5$	Unacceptable

The Cronbach's alpha value is calculated for all the factors, namely Green Logistics Transportation Practices, Green Logistics Warehousing Practices, Green Logistics Packaging Practices, Green Logistics Value-Added Practices, Environmental Performance, Economic Performance, and Government and Environment Policies. The Cronbach's Alpha has been calculated for Green Logistics Transportation Practices after deleting GTP3 and GTP7, which increases the reliability further. After the deletion, the number of items is six, and reliability is 0.918, as shown in table 7.4. The items that have been deleted are GTP3 and GTP7.

The Cronbach's Alpha has been calculated for Green Logistics Warehousing Practices after deleting GWP1, which increases the reliability further.

Table 7.4 Cronbach's alpha for Green Logistics Transportation Practices (Source: Primary Data)

S. No.	GLTP	Cronbach's Alpha (if deleted)	No. of items	Cronbach's Alpha
1	GTP1	0.853	6	0.918
2	GTP2	0.858		
3	GTP4	0.860		
4	GTP5	0.864		
5	GTP6	0.864		
6	GTP8	0.869		

After the deletion, the number of items is five, and reliability is 0.819, as shown in table 7.5. The item that has been deleted is GWP2.

Table 7.5 Cronbach's alpha for Green Logistics Warehousing Practices (Source: Primary Data)

S. No.	GLWP	Cronbach's Alpha (if deleted)	No. of items	Cronbach's Alpha
1	GWP2	0.830	5	0.891
2	GWP3	0.831		
3	GWP4	0.834		
4	GWP5	0.826		
5	GTP6	0.826		

The Cronbach's Alpha has been calculated for Green Logistics Packaging Practices after deleting GPP2, which increases the reliability further. After the deletion, the number of items is four, and reliability is 0.826, as shown in table 7.6. The item that has been deleted is GPP2.

Table 7.6 Cronbach's alpha for Green Logistics Packaging Practices (Source: Primary Data)

Sl. No.	GLPP	Cronbach's Alpha (if deleted)	No. of items	Cronbach's Alpha
1	GPP1	0.730	4	0.826
2	GPP3	0.745		
3	GPP4	0.772		
4	GPP5	0.801		

The Cronbach's Alpha has been calculated for Green Logistics Value-added

Practices after deleting GVE2, which increases the reliability further. After the deletion, the number of items is four, and reliability is 0.886, as shown in table 7.7. The item that has been deleted is GVE2.

Table 7.7 Cronbach's alpha for Green Logistics Value- Added Practices (Source: Primary Data)

Sl. No.	GLVP	Cronbach's Alpha (if deleted)	No. of items	Cronbach's Alpha
1	GVE1	0.790	4	0.886
2	GVE3	0.833		
3	GVE4	0.799		
4	GVE5	0.810		

The Cronbach's Alpha is calculated for Environmental Performance and none of the items is required to be deleted from the Table 7.8 with the value of reliability as 0.794.

Table 7.8 Cronbach's alpha for Environmental Performance (Source: Primary Data)

Sl. No.	EP	Cronbach's Alpha (if deleted)	No: of items	Cronbach's Alpha
1	EP1	0.642	4	0.794
2	EP2	0.649		
3	EP3	0.791		
4	EP4	0.792		

The Cronbach's Alpha is calculated for Economic Performance and none of the items is required to be deleted from the Table 7.9 with the value of the reliability of 0.944.

Table 7.9 Cronbach's alpha for Economic Performance (Source: Primary Data)

Sl. No.	EcP	Cronbach's Alpha (if deleted)	No. of items	Cronbach's Alpha
1	EcP1	0.923	6	0.944
2	EcP2	0.928		
3	EcP3	0.939		
4	EcP4	0.938		
5	EcP5	0.939		

6	EcP6	0.934		

The Cronbach's Alpha is calculated for Government and Environmental Policies and none of the items is required to be deleted from the Table 7.10 with the value of reliability as 0.877.

Table 7.10 Cronbach's alpha for Government and Environment Policies (Source: Primary Data)

Sl. No.	GEP	Cronbach's Alpha (if deleted)	No. of items	Cronbach's Alpha
1	GEP1	0.845	3	0.877
2	GEP2	0.852		
3	GEP3	0.780		

After the deletion of the items as per the above tables, the descriptive analysis is carried out again removing those deleted items. Table 7.11 shows the descriptive statistics of the dataset.

Table 7.11 Descriptive Statistics

	N	Minimum	Maximum	Mean	Std. Deviation	Skewness	
	Statistic	Statistic	Statistic	Statistic	Statistic	Statistic	Std. Error
GLTP	262	1.00	5.00	3.4268	.97710	-.384	.150
GLWP	262	1.40	5.00	3.4893	.91062	-.040	.150
GLPP	262	1.00	5.00	3.1479	.89289	-.332	.150
GLVP	262	1.00	5.00	3.0534	.97503	.380	.150
EP	262	1.00	5.00	3.2672	.89469	-.368	.150
EcP	262	1.00	5.00	3.4084	1.03734	-.470	.150
GEP	262	1.00	5.00	3.3104	1.01767	-.610	.150

7.2.2 KMO and Barlett's Test

Factor analysis is a statistical method used to describe the heterogeneity between measurable variables associated with a potentially small number of unobserved variables called factors. The first step in factor analysis is to perform the KMO and Barlett tests, and then the loading of the factor is performed by rotating the part matrix. Uh, Kaiser-Meyer-Olkin and Bartlett. The Kaiser-Meyer-Olkin Measure of Sampling Adequacy is a statistic that indicates the proportion of variances in the variables that can be caused by the underlying factors. High values (close to 1.0) usually mean that the measurement of a factor can be useful for the results of the study. If the value is less than 0.50, the results of the factor analysis will not be useful. The KMO value of this study sample shown in Table 7.12 shows a value of 0.852, which is appropriate. The Bartlett Sphericity Test checks the hypothesis that the correlation matrix is an identity matrix, which means that the variables are unrelated and thus not suitable for structural detection. Small values of p (less than 0.05) of the significance level indicate that a factor analysis might be valuable for the results. As per Table 7.12, the value of the Barlett Sphericity test in this research study is 0.00, which shows it is significant and appropriate.

Table 7.12 KMO and Bartlett's Test

KMO and Bartlett's Test		
Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		0.852
Bartlett's Test of Sphericity	Approx. Chi-Square	6623.700
	df	496
	Sig.	0.000

7.2.3 Factor Analysis

The data matrix should have enough correlations for the application of factor analysis. If the visual inspection does not show a significant number of correlations greater than 0.30, then the study of the factor is probably not sufficient" (Hair, 2003). The correlation coefficient matrix was also calculated for the data to verify the correlation between different variables. To be suitable for the factor analysis, the variables must be associated. Factor loadings are part of the outcome of the factor analysis, which acts as a data reduction technique designed to clarify the association between observed variables by using a smaller number of factors. Community is the proportion of variability of each variable that is clarified by the variables. Community value is the same for unrotated factor loadings or rotated factor loadings for analysis. Community principles determine how well the variables describe each variable. The closest the group is to 1, the more the variables describe the variable. It also helps to determine whether to add a factor if the factor contributes significantly to the adaptation of such variables.The communalities for the dataset under study were carried out on SPSS 25.0 and Table 7.13 shows the values for each of the factor/constructs under the analysis. The values higher than 0.7 are the preferred values although the values above 0.6 are also acceptable as a general rule.

Table 7.13 Communalities of the factors in EFA

Communalities		
	Initial	Extraction
GTP1	1.000	0.837
GTP2	1.000	0.802
GTP4	1.000	0.734
GTP5	1.000	0.714
GTP6	1.000	0.643
GTP8	1.000	0.628
GWP2	1.000	0.660
GWP3	1.000	0.736
GWP4	1.000	0.690
GWP5	1.000	0.726
GWP6	1.000	0.719
GPP1	1.000	0.752
GPP3	1.000	0.733
GPP4	1.000	0.620
GPP5	1.000	0.794
GVE1	1.000	0.778
GVE3	1.000	0.679
GVE4	1.000	0.812
GVE5	1.000	0.762
EP1	1.000	0.945
EP2	1.000	0.938

EP3	1.000	0.640
EP4	1.000	0.663
EcP1	1.000	0.896
EcP2	1.000	0.840
EcP3	1.000	0.725
EcP4	1.000	0.758
EcP5	1.000	0.739
EcP6	1.000	0.773
GEP1	1.000	0.790
GEP2	1.000	0.787
GEP3	1.000	0.846
Extraction Method: Principal Component Analysis.		

The next is variance explained by the initial solution, extracted components, and rotated components are displayed as shown in Table 7.14. This first section of the table displays the initial values. The Total Column gives the own value or the sum of variance in the original variables of each component. The percent of the variable column gives the ratio, expressed as a percentage, of the variance of each factor to the total variance of all variables. There are as many components as variables for the initial solution, and the sum of the own values is equal to the number of components in the correlation analysis. As in the analysis that eigenvalues greater than 1 be extracted, so the first seven principal components from the extracted solution.

The purpose of the rotation is to simplify and explain the structure of the data (Paneerselvam, 2007). There are two types of rotation available. Uncorrelated factors are caused by orthogonal rotations, while the factors are associated with oblique methods (Field, 2009). The literature explained that varimax rotation (orthogonal) is the most common form of rotation because it creates a clear and simple structure in a single matrix that is easy to interpret (Costello and Osborne 2005; Paneerselvam 2007). An un-rotated factor matrix suggests the association between the factors and individual variables but sometimes it produces factors that cannot be interpreted because the factors are correlated with many variables (Malhotra, 2011).

Table 7.14 Total Variance Explained on the Factors by EFA

Total Variance Explained									
Component	Initial Eigenvalues			Extraction Sums of Squared Loadings			Rotation Sums of Squared Loadings		
	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	9.472	29.599	29.599	9.472	29.599	29.599	4.889	15.278	15.278
2	3.323	10.384	39.983	3.323	10.384	39.983	4.390	13.720	28.998
3	2.934	9.170	49.152	2.934	9.170	49.152	3.620	11.312	40.309
4	2.652	8.286	57.439	2.652	8.286	57.439	3.092	9.663	49.972
5	2.151	6.722	64.161	2.151	6.722	64.161	2.702	8.443	58.415
6	1.530	4.781	68.942	1.530	4.781	68.942	2.480	7.751	66.166
7	1.401	4.377	73.319	1.401	4.377	73.319	2.289	7.153	73.319
8	0.985	3.079	76.399						
9	0.779	2.433	78.832						
10	0.664	2.076	80.908						
11	0.611	1.910	82.818						
12	0.532	1.663	84.481						
13	0.472	1.474	85.955						
14	0.440	1.374	87.329						
15	0.409	1.277	88.606						
16	0.394	1.233	89.839						
17	0.336	1.049	90.887						
18	0.334	1.044	91.931						
19	0.298	0.931	92.862						
20	0.293	0.914	93.777						
21	0.268	0.838	94.615						
22	0.253	0.792	95.407						
23	0.242	0.757	96.164						
24	0.231	0.722	96.887						
25	0.201	0.629	97.515						
26	0.173	0.539	98.055						
27	0.159	0.495	98.550						
28	0.140	0.436	98.986						
29	0.133	0.415	99.401						
30	0.109	0.339	99.740						
31	0.066	0.205	99.945						
32	0.017	0.055	100.000						
Extraction Method: Principal Component Analysis.									

In this research, varimax rotation was adopted. The rotated matrix when using the varimax rotation seemed to produce better solutions with a clearer factor structure (Field, 2009). The factor pattern matrix showing the correlation between the factors and the items provided should be equal to or greater than. 0.7 according to the variance extraction law. If the variance is less than 0.7, it would not be considered as a factor. The item values for the seven variables are obtained after rotation in Table 7.15 and are all greater than 0.7.

Table 7.15 Rotated Component Matrix

Rotated Component Matrix							
	Component						
	1	2	3	4	5	6	7
GTP1		.888					
GTP2		.880					
GTP4		.821					
GTP5		.800					
GTP6		.762					
GTP8		.729					
GWP2			.778				
GWP3			.820				
GWP4			.803				
GWP5			.821				
GWP6			.814				
GPP1					.826		
GPP3					.804		
GPP4					.739		
GPP5					.750		
GVE1				.855			
GVE3				.770			
GVE4				.869			
GVE5				.851			
EP1							.905
EP2							.895
EP3							.728
EP4							.715
EcP1	.892						
EcP2	.840						

EcP3	.811							
EcP4	.842							
EcP5	.801							
EcP6	.798							
GEP1							.832	
GEP2							.846	
GEP3							.852	

7.3 Confirmatory Factor Analysis for Green Logistics framework

Confirmatory Factor Analysis (CFA) is the next phase after an Exploratory Factor Analysis which is used to determine the structure of the study dataset. CFA is a theoretically based confirmatory technique (Schreiber et al., 2006). This study is useful when the researcher tries to analyze the theoretical relationship between the observed measures and the latent variables/factors. CFA is a hypothesized technique, and the researcher uses a hypothesized model to test the population covariance matrix (Brown, 2015). The primary aim is to reduce the disparity between the expected and the observed variables through the confirmatory process. In CFA, it is determined in advance the number of constructs/factors and the pattern of loading of the indicator factor. For each latent variable, a variety of goodness-of-fit indices is used as a separate structural model. As a consequence, the researcher needs to have a prior sense based on past evidence and the theory of factors that exists in the data. In the Confirmatory Factor Analysis, a theoretical model was first constructed for each factor, a path diagram of the casual relationship was then drawn up and the parameter calculated in the model was examined based on the goodness of the fitness measures available in the SPSS performance (Byrnes, 2006). In the EFA, the structure of the factor (how the variables relate and the category based on inter-variable correlations) has been analyzed whereas, in the CFA, the structure of the factor derived is confirmed. The Confirmatory Factor Analysis confirms the loadings as extracted in EFA, and thus confirms the scale for various factors in the study. Table 7.16 shows the Standardized loadings as extracted by the analysis using AMOS 26.0 during the study.

Table 7.16 Standardized Regression Weights

			Estimate
GTP1	<---	GLTP	0.881
GTP2	<---	GLTP	0.830
GTP4	<---	GLTP	0.818
GTP5	<---	GLTP	0.814
GTP6	<---	GLTP	0.792
GTP8	<---	GLTP	0.682
GWP3	<---	GLWP	0.794
GWP4	<---	GLWP	0.781
GWP5	<---	GLWP	0.817
GWP6	<---	GLWP	0.804
GPP1	<---	GLPP	0.890
GPP3	<---	GLPP	0.868
GPP4	<---	GLPP	0.607
GPP5	<---	GLPP	0.721
GVE1	<---	GLVP	0.839
GVE3	<---	GLVP	0.744
GVE4	<---	GLVP	0.859
GVE5	<---	GLVP	0.796
EP1	<---	EP	0.989
EP2	<---	EP	0.989
EP3	<---	EP	0.698
EP4	<---	EP	0.670
EcP1	<---	ECP	0.960
EcP2	<---	ECP	0.925
EcP3	<---	ECP	0.783
EcP4	<---	ECP	0.790
EcP5	<---	ECP	0.815
EcP6	<---	ECP	0.862
GEP1	<---	GEP	0.807
GEP2	<---	GEP	0.793
GEP3	<---	GEP	0.921
GWP2	<---	GLWP	0.747

7.3.1 Convergent and Discriminant validity

In this study, the convergent validity and the discriminant validity of the constructs are checked. After that, the fit of the model is evaluated according to the different fit indices. Until carrying the validity of the structures, the names must be allocated and the types of the variables must be defined. Table 7.17 sets out the type, labels, and names of the variables.

Table 7.17 Variable type, labels, and names in the Conceptual Model (Source: Primary Data)

Type of variable	Variable labels	Variable Names
Observed Endogenous variables	[GTP1 GTP2, GTP4, GTP5, GTP6, GTP8]	Items of Green Logistics Transportation Practices
	[GWP2, GWP3, GWP4, GWP5, GWP6]	Items of Green Logistics Warehousing Practices
	[GPP1,GPP3,GPP4, GPP5]	Items of Green Logistics Packaging Practices
	[GVE1,GVE3, GVE4, GVE5]	Items of Green Logistics Value- Added Practices
	[EP1,EP2,EP3,EP4]	Items of Environmental Performance
	[EcP1, EcP2, EcP3, EcP4, EcP5, EcP6]	Items of Economic Performance
	[GEP1, GEP2, GEP3]	Items of Government and Environment Policies

Unobserved Exogenous variables	GLTP	Green Logistics Transportation Practices
	GLWP	Green Logistics Warehousing Practices
	GLPP	Green Logistics Packaging Practices
	GLVP	Green Logistics Value-Added
	EP	Environmental Performance
	EcP	Economic Performance
	GEP	Government and Environmental Policies
Unobserved Exogenous Variables (Errors)	e1 e2 e4 e5 e6 e8 e10 e11	Errors
	e12 e13 e14 e15 e17 e18 e19 e20	
	e22 e23 e24 e25 e26 e27 e28 e29	
	e30 e31 e32 e33 e34 e35 e36 e37	

As mentioned earlier, observed variables are the measured variables and the unobserved ones are inferred or are residual errors. Exogenous variables are independent variables and endogenous are dependent ones. Table 7.18 gives the number of variables used and Figure 7.3 shows the frequency of the variables in the model.

Table 7.18 Number of Variables in the Model (Source: Primary Data)

Number of variables in the model	71
Number of observed variables	32
Number of unobserved variables	39
Number of exogenous variables	39
Number of endogenous variables	32

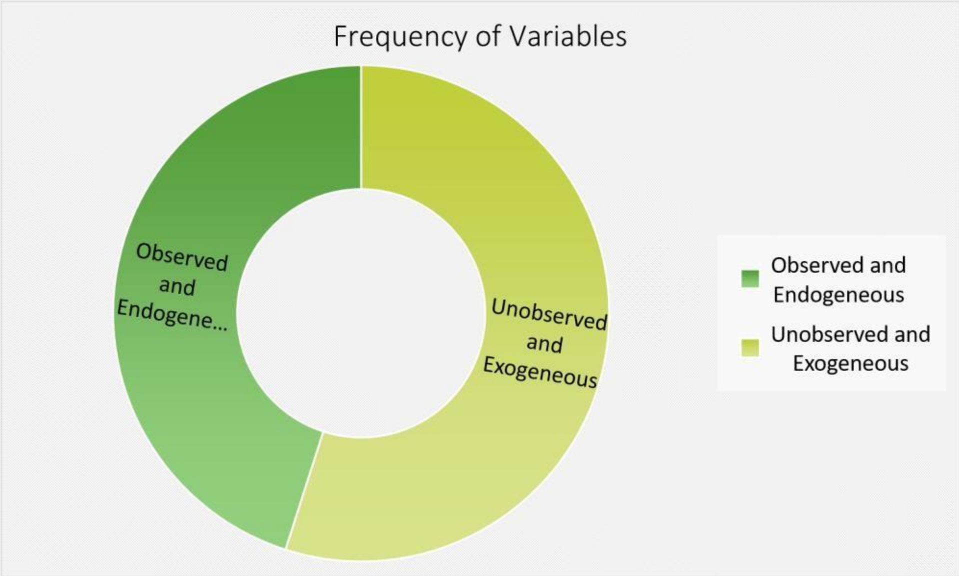

Figure 7.3 Frequency of variables in CFA

In the Confirmatory Factor Analysis (CFA), the dataset is processed on AMOS, followed by a converging and discriminatory analysis. Convergent and discriminant analyses are thus obtained in the CFA. Table 7.19 shows the converging and discriminating beliefs. And the values of the composite reliability. The reliability of the scales was calculated using the Composite Reliability (CR) values. Composite reliability is the proportion of variance described by the latent variable (Fornell and Larcker 1981). The values vary from 0 to 1 and the value for reliable structures in the study should be higher than 0.70. As shown in Table 7.19, all CR statistics exceed 0.7 of the cut-offs described in the literature. The validity of the constructs is a significant CFA parameter that confirms the objects for all the constructs. The loading value of the factor is obtained and, as stated in the literature, it should be above 0.7 to be satisfactory. In this analysis, the total loading of each of the constructs is more than 0.70, as shown in Figure 7.4. Convergence and discriminatory validity of CFA are calculated using Average Variance Extracted (AVE) and Maximum Shared Variance (MSV).

Convergent validity is the valuation to calculate the degree of association of several measures of the same factor agreed upon. The AVE value should be greater than 0.50 to be sufficient for convergent validity. AVE is the sum of variation that is apprehended by a construct due to an error of measurement. In this research study, all the constructs namely GLTP, GLWP, GLPP, GLVP, EP, EcP, and GEP statistically achieved a value higher than 0.50 which is accepted for AVE as shown in table 7.19 and depicted in Figure 7.5.

Table 7.19 Convergent and Discriminant Validity

	CR	**AVE**	**MSV**	**ECP**	**GLTP**	**GLWP**	**GLPP**	**GLVP**	**EP**	**GEP**
ECP	0.944	0.737	0.222	**0.858**						
GLTP	0.917	0.648	0.181	0.426	**0.805**					
GLWP	0.892	0.622	0.178	0.320	0.242	**0.789**				
GLPP	0.821	0.546	0.178	0.139	0.191	0.422	**0.739**			
GLVP	0.884	0.657	0.127	0.357	0.240	0.156	0.205	**0.811**		
EP	0.823	0.576	0.164	0.405	0.367	0.202	0.302	0.303	**0.759**	
GEP	0.879	0.709	0.222	0.471	0.272	0.188	0.234	0.248	0.396	**0.842**

As such, it confirms that the converging validity of the multi-item scales is adequate (Fornell and Larcker 1981). The discriminant validity is another statistical measure obtained from the CFA. It is referred to the level to which the construct is divergent from one another analytically. It is evaluated by statistical Maximum Shared Values and as per the literature, the value of MSV should be less than the AVE. In this study analysis, the MSV values for all the constructs are less than corresponding AVE values. This is shown in Table 7.19 and in charted in Figure 7.6.

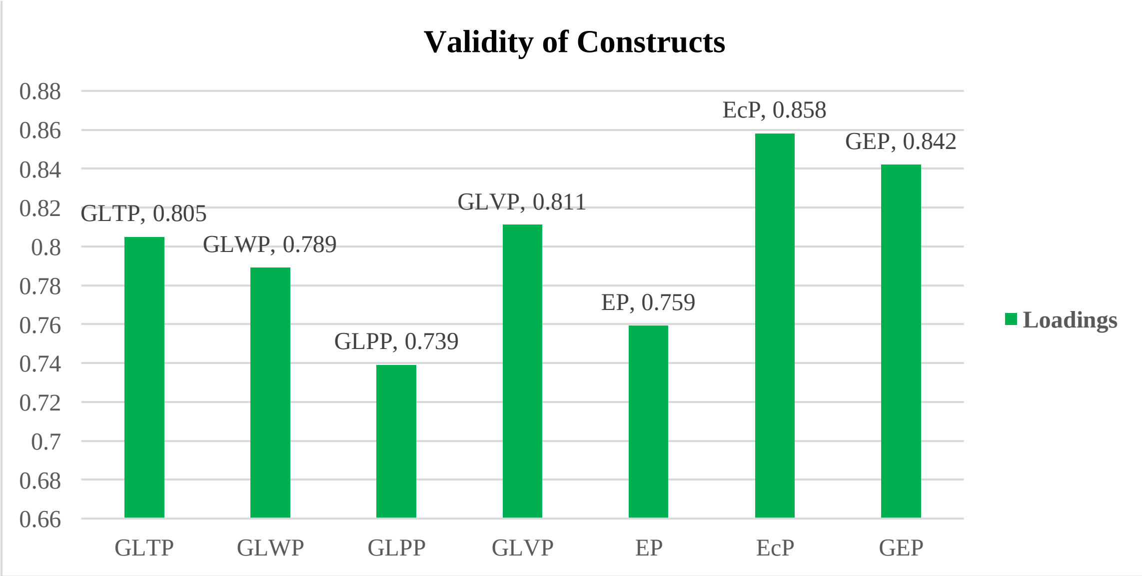

Figure 7.4 Validity of Constructs in CFA

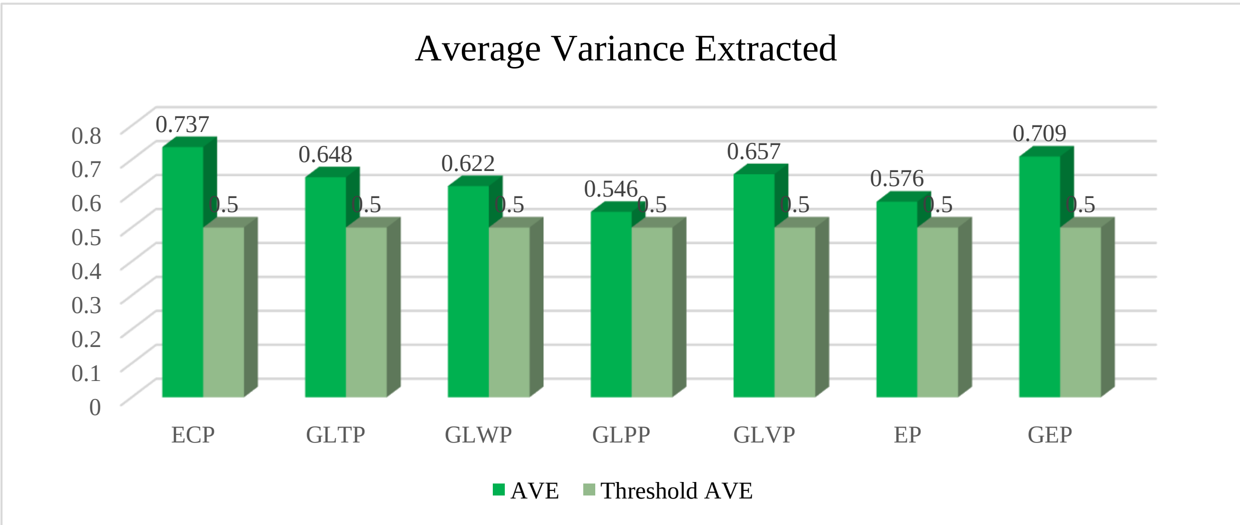

Figure 7.5 Average Variance Extracted (Convergent Validity) in CFA

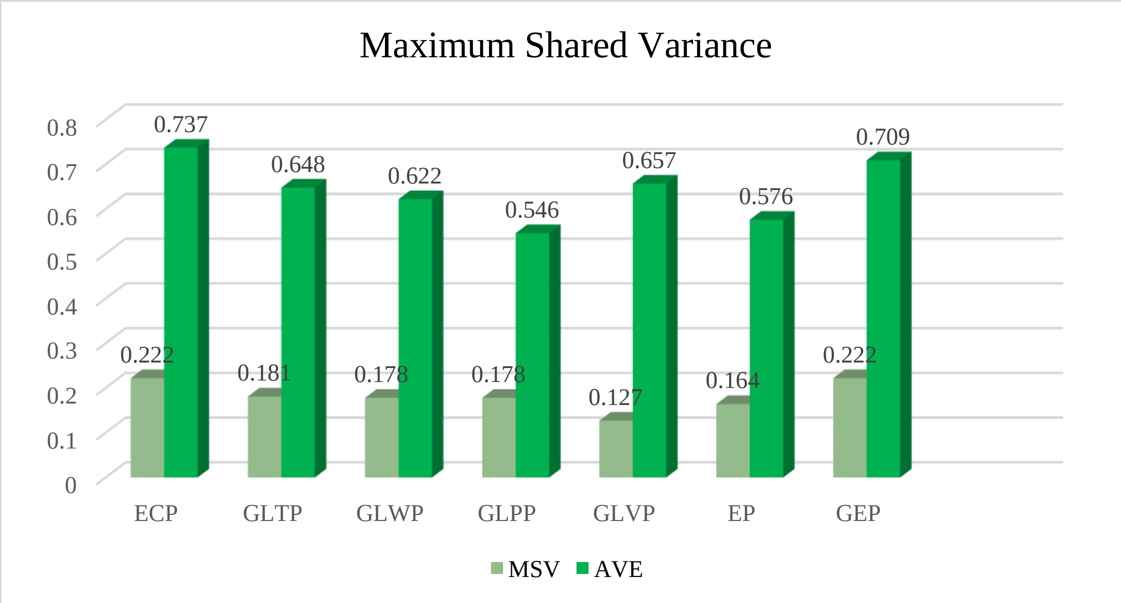

Figure 7.6 Maximum Shared variance (Discriminant Validity) in CFA

The factor loadings of all the items for the seven constructs along with the CR, and AVE are shown in Table 7.20. The next step is to carry out the model fit of the CFA using few fit indices.

Table 7.20 Results of Confirmatory Factor Analysis

Construct	Items	Standardized Loadings	Sig.	Composite Reliablity (CR)	Average Variance Extracted (AVE)
Green Logistics Transportation Practices(GLTP)	GTP1 GTP2 GTP4 GTP5 GTP6 GTP8	0.881 0.830 0.818 0.814 0.792 0.682	0.00	0.917	0.648
Green Logistics Warehousing Practices	GWP2 GWP3 GWP4 GWP5 GWP6	0.747 0.794 0.781 0.817 0.804	0.00	0.892	0.622
Green Logistics Packaging Practices	GPP1 GPP3 GPP4 GPP5	0.890 0.868 0.607 0.621	0.00	0.821	0.546

Green Logistics Value-Added Practices	GVE1 GVE3 GVE4 GVE5	0.839 0.744 0.859 0.796	0.00	0.884	0.657
Environmental Performance	EP1 EP2 EP3 EP4	0.989 0.989 0.658 0.670	0.00	0.823	0.576
Economic Performance	EcP1 EcP2 EcP3 EcP4 EcP5 EcP6	0.960 0.925 0.783 0.790 0.815 0.862	0.00	0.944	0.737
Government and Environment Policies	GEP1 GEP2 GEP3	0.807 0.793 0.921	0.00	0.879	0.709

7.3.2 Model Fit Summary

Model fit refers to the degree to which the proposed model accounts for the associations between variables in the dataset. If all the big correlations inherent in the data set (concerning the variables in the study model), then it will be in good shape; if not, there is a big difference between the proposed correlations and the observed correlations, and thus that's a bad model fit. To determine the degree to which the models described matched the results, the researcher used a range of fitness indices. Also, both absolute fit indices and incremental fit indices can be considered for the model fit index. Absolute indices test how well a model replicates the same data, while incremental fit indices assess proportional change in fitness by comparing the said model with a more constrained, nested baseline model (Hu & Bentler, 1999).

The apriori model consisting of the latent variables Green Logistics Practices, Economic Performance, Environmental Performance, and Government &

Environmental Policies with the respective observed variables have been checked to assess if the population covariance matrix relative to the covariance matrix observed is consistent with the estimates. The fit indexes offer guidance to help assess fitness, based on some of the rules available in the literature. There are various indices to show the goodness of the fit for the model. In this research study, the indices that are taken into consideration are Chi-square, Comparative Fitness Index (CFI), Goodness of Fit (GFI), Normed Fit Index (NFI), Minimum Discrepancy per degree of freedom (CMIN/DF), and Root Mean Square Error of Approximation (RMSEA) are seen. The Chi-Square value is considered as the most fundamental absolute fit Index (Hair et.al.2006). The acceptable level for the statistic is $p > 0.05$ The Comparative Fit Index (CFI) considers the sample size and tests the relative improvement of the researcher model in terms of the degree of fit against the independent model (Byrne, 2001). The CFI values range from 0 to 1.0 and the value about 0.90 represents the appropriate fit of the researcher model (Byrne, 2001; Hu and Bentler, 1999);. Comparative fit measurement (CFI) can only be perceived by comparing two different versions. The CFI value which is greater than 0.90 is appropriate (Hu & Bentler, 1999). The CFI value in this model is 0.921. The Goodness-of-Fit statistic can be used to measure the proportion of variance that is compensated for by the calculated population covariance (Tabachnick & Fidell, 2007). It is traditionally recommended that the omnibus cut-off point be 0.80 or greater than 0.80 for the GFI. In this analysis, the GFI value is 0.824 indicating a good fit. The Incremental Fit Index (IFI) modifies the Standard Fit Index (NFI) for sample size and degree of freedom (Bollen's, 1989). Over 0.90 is a good match, but the index may exceed 1. The IFI value for the research model is 0.92, which is within a reasonable range. The minimal difference in the degree of freedom (CMIN/DF) is another index for the fitness of the model suit. The CMIN/DF < 3 shows an acceptable fit between the hypothetical model and the sample data (Kline, 1998). The value of the proposed model is 2,165, which is within the model's fitness level. The Root-Mean Square Error of Approximation is another fitness index of the model (Kline2005), which shows the difference between the hypothesized model of the sample covariance matrix and the population covariance matrix. A value less than or equal to 0.08 is acceptable for the model fit (Hu & Bentler, 1999, cited in Singh, Junnarkar, Kaur, 2016). The RMSEA value in this model is 0.067. The results of the CFA are compared with the fit indices to decide whether the data is appropriate for model construction. Based on a comparison with the values listed above, it was found that the model is acceptable based on the fitness of the indices as shown below in Table 7.21 and the CFA model is depicted in Figure 7.7.

Table 7.21 Model Fit Indices(CFA)

Indicators	Threshold range	Current values
CMIN/DF	Less or equal 3	2.165
GFI	Equal or greater .80	.824
CFI	Equal or greater .90	.921
IFI	Equal or greater .90	.922
RMSEA	Less or equal .08	.067

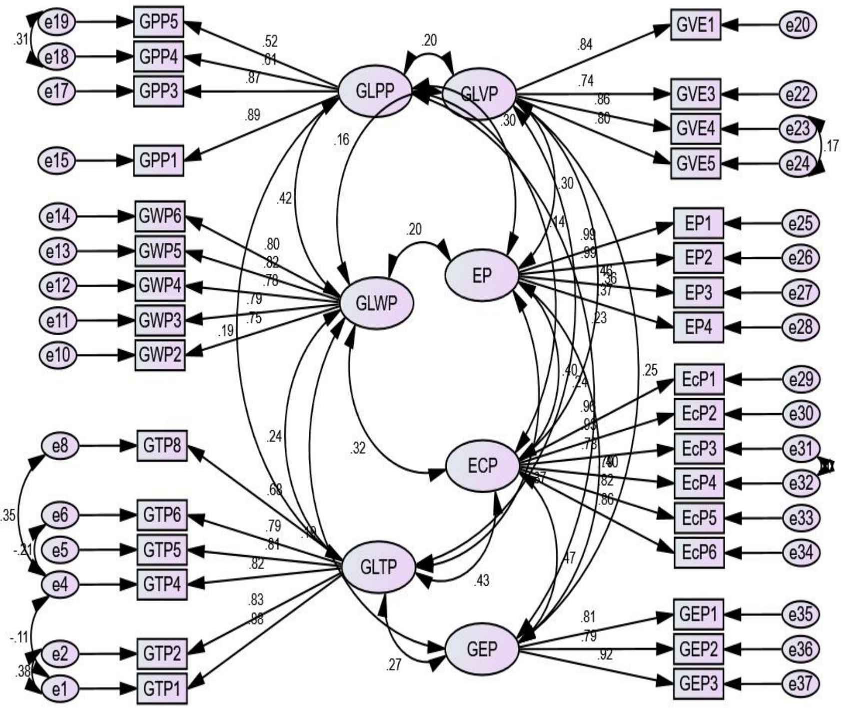

Figure 7.7 Confirmatory Factor Analysis Model

7.4 Structural Equation Modelling for Hypotheses Testing

A statistical hypothesis is a hypothesis that can be tested based on the observed data modelled on the actual values taken from a collection of random variables. The data collection (or multiple data sets were taken together) is modeled as the realized values of a group of random variables with a common probability distribution in a set of possible joint distributions. The hypothesis being tested is precisely the set of possible distributions of probability. A statistical hypothesis test is a method of statistical inference. Structural Equation Modelling is a multivariate statistical analysis technique used to evaluate structural relationships. It is a mixture of factor analysis and multiple regression analysis and is used to evaluate the relationship between observable variables and latent constructs. It is preferred by the researcher to estimate multiple and interrelated dependencies in a single study.

7.4.1 Hypotheses Testing

Structural Equation Modelling is an extension of the General Linear Model (GLM) that allows a researcher to analyze multiple regression equations simultaneously. According to Yoon, et al. (2001), the proposed conceptual model includes the observed indicators and the hypothetical constructs are validated by SEM. The hypothesized model is designed to calculate the causal relationship between the unobserved constructs defined based on prior empirical research and theory. SEM represents relationships between observed and unobserved variables using path diagrams. In this analysis, endogenous variables and exogenous variables are used. Ovals or circles are latent variables, whereas rectangles or squares are calculated variables. Residuals are often unobserved so that they are represented by ovals or circles. Figure 7.2 above shows the proposed framework of SEM involving Green Logistics Practices, Environmental Performance, and Economic Performance, where

Environmental Performance serves as a mediator between practices and Economic Performance. Government and Environment policies serve as a moderator between Green Logistics Practices and Environmental Performance and Green Logistics Practices and Economic Performance. The Structural Equation Model uses the Maximum Likelihood Calculation. Table 7.22 sets out the type, labels, and names of the variables.

Table 7.22 Variable type, labels, and Names in the Model

Type of Variable	**Variable Label**	**Name of variable**
Observed, endogenous variables	EcP EP	Economic Performance Environmental Performance

Observed, exogenous variables	GLTP GLWP GLPP GLVP	Green Logistics Transportation Practices Green Logistics Warehousing Practices Green Logistics Packaging Practices Green Logistics Value-Added Practices
Unobserved, exogenous variables	e1 e2	Errors

Table 7.23 gives the number of variables used. As mentioned earlier, observed variables are the measured variables and the unobserved ones are inferred or are residual errors. Exogenous variables are independent variables and endogenous are dependent ones.

Table 7.23 Number of Variables in the Model (Source: Primary Data)

Number of variables in the model:	8
Number of observed variables:	6
Number of unobserved variables:	2
Number of exogenous variables:	6
Number of endogenous variables:	2

Structural Equation Modelling was performed to test Hypothesis 1 to Hypothesis 20. The proposed study structural models have been evaluated during the testing process. The simulations were calculated to use structural equation modeling in AMOS 26.0. The different outputs for SEM are obtained for standardized regression weights, covariances, and correlations (Appendix-2). The regression weights for the first eight hypotheses are depicted in Table 7.24. The effect of the various Green Logistics Practices on the Environmental Performance as well as Economic Performance is shown in the same table. The mediation analysis in Table 7.25 shows the effect of partial mediation of Environmental Performance on Economic Performance. The moderation has been shown in Table 7.26 which displays the Government and Environmental Policies effect among the relation of Green Logistics Practices and Green Logistics Performances.

Table 7.24 Regression Weights

			Estimate	S.E.	C.R.	P	Label
EP	<---	GLTP	.280	.052	5.423	***	par_5
EP	<---	GLWP	.114	.057	2.004	.045	par_6
EP	<---	GLPP	.147	.059	2.508	.012	par_7
EP	<---	GLVP	.175	.051	3.411	***	par_8
EcP	<---	GLTP	.188	.059	3.174	.002	par_1
EcP	<---	GLWP	.223	.063	3.561	***	par_2
EcP	<---	GLPP	-.102	.065	-1.583	.113	par_3
EcP	<---	GLVP	.177	.057	3.089	.002	par_4
EcP	<---	EP	.402	.068	5.954	***	par_9

Table 7.25 Mediation Analysis (EP as mediator)

	GLVP	**GLPP**	**GLWP**	**GLTP**	**EP**
EP	...	...	...	...	...
EcP	.010	.017	.077	.010	...

Table 7.26 Moderation Analysis (GEP as moderator)

	GLVP*GEP	**GLPP*GEP**	**GLWP*GEP**	**GLTP*GEP**	
EP	**.000**	**.047**	**.007**	**.027**	
EcP	**.007**	**.100**	**0.612**	**0.000**	**...**

7.4.2 Model Fit Summary for SEM

Various fitness indices for the SEM model are also used to assess the degree to which the models referred to match the results. The critical step in applying the Structural Equation Modeling (SEM) is to assess the fitness of the proposed model with the data. If the maximum probability is used to measure the model, the probability ratio (LR) test statistic is considered to be the most widely used test for the assessment of overall fitness (Jöreskog, 1969; Maydeu-Olivares, 2017). Assuming that the proposed model is correctly defined, the test statistic follows the central chi-square distribution asymptotically. As a result, the chi-square test allows researchers to evaluate the fitness of the model. The Goodness-of-Fit Index (GFI) provides an absolute measure of how well the model represents the results. The GFI is conceptually linked to the proportion of variance expressed in the model, such as regression. The range is therefore between 0 (bad) and 1 (bad) (perfect). The Comparative Fitness Index (CFI) is a fitness index that ranges from 0 to 1, with values above.90 suggesting a good fit. More precisely, CFI considers how much the non-central parameter is decreased as a transition from a baseline model to a candidate model (in terms of fit).RMSEA is a badness-of-fit metric that yields lower values for better fitness. The RMSEA ≤ .06 can be considered acceptable (Hu & Bentler, 1999), while the RMSEA model ≥ .10 is not worthy of serious consideration (Browne & Cudeck, 1993). Table 7.27 shows the model fit summary which shows the value of various indices namely CMIN/DF, GFI, CFI, IFI, and RMSEA. The values indicate that they are in the range and thus the model for SEM has a good fit.

Table 7.27 Model fit summary for SEM

Indicators	Threshold range	Current values
CMIN/DF	Less or equal 3	2.165
GFI	Equal or greater .80	.824
CFI	Equal or greater .90	.921
IFI	Equal or greater .90	.922
RMSEA	Less or equal .08	.067

Table 7.28 displays the effects of the structural model hypotheses, including the moderation and mediation variables. The fact that the observed and predicted covariance matrix has shown a good fit for the respective structural model. The twenty hypotheses were evaluated and analyzed, and based on the model fit indices values, out of all the hypotheses from H1 to H20, hypotheses from H1 to H8 include the testing of

Environmental Performance and Economic Performance Hypotheses with Green Logistics Activities. Out of all eight of these hypotheses, H7 is the only hypothesis to be rejected as the p-value is 0.113 which is higher than 0.05 and thus not significant. The mediation research hypotheses range from H9 to H12, and out of all H10 is rejected as the p-value is 0.77 in partial mediation effect and all other mediation hypotheses are approved. In the hypotheses, H13 to H20, which include moderation study, H18, and H19 are rejected in the analysis as the p values are 0.612 and 0.10 which is not significant at 95% confidence level, and all others are approved for a moderation analysis. The Structural equation model which includes moderation and mediation is shown in Figure 7.8.

Table 7.28 Results of Hypotheses Testing

Structural Equation Modelling							
Hypothses	**Direction**			**Estimate**	**S.E.**	**P**	**Decision**
H1	GLTP	→	EP	.305	.052	.000	Accepted
H2	GLWP	→	EP	.116	.057	.045	Accepted
H3	GLPP	→	EP	.147	.059	.012	Accepted
H4	GLVP	→	EP	.191	.051	.000	Accepted
H5	GLTP	→	EcP	.177	.059	.002	Accepted
H6	GLWP	→	EcP	.196	.063	.000	Accepted
H7	GLPP	→	EcP	-.088	.065	.113	Rejected
H8	GLVP	→	EcP	.166	.057	.002	Accepted
Mediation Analysis							
Hypotheses	**Direction**			**Estimate**	**S.E.**	**P**	**Decision**
H9	GLTP	→	EP	.106	.034	.010	Accepted
H10	GLWP	→	EP	.040	.021	.077	Rejected
H11	GLPP	→	EP	.051	.021	.017	Accepted
H12	GLVP	→	EP	.066	.024	.010	Accepted
Moderation Analysis							
Hypotheses	**Direction**			**Estimate**	**S.E.**	**P**	**Decision**
H13	GLTP*GEP	→	EP	.059	.050	.027	Accepted
H14	GLWP*GEP	→	EP	-.146	.052	.007	Accepted
H15	GLPP*GEP	→	EP	-.093	.061	.047	Accepted

H16	GLVP*GEP	→	EP	-.191	.054	.000	Accepted
H17	GLTP*GEP	→	EcP	.300	.048	.000	Accepted
H18	GLWP*GEP	→	EcP	.027	.053	.612	Rejected
H19	GLPP*GEP	→	EcP	-.092	.063	.100	Rejected
H20	GLVP*GEP	→	EcP	-.149	.054	.007	Accepted

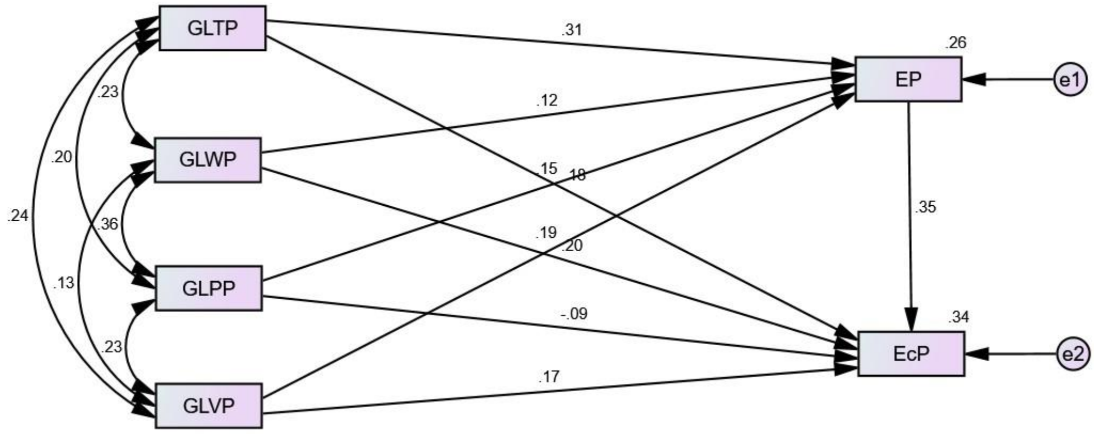

Figure 7.8 Structural Equation Model

7.4.3 Moderation Graphs

Moderation results are difficult to understand without a graphic. It helps to see the impact of an individual value on the various values of the moderator. If the independent variable is categorical, its influence is calculated by mean differences, and these differences are easier to see using graphs. Moderation says that these mean variations are not the same for each moderator value. It can be hard to distinguish the trend of how they vary without seeing it. The moderator GEP can below as well as high when it acts as a moderator. The moderation graph between GLTP and EP is shown in Figure 7.9. The low moderator when acts between GLTP and EP shows the value 2.37 with low GLTP and 2.91 with high GLTP. When the moderator is high, the EP value is 2.97 with low GLTP and 3.75 with high GLTP. The moderation graph between GLWP and EP is shown in Figure 7.10. The low moderator along with the low GLWP has a value of 2.25 of EP and with high GLWP the value is 2.95. However, when the moderator is high the value of EP is 3.35 for low GLWP and 3.45 for high GLWP. The moderation graph between GLPP and EP is shown in Figure 7.11. The low moderator along with the low GLPP has a value of 2.33 of EP and with high GLPP the value is 2.89. However, when the moderator is high the value of EP is 3.29 for low GLPP and 3.49 for high GLPP. The moderation graph between GLVP and EP is shown in Figure 7.12. The low moderator along with the low GLVP has a value of 2.24 of EP and with high GLVP the value is 3.08. However, when the moderator is high the value of EP is 3.3 for low GLVP and 3.38 for high GLVP. The moderation graph between GLTP and EcP is shown in Figure 7.13. The low moderator along with the low GLTP has a value of 2.58 of EcP and with high GLTP the value is 2.74. However, when the moderator is high the value of EcP is 2.66 for low GLTP and 4.02 for high GLTP. The moderation graph between GLWP and EcP is shown in Figure 7.14. The low moderator along with the low GLWP has a value of 2.39 of EcP and with high GLWP the value is 2.83. However, when the moderator is high the value of EcP is 3.11 for low GLWP and 3.67 for high GLWP. The moderation graph between GLWP and EcP is shown in Figure 7.15. The low moderator along with the low GLPP has a value of 2.45 of EcP and with high GLPP the value is 2.73. However, when the moderator is high the value of EcP is 3.45 for low GLPP and 3.37 for high GLPP. The moderation graph between GLWP and EcP is shown in Figure 7.16. The low moderator along with the low GLVP has a value of 2.27 of EcP and with high GLVP the value is 3.05 However, when the moderator is high the value of EcP is 3.25 for low GLVP and 3.43 for high GLVP.

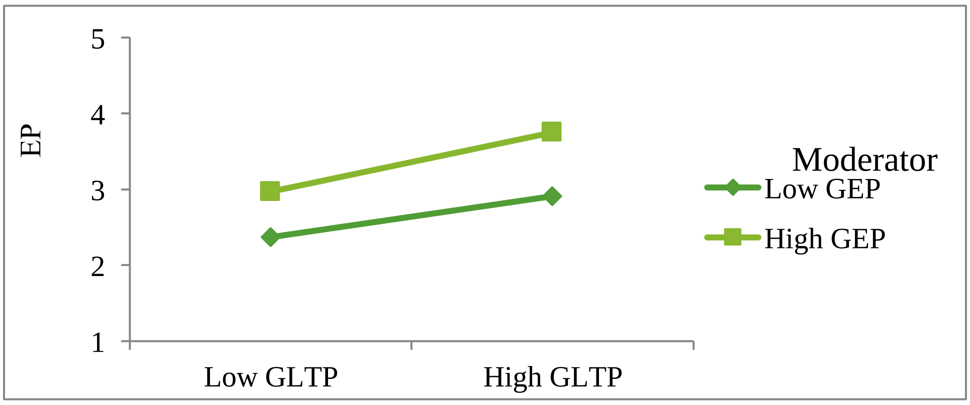

Figure 7.9 GEP moderating impact between GLTP and EP

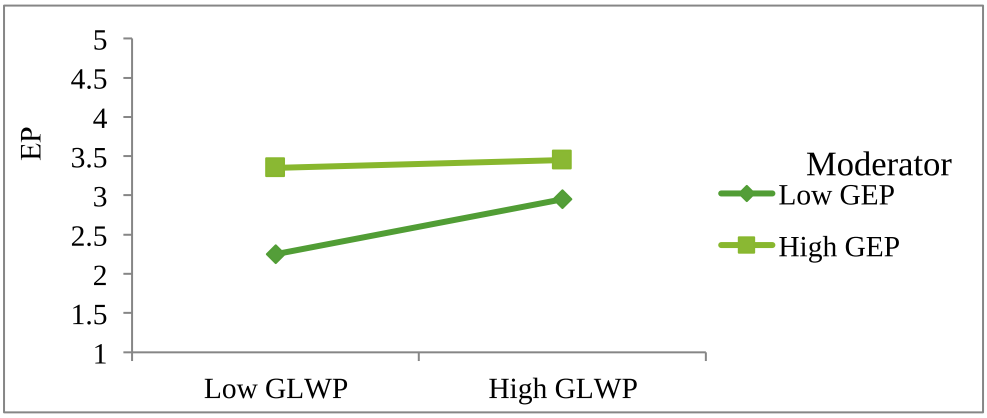

Figure 7.10 GEP moderating impact between GLWP and EP

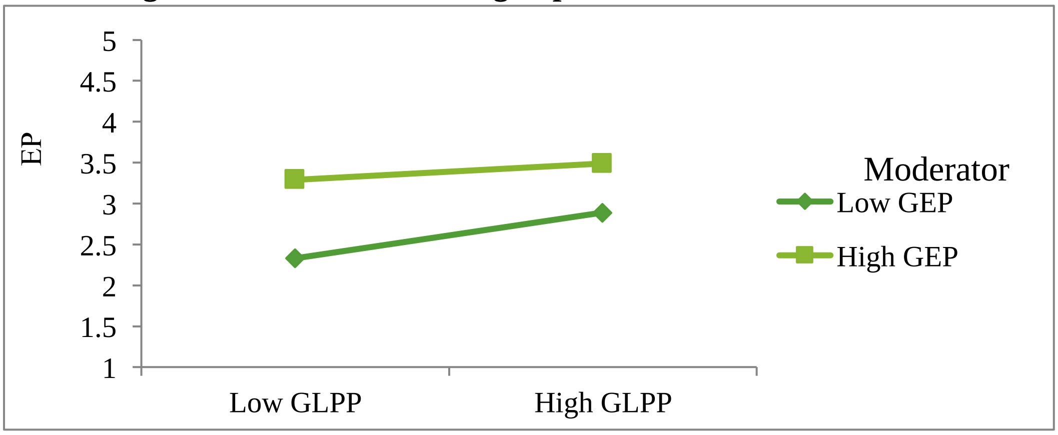

Figure 7.11 GEP moderating impact between GLPP and EP

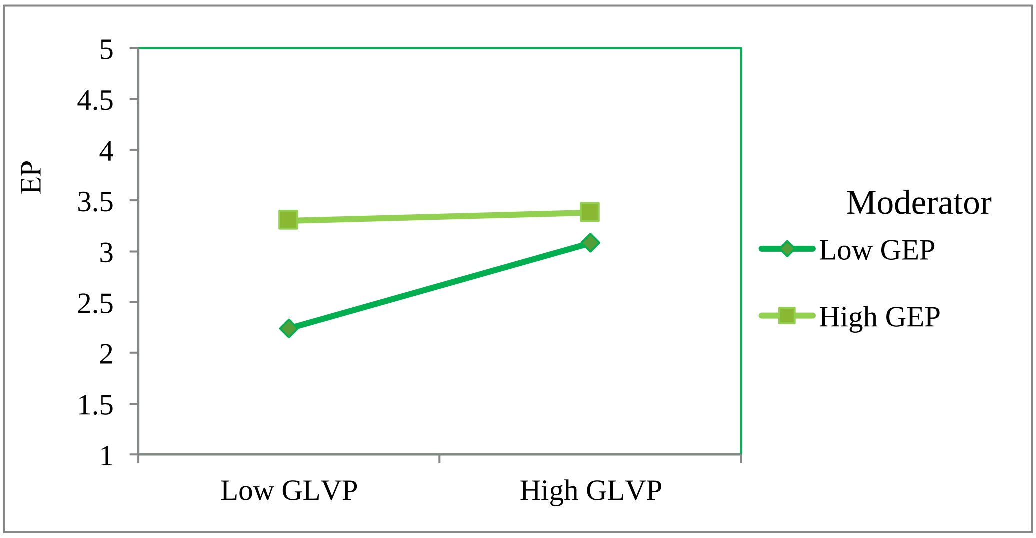

Figure 7.12 GEP moderating impact between GLVP and EP

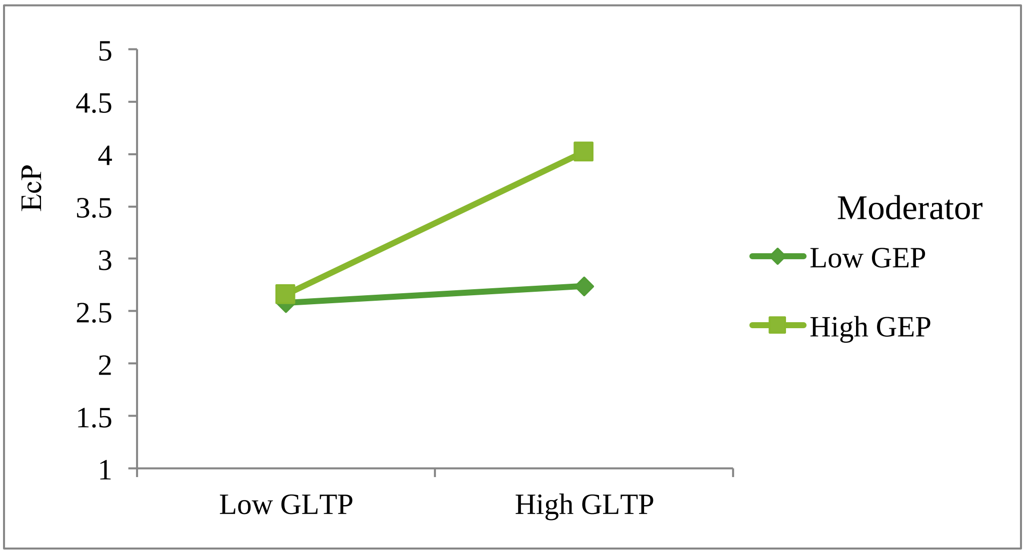

Figure 7.13 GEP moderating impact between GLTP and EcP

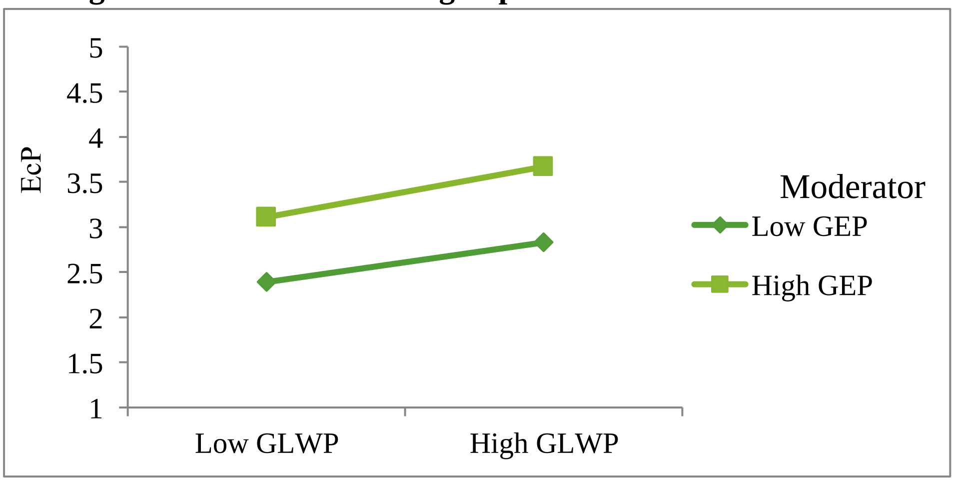

Figure 7.14 GEP moderating impact between GLWP and EcP

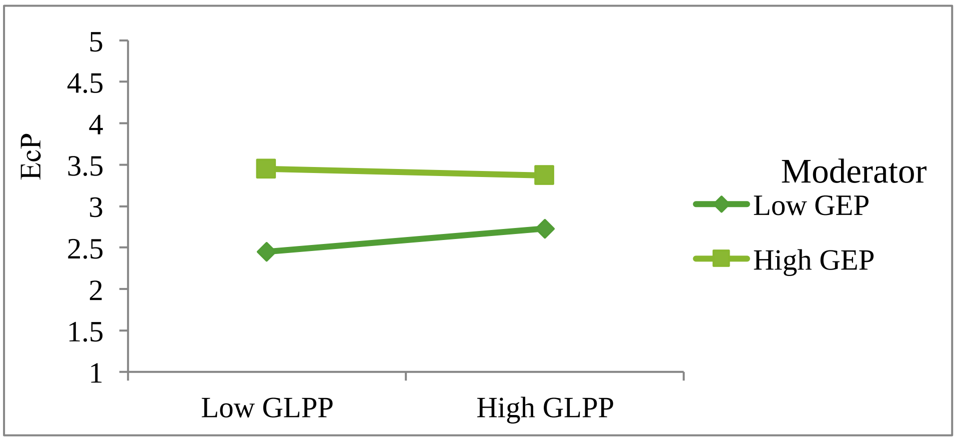

Figure 7.15 GEP moderating impact between GLPP and EcP

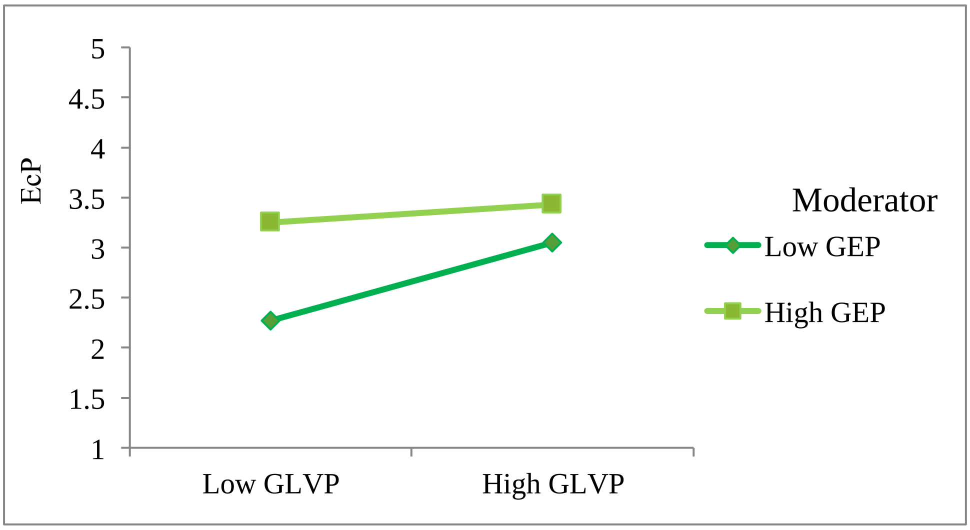

Figure 7.16 GEP moderating impact between GLVP and EcP

7.5 Chapter Summary

The study has contributed Green logistics practices and performance framework for the Indian manufacturing Industry (Oil and Gas Sector). This model will help the logistics managers to identify and prioritize the drivers and barriers, which are essential in terms of motivators and hindrances, respectively, for them to progress the implementation of green logistics practices and ultimately relate with performance parameters. The green logistics practices include Green Transportation, Green Warehousing, Green packaging, and Green value-added services. The performance parameters include Environmental Performance and Economic Performance. This framework, after doing all the analysis of the practices and performance parameters, would be beneficial for the logistics companies to implement these logistics practices in the future. Initially, the EFA analysis is done for evaluation and validation of the seven constructs. The reliability test by Cronbach alpha was carried out for all the items and during the test, four items were deleted. The KMO and Barlett's Test was also done for verifying the significance of the dataset. Then the factor analysis was carried and scales for various items under the factors were generated. The CFA analysis was carried out and the results of convergent and discriminant validity along with the constructs were involved. The Composite Reliability was evaluated for each of the constructs under the study. The values came out to be appropriate for all the seven constructs. The values of AVE and MSV were calculated and checked for the convergent and discriminant validity of the constructs. The hypotheses testing was done using Structural equation Modeling for the twenty hypotheses. The twenty hypotheses were framed from the Green Logistics Practices and Performances. Out of all, the first eight hypotheses showed the effect of various GLP on Environmental Performance and Economic Performance. The next four hypotheses involved the Environmental Performance as the mediator between the GLP and Economic Performance. The last eight hypotheses involved the moderator known as Government and Environmental policies (derived from the GL drivers). The hypotheses number H7, H10, H18, and H19 are rejected as their value p is more than 0.05 and thus these relations are not significant according to the study. Rest all the sixteen hypotheses were significant.

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Chapter- 8

Conclusion

8.1 Introduction

The relevant conclusions and meaningful recommendations are associated with good quality research. Conclusions should be about the various objectives of the study, which makes the research relevant. The recommendations based on research outputs are considered meaningful if the findings can be put into real conditions. Although the conclusions are subjected to various limitations, thus the limitations would provide guidelines to the researchers working in a similar area.

In the era of economic liberalization and increased competition with the emergence of new products and improved services as well as fast growth in customer needs and expectations for green or eco-friendly products and the clean environment, the manufacturing industry faces tremendous competition and are under immense pressure to become more responsive to customer needs and governmental regulations. The assessment of green logistics practices, green logistics drivers, green logistics barriers, and measures of economic and environmental performance is important for the Indian manufacturing industry. It is needed to be studied and analyzed to minimize the impact of environmental degradation during its operations. In India, typically researchers have not given adequate attention to the studies exploring the subject of

Green Logistics Practices in the Manufacturing Industry and especially in the Oil and Gas sector, and thus as a result, very fewer studies are seen in this area. Very few researchers have tried to attempt this area from varied perspectives and have mainly focused on theories to identifying Green Logistics Practices criterion, exploring individual green practices however very few researchers have attempted to explore the complete integration of all the Green Logistics Practices in the area of Oil and Gas

Industry. This study is about Green Logistics Practices, Drivers for Green Logistics Practices, Barriers for Green Logistics Practices, and the performance of Green Logistics in the context of the Indian Manufacturing Industry (Oil and Gas).

The first chapter of the research study deals with the introduction of the concept and practices of Green Logistics, performance parameters, and the Indian manufacturing industry (Oil and Gas). The second chapter is dedicated to the review of Green Logistics literature in detail, which includes identifying drivers, barriers, practices, and performance parameters. The research objectives, along with the methodology of the study, are discussed in chapter third. The fourth chapter justifies Green Logistics Practices over non-green logistics in the Indian Manufacturing Industry. The fifth chapter entirely deals with analyzing the Green Logistics Barriers in an Indian manufacturing industry. The next chapter deals with the data analysis and interpretation for ranking of the Green Logistics Drivers and Green Logistics Practices for the select manufacturing industry(Oil and Gas) The seventh chapter includes the hypotheses testing and modeling using SEM doing the statistical analysis and interpretation. Based on all the analysis and other research work, some conclusions are drawn in the last chapter. Specific recommendations are also made, which will help future researchers working in a similar field expected to benefit the environment in general and working for Oil and Gas in particular. In this chapter, all the significant limitations of this study are also being mentioned. Based on these limitations, the study provides directions for future researchers.

8.2 Summary of the work done

An in-depth literature survey was conducted to identify contemporary research issues and their relevance in the Indian logistics context. As an outcome of the survey, a comprehensive bibliography is prepared, which consists of 250 articles on green logistics published in referred national and international journals, books, and relevant websites were covered. It is expected that this bibliography will be useful to researchers and practitioners of this subject.

- Based on the literature survey and exploratory discussions with the experts of the Oil and Gas Industry, a set of items for measurement of Green Logistics in different sections were identified. The four main activities namely Green Transportation, Green warehousing, Green Packaging, and Green value-added services were identified to be studied for this research. The Green Logistics Barriers and Drivers were also discussed in the chapter. The two performance parameters to be studied in this research were also finalized. The performance has been studied in terms of Economic Performance and Environmental Performance. Total 6 major factors/constructs of Green Logistics practices and performance for Oil and Gas Industry, were identified through a review of literature and expert's opinion. These constructs included Green Logistics Transportation (GLTP), Green Logistics Warehousing Practices (GLWP), Green Logistics Packaging Practices (GLPP), Green Value-added Practices(GLVP), Environmental Performance (EP), and Economic Performance (EcP).
- The various parameters of green logistics namely barriers, drivers, practices, and performances were tabulated with the identified items under each factor/construct. It consisted of 11 items for Green Logistics Drivers, 16 items for Green Logistics Barriers, 8 items for Green Transportation Practices, 6 items

for Green Warehousing Practices, 6 items for Green Value-added Practices. The items for the Economic and Environmental performance were also studied. 4 items for Environmental Performance and 6 items for Economic Performance were obtained from the literature after the suggestions from the expert of the Oil and Gas Industry. One factor i.e. Government and Environmental policies (GEP) is framed which consisted of three items from the Green Logistics Drivers. This factor acts as the moderator among the Green Logistics Practices and both the Performances.

- Initially, the AHP technique is used for justification of Green logistics over nonGreen logistics in the Indian Manufacturing Industry. The entire research focuses on the implementation of Green Logistics Practices, so it becomes important to justify Green Logistics in the Indian Manufacturing Industry.
- The implementation of Green Logistics is always hindered by the barriers; therefore the 16 most important and related barriers were identified from the literature and analyzed using the DEMATEL technique to find the cause and effect. Also, the ranking of the barriers was found
- A questionnaire was designed based on the inputs from the literature after improvement from the experts. Further, this questionnaire was validated using proven statistical tools and methodologies. Survey data were collected from the respondents working for the logistics activities of the Oil and Gas Industry in India. 262 filled questionnaires were collected. SPSS 25.0 software was used to conduct the descriptive analysis of the Green Logistics Drivers and all the Green Logistics Practices for ranking them in order of importance.
- The Exploratory factor analysis is then carried out. Factor loadings are checked for all the factors and on basis of reliability 4 items were deleted..Then the

Confirmatory factor analysis is also done using AMOS 26.0 for confirming the factors and items obtained from EFA. The fitness of the model of CFA is also checked using the various fit indices values.

- Further, the relations between various practices and the performances have been defined, which helps in analyzing their relationship by SEM using AMOS 26.0 for testing the twenty framed hypotheses involving the mediator and moderation. The twenty hypotheses are checked for their significance. Also, the fit of the SEM model is done using AMOS 26.0.

8.3 Conclusion and Discussion based on Objectives

The conclusion of the study are presented below as per the objectives delineated in chapter 1 of this thesis:

1) *Justification of Green Logistics over Non-Green Logistics in the context of the Indian Manufacturing Industry*

Logistics activities play a crucial role in the manufacturing sector, especially after globalization. Carbon emissions are a matter of concern and thus the industries are moving towards green logistics. However, it becomes viable for the study to justify Green Logistics over non- Green Logistics in the context of the Indian Manufacturing Industry. The six major benefits were taken into consideration over the two alternatives. With the use of the AHP technique, the Global desirability index of the two options was evaluated, and the value for Green Logistics was calculated as 0.863, over 0.136 for non- Green Logistics, which justified the Green Logistics.

2) *Identification and ranking of crucial barriers hindering the implementation of Green Logistics Practices in the context of the Indian Manufacturing Industry.*

The barriers pose problems in the implementation of Green Logistics Practices in the manufacturing industry, so it becomes highly important to identify the barriers and analyze these barriers too. The analysis will help to understand the factors which act as hindrances towards greener elements in logistics. The various barriers were identified through the critical literature review and sixteen barriers were finalized. A group of experts from industry and academia was referred for giving the dependence of one barrier over another and DEMATEL methodology. MATLAB was used to develop the relative relationship among the identified barriers. The results are supportive in recognizing the significant barriers, identifying the barriers under the dependent and independent category, finding the most critical barrier, and thus helping the policymakers to understand which barriers hinder the implementation of Green Logistics Practices. Out of all the barriers, the most important barrier came out to barrier - 4, which is '*Non-interest of Top-level management towards GLP*'. It has been seen in the industry that where the Top-level management takes an interest in GLP the implementation of these practices becomes very easy. The least important barrier in the implementation of the Green Logistics Practices came out to be barrier - 11, i.e., '*the complexity of design to reuse and recycle*.'

The results generated will help the industries to remove the major barriers to the implementation of GLP. This will help the company owners, policymakers, and even the government. The barriers which affect the most should be focused on and worked upon by the practitioners. In the future, this relationship model using DEMATEL can be used to develop a platform for the adoption of Green Logistics by reducing the important barriers.

3) *<u>Identification and ranking of important drivers in select Indian Manufacturing Industry(Oil and Gas) for the implementation of Green Logistics Practices.</u>*

Drivers, which are considered motivators lead to influence the sustainability and environmentally friendly logistics practices originate from some external and internal factors. Various researchers have shown that there are drivers that lead to the adoption of sustainable logistics movements. All the major drivers are explored in chapter 2 from the previous research studies both in the Indian and International context of the manufacturing sector. After careful examination, the list of eleven major Green Logistics Drivers was prepared in consultation with the experts of the Oil and Gas sector (Refer, Table 2.6). Findings in Table 6.5 revealed that the driver, *'GLD2 - Complying with the Government*', with the mean value of 4.19, is considered as the most important driver. This indicates that the respondents working for the Oil and Gas Industry have a view that the government regulations related to green practices act as the highest motivator. So it can be recommended that if the government formulate specific rules and regulations for the Manufacturing Industry about Green Logistics, this acts as the motivator. The next is the least ranked driver in Table 6.5, which is *'GLD 5 Collaborating with the Customers'*. It shows that when it comes to collaborating with customers, Manufacturing Industry does not find it very important and appropriate for Green Logistics Practices. Therefore, the logistics domain of the Indian manufacturing industry (Oil and gas sector) are motivated by the govt. Green policies in terms of green implementation.

4) *Identification and ranking of important Green Logistics Practices in select Indian Manufacturing Industry (Oil and Gas).*

Green Logistics highlights various practices followed to reduce the environmental problems of logistics operations, especially related to greenhouse emissions, transportation, packaging, warehousing, and to achieve sustainability among the economy and environment. As the contribution of the manufacturing sector in the growth of the Indian economy, the need for research to motivate the Indian Manufacturing Industry towards adapting the procedures of Green Logistics in the greater interest of the global ecological framework. The study included four parameters of practices for green logistics activities, namely Green Logistics Transportation, Green Logistics Warehousing, Green Logistics Packaging, and Green Logistics Value-added services. Table 6.7 shows the ranking of Green Transportation Practices, and as per the analysis, *'GLPT1 - Standardization'* is ranked as the most important practice of Green Logistics. Thus, the Manufacturing Industry must focus more on standardization in the future. *Green Logistic Practices (Warehousing)*, Table 6.8 shows '*GLPW5 – Low Carbon Storage* as the highest-ranked warehousing practice. The current and latest research also shows a lot of work is done in this area as the storage should have fewer carbon emissions. It should be emphasized to have tools and equipment in the warehouse which have the minimum of carbon emissions and use renewable sources of energy. *Green Logistics Practices (Packaging)*, Table 6.9 shows that '*GLPP - 1 Ecological Material*' is the highest-ranked packaging practice. The Manufacturing Industry should use these sustainable materials during the packaging activity of logistics operations and thus should be encouraged. *Green Logistics Practices (Valueadded Services)*: Table 6.10 shows the ranking of value-added services in logistics activities. The topmost is '*GLPVE - 1 Environmental Reports*. The focus on the environmental reports regularly is the most important practice and this indirectly helps in maintaining the carbon footprint of the sector.

5) *Analyzing Green Logistics Practices and Performance parameters after the implementation of Green Logistics Practices in select Indian Manufacturing Industry (Oil and Gas).*

It is essential to investigate and analyze the performance parameters because the Manufacturing Industry will be knowing the relationship between the performances and practices of Green Logistics and thus would make appropriate decisions rather than judgemental decisions. Therefore, this study has tried to find out the relationship between Green Logistics Practices and Performance parameters. The research study reveals that these logistics practices improve the overall performance of logistics activities of the Indian Manufacturing Sector (Oil and Gas). The Green Logistics Practices enhance Environmental Performance and Economic Performance. The Green Transportation Practices, Green Warehousing Practices, Green Packaging Practices, and Green Value-added services affect Environmental as well as Economic Performance in the case of the Oil and Gas Industry in India. The EFA was done for all the factors and after the reliability and factor loadings, four items are deleted. The CFA was carried out after the EFA and the factors were acceptable as the values of Convergent and Discriminant validity were as per the threshold. By carrying out the EFA and CFA the scale for the various items of the constructs under the research study were developed and confirmed after the analysis. The fitness of the CFA model was also checked using various fit indices namely chi-square, CFI, GFI, IFI, and RMSEA. The model has been considered fit as all the indices came out to be within the range. The good fit model refers to how closely observed data matches the relationships specified in a hypothesized model. Basically in our study, the model came in fit which means a good model. The results would help the Manufacturing Industry to evaluate the practices and performances under the domain of the established items for the constructs of Green Logistics.

6) *To develop a conceptual framework for the logistics activities of the Indian Manufacturing Industry (Oil and Gas) that will help the successful implementation of Green Logistics practices in the future.*

In the current competitive situation, when greening of activities is essential, the logistics activities of the Indian Manufacturing sector need a tool that could help them to evaluate the relationship and give the measure of the relationship between the Green Logistics Practices and the two performance parameters. The study has developed a framework between the Green logistics practices and performance of the manufacturing Industry (Oil and Gas Sector). This model will help the logistics managers, top management, and policymakers to identify and prioritize the drivers and barriers, which are essential in terms of motivators and hindrances, respectively, for them to progress the implementation of Green Logistics Practices and ultimately relate with performance parameters. The developed framework, after doing all the analysis of the practices and performance parameters, would be beneficial for the Indian Manufacturing Industry to implement these logistics practices in the future. The twenty hypotheses were framed from the green logistics practices and performances. Out of all, the first eight hypotheses showed the effect of various GLP on Environmental Performance and Economic Performance. The next four hypotheses involved the Environmental Performance as the mediator between the GLP and Economic Performance. It was analyzed to see the Environmental performance partially mediating the relationship between the practices and the Economic performance. As the policymakers of the Manufacturing industry, the strategy might be framed to have Environmental performance as the mediating factor among the activities and the profits. This would ensure the practices would focus on improving the environment along with the economy. The last eight hypotheses involved the moderator known as Government and

Environmental policies(derived from the GL drivers). This construct was chosen as the moderator which moderated the relationship between the practices and both the performances. The various hypotheses were analyzed using SEM in AMOS 26.0 and the results of the various hypotheses are expressed below:

Table 8.1 Results of Hypotheses Testing

Hypothesis	Direction			Estimate	S.E.	P	Decision
H1	GLTP	→	EP	.305	.052	.000	Accepted
H2	GLWP	→	EP	.116	.057	.045	Accepted
H3	GLPP	→	EP	.147	.059	.012	Accepted
H4	GLVP	→	EP	.191	.051	.000	Accepted
H5	GLTP	→	EcP	.177	.059	.002	Accepted
H6	GLWP	→	EcP	.196	.063	.000	Accepted
H7	GLPP	→	EcP	-.088	.065	.113	Rejected
H8	GLVP	→	EcP	.166	.057	.002	Accepted

Mediation Analysis

Hypothesis	Direction			Estimate	S.E.	P	Decision
H9	GLTP	→	EP	.106	.034	.010	Accepted
H10	GLWP	→	EP	.040	.021	.077	Rejected
H11	GLPP	→	EP	.051	.021	.017	Accepted
H12	GLVP	→	EP	.066	.024	.010	Accepted

Moderation Analysis

Hypothesis	Direction			Estimate	S.E.	P	Decision
H13	GLTP*GEP	→	EP	.059	.050	.027	Accepted
H14	GLWP*GEP	→	EP	-.146	.052	.007	Accepted
H15	GLPP*GEP	→	EP	-.093	.061	.047	Accepted
H16	GLVP*GEP	→	EP	-.191	.054	.000	Accepted
H17	GLTP*GEP	→	EcP	.300	.048	.000	Accepted
H18	GLWP*GEP	→	EcP	.027	.053	.612	Rejected
H19	GLPP*GEP	→	EcP	-.092	.063	.100	Rejected
H20	GLVP*GEP	→	EcP	-.149	.054	.007	Accepted

8.4 Implications of The Research

The study results have several implications towards implementing Green Logistics Practices amongst the Oil and Gas Sector (India). The insight gained may be viewed from managerial as well as from the perspectives of academicians, which may become leads for future research in this area.

8.4.1 Managerial Implications

This study provides several important implications for practitioners:

- The study developed tools for Green Logistics Practices- Managers, Government, top management and are expected to use these tools for continuously measuring and monitoring their scores in the different broad areas.

  Further, the respective Green Logistics rankings of the Drivers, Barriers, and Practices could be used while framing the various practices, policies, new technologies, and systems in the manufacturing industry.

- Within the logistics department of the manufacturing industry, the analyses and effects of the Green Logistics practices on Environmental and economic performance can also be seen and understood. This may also help for internal benchmarking purposes. The effect of moderator and mediation among the performances and practices also helps the management and the government to take decisions accordingly.

- The results of the analysis after the EFA, CFA, and SEM developed the scales for the items of the practices and the performances. The study has not only taken the items of the Environmental Performance but also 6 items were taken for the Economic performance. This would motivate the top management of the Manufacturing Industry to implement various practices like Publishing Environmental reports, staff training, etc to achieve Green Logistics.

8.4.2 Implications for Academia

The study has also provided significant implications for academicians, which may also become directions for future research. • The compilation of Green Logistics Practices and measures and in the area of the Indian Manufacturing Industry. Based on the indications in the survey, it appeared that the nature and extent of deployment of Green Logistics Practices depend on the strategic disposition of an industry. The linkage between Practices, Environmental, and Economic performance of the manufacturing industry is an important area for academic research.

The findings of this study for different sections of the green logistics may be linked to developing a long-term strategy for manufacturing sectors.

The present research has attempted first time implanted various tools and techniques for GLP in the Indian manufacturing environment. The relevant data for this study was based on the responses gathered from oil and gas sector. Further, similar type of study may be worked out with service industry as focus. The bibliography on service quality may be used for future research on this topic and also as an aid to class room teaching. Mainly, keeping Indian industries, practicing managers, governmental agencies and academia in view following implications and benefits of the research are outlined.

8.5 Limitations of the Research

In a society where we survive only among scarcities, everything we do is always subject to certain limitations. The present study related to the Green Logistics Practices and Performance issues in the select Indian Manufacturing Industry is also subjected to the following limitations.

- The Green Practices are the new policies and strategies that the industry is trying to implement or implementing in various activities of Logistics. Green Logistics as an organized function being at a very nascent stage in actual implementation, the respondents were a bit reluctant in divulging their information.
- The sample size for the research study was determined on the pretext of the

previous studies in this field. In future studies, if it is calculated statistically, the size may vary. This variation in the sample size might lead to any variation in the overall results of the study.

- For this study, the researcher contacted the respondents on a convenience and referral basis. If any other non-probabilistic or probabilistic approach is followed in the future, the results might be different.
- The research study has been done for the select Manufacturing Industry i.e. for the Oil and Gas Industry. The various respondents chosen are working for this industry. Thus the framework is modeled for this particular industry and can be used for a similar type of industry which is the logistics-intensive industry.

8.6 Future scope of this research

Based on the above limitations, this study seeks the attention of future researchers towards the following points.

- The sampling method chosen for this study was non-probability and the sample size was determined with the help of previous studies. Future researchers may opt for any other non-probability or probability sampling technique or take a different sample size following any other method of sample size determination. Future researchers could try other methods of data collection to empirically examining the relevance of the results of this study
- Future researchers may also conduct the same study in other industries like electrical & electronics, automobile, garments, papers publishing, auto component, etc. The only important suggestion to future researchers is that the industry chosen should be a logistics-intensive industry where the activities involved for logistics should be high.

- The research has analyzed the two performance parameters in terms of environment and economy. There is another performance parameter that is gaining importance nowadays i.e. Societal Performance. A recent area of Green logistics: Green Logistics as an organized function being at a very nascent stage, the respondents were very much reluctant in divulging their information. In this study, the focus is not given to the impact of Green Logistics on society.
- In the future, the researchers can incorporate other moderators also from the list of the Green logistics Drivers. The influence of the market can be easily taken as another moderator along with the present moderator in the future study.
- Future researchers may also conduct a comparative study of domestic and international Green Logistics Practices in the Oil and Gas industry.

8.7 Chapter Summary

In this chapter, researchers tried his best to conclude from the results which are meaningful with the objectives of this study. Thereafter, certain recommendations were made for the top management of the manufacturing industry, government as well as environmental NGO, and logistics department of the Oil and Gas Industry in particular.

In the last two sections, the researcher has mentioned the major limitations of this research work, and based on these limitations, the researcher has provided directions for future research. Eventually, after these chapters, a detailed list of references in Harward style is presnted followed by the appendices containing annexured documents and relevant information.

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Appendix-1

PARTICIPANT INFORMATION SHEET

QUESTIONNAIRE FOR GREEN LOGISTICS RESEARCH

(Intended to be filled by Indian Logistics officials/managers working for the Indian Oil and Gas industry)

Dear Prospective Respondent

I am Deepti Chhabra, a research student in the Mechanical Department of Delhi Technological University, Delhi. I am inviting you to participate in a survey entitled Green Logistics questionnaire for Indian Logistics, Distribution, and Manufacturing Officials working for the Oil and Gas Industry in India.

The aim is to study Green Logistics Practices and Performance Issues in the Oil and Gas Industry. The respondents selected are logistics, transport, and distribution officials working with the select industry One of our most significant objectives is to determine how these Green Logistics Practices will affect the performances so that a generic framework for best GL practices can be suggested for the manufacturing industry in the country.

The questionnaire is structured to determine the drivers in the implementation of Green Logistics Practices and to explore the Green Logistics Practices and the impact on Performance parameters. By participating in the survey, you are not only making a valuable contribution to Green Logistics research in the country, but you are also helping to improve the environment by achieving sustainability. The reason for your selection is linked to your engagement in logistics activities for Oil and Gas industry. Your contribution to the study involves completing a questionnaire, which will take approximately 20 minutes of your time. Clear instructions are provided at the top of each section to assist you in completing the survey. Please note, participation is **voluntary, and your response will be kept strictly confidential and anonymous.** There is no penalty or loss of benefit for nonparticipation. You are free to withdraw at any time and without giving a reason, although once the questionnaire has been submitted, it will not be possible to withdraw. If you would like to be informed of the final research findings or should you require any further information, please contact the undersigned

Thank you for taking the time to read this information sheet and for participating in this study.

Deepti Chhabra

CONSENT TO PARTICIPATE IN THIS STUDY

1. I confirm that the person asking my consent to take part in this research has told me about the nature, procedure, potential benefits, and anticipated inconvenience of participation.
2. I have read (or had explained to me) and understood the purpose of the study as explained in the information sheet.
3. I have had sufficient opportunity to ask questions and am prepared to participate in the study.
4. I understand that my participation is voluntary and that I am free to withdraw at any time without penalty (if applicable).
5. I agree with the recording of the survey.
6. I have received a signed copy of the informed consent agreement.

I understand and accept the above.

Please choose **only one** of the following: ☐ Yes ☐ No

Name and Signature /Company Stamp with Date (Please put in the space below)

(Disclaimer)

Dear Sir/Madam,

I am a Ph.D. student in the Department of Mechanical at Delhi Technological University, Delhi pursuing research on the topic "**Some Studies on Green Logistics Practices and Performance issues in select Indian Manufacturing Industry**." I solicit your kind cooperation to assess your views and experiences in gathering information by filling up this questionnaire. I request you to kindly give your unobstructed opinions and suggestions in the space provided. The data is being collected for academic research purpose only, and confidentiality will be maintained. I shall be highly thankful to you.

Please find the survey questionnaire on the subsequent pages. It will take not more than 20 minutes to fill the questionnaire.

Yours sincerely

Deepti Chhabra

Research Student- PhD

Questionnaire – Part A

1) Position (Choose Any One of the Following)

- Lower Level management
- Middle Level Management
- High Level Management

2) Company Turnover per Annum (Choose Any One of the Following)

- Less than INR 5cr.
- Between INR 5cr. – INR 20cr.
- Between INR 20cr.- INR 100cr.
- More than INR 100cr.

3) Number of Employees in the Company (Choose Any One of the Following)

- Less than 50
- Between 51- 100
- Between 101- 200
- More than 200

4) Number of vehicles in the Company (Choose Any One of the Following)

- Less than 10
- Between 11 – 30
- Between 31- 50
- More than 51

5) Area of Warehousing (Sq. Meters) (Choose Any One of the Following)

- Less than 5000 Sq. Meters
- Between 5001 Sq. Meters – 10000 Sq. Meters
- Between 10001 Sq. Meters – 20000 Sq. Meters
- More than 20001 Sq. Meters

Questionnaire- Part B

(Green Logistics Drivers in implementing Green Logistics Practices)

Green Logistics Drivers - Drivers are the factors that motivate or ease the implementation of Green logistics Practices.

- Five points Likert-type scale is used to answer the question of Green logistics practices.

1 = Not important
2 = less important
3 = moderately important
4 = important
5 = Extremely important

Green Logistics Drivers

On a scale 1-5, please rate the importance of each driver using the rating scale as above.

Driver(s) Description	**not important (1)**	**(2)**	**(3)**	**(4)**	**Extremely Important (5)**
Decrease in Availability of fossil fuels					
Complying with Govt.					
Decreasing fuel bills					
Differentiating with Competitors					
Collaborating with the customers					
Complying with internal regulations					
Improving Public Relations/Brand					
Marketing Pressures					
Increasing Supply Chain Efficiency					
Part of Corporate Social Responsibility					
Policies by Environmental Advocacy Groups					

Questionnaire- Part C

Green Logistics Practices

Five points Likert-type scale will be used to answer the question of Green logistics practices. These practices have been categorized as follows:

1) Green Transportation Practices:

Please find below the list of the Green Transportation Practices, kindly fill the questionnaire with the most appropriate reply in the range of 1 to 5.

(1 = not important, 2 = less important it, 3 = moderately important,4 = important, 5 = extremely important)

S.No.	Green Transportation Practices	Not Important (1)	less Important (2)	Moderately important (3)	Important (4)	Extremely important (5)
1)	Standardization of the trucks					
2)	Clean Vehicles and the use of alternative fuel for transportation					
3)	Wireless technologies for transportation					
4)	Promote the reduction of backhauling (nonempty returns of the trucks)					
5)	Scheduling of deliveries properly					
6)	Optimization of transport routes					
7)	Freight Consolidation					
8)	Monitoring devices for monitoring pollutants, driving mileage, the life of vehicles, etc.					

2) Green Warehousing Practices:

Please find below the list of the Green Warehousing Practices, kindly fill the questionnaire with the most appropriate reply in the range of 1 to 5.

S.No.	Green Warehousing Practices	Not Important (1)	Less important (2)	Moderately Important (3)	important (4)	Extremely important (5)
1)	Reconditioning and reuse of pallets and containers					
2)	Clean material handling equipment					
3)	Improved or innovative handling systems in warehousing					
4)	Process optimization during warehousing					
5)	Minimization of inventories					
6)	Low carbon storage of the products					

3) Green Packaging Practices:

Please find below the list of the Green Packaging Practices, kindly fill the questionnaire with the most appropriate reply in the range of 1 to 5.

S.No.	Green Packaging Practices	Not important (1)	less Important (2)	Moderately important (3)	Important (4)	Extremely important (5)
1)	Recycle and reuse of outer packaging in the logistics process					
2)	Ecological material for inner packaging					
3)	Purchase the raw material from ISO14000 certified suppliers					
4)	Environmental messages on the packaging?					
5)	Restrict excessive packaging?					

4) Green Value-Added Services:

Please find below the list of the Green Value-Added Practices, kindly fill the questionnaire with the most appropriate reply in the range of 1 to 5.

S.No.	Green Value-Added Practices	Not Important (1)	Less important (2)	Moderately important (3)	Important (4)	Extremely important (5)
1)	Publish environmental footprint reports					
2)	Staff training on environmental issues					
3)	Long environmental objectives					
4)	An ISO 14000 certified					
5)	Top management support					

Green Logistics Performance

Five-Point Likert-type scale will be used to answer the questions of Green Logistics Performance.

1) Environmental Performance after implementation of GL Practices:

Please find below the list of the Environmental Performance parameters after implementation of Green Practices, kindly fill the questionnaire with the most appropriate reply in the range of 1 to 5.

(1 = not at all, 2 = a little bit, 3 = to some degree, 4 = relatively significant, 5 = significant)

S.No.	**Environmental Performance Parameters**	**Not at All (1)**	**Little Bit (2)**	**To Some Degree (3)**	**Relatively Significant (4)**	**Significant (5)**
1)	Improvement in fuel efficiency					
2)	Carbon footprint /Carbon emission reduction					
3)	Energy saving					
4)	Decrement in the frequency of environmental disasters					

2) Economic Performance after implementation of GL practices:

Please find below the list of the Economic Performance Parameters after application of Green Logistics Practices, kindly fill the questionnaire with the most appropriate reply in the range of 1 to 5.

(1 = not at all, 2 = a little bit, 3 = to some degree, 4 = relatively significant, 5 = significant)

S.No.	Economic Performance (Positive) Parameters	Not at All (1)	Little Bit (2)	To Some Degree (3)	Relatively Significant (4)	Significant (5)
1)	Decrease in energy consumption cost					
2)	Fuel cost reduction due to optimized routes					
3)	Decrease in waste disposal cost					
4)	More business due to brand image improvement					
5)	Reduction in the Value of Travel Time costs					
6)	Decrease in vehicle costs as better life of vehicles					

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Appendix-2

(EFA, CFA, SEM Outputs imported from SPSS & AMOS)

```
RELIABILITY
  /VARIABLES=GTP1 GTP2 GTP4 GTP5 GTP6 GTP8
/SCALE('ALL VARIABLES') ALL
/MODEL=ALPHA.
```

Reliability

Scale: ALL VARIABLES

Case Processing Summary

		N	%
Cases	Valid	262	100.0
	Excluded[a]	0	.0
	Total	262	100.0

a. Listwise deletion based on all variables in the procedure.

Reliability Statistics

Cronbach's Alpha	N of Items
.918	6

```
RELIABILITY
  /VARIABLES=GWP2 GWP3 GWP4 GWP5 GWP6
/SCALE('ALL VARIABLES') ALL   /MODEL=ALPHA.
```

Reliability

Scale: ALL VARIABLES

Case Processing Summary

		N	%
Cases	Valid	262	100.0
	Excluded[a]	0	.0
	Total	262	100.0

a. Listwise deletion based on all variables in the procedure.

Reliability Statistics

Cronbach's Alpha	N of Items
.891	5

RELIABILITY
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Reliability

Scale: ALL VARIABLES

Case Processing Summary

		N	%
Cases	Valid	262	100.0
	Excluded[a]	0	.0
	Total	262	100.0

a. Listwise deletion based on all variables in the procedure.

Reliability Statistics

Cronbach's Alpha	N of Items
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RELIABILITY
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Reliability

Scale: ALL VARIABLES

Case Processing Summary

	N	%

Cases	Valid	262	100.0
	Excluded[a]	0	.0
	Total	262	100.0

a. Listwise deletion based on all variables in the procedure.

Reliability Statistics

Cronbach's Alpha	N of Items
.886	4

RELIABILITY
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Reliability

Scale: ALL VARIABLES

Case Processing Summary

		N	%
Cases	Valid	262	100.0
	Excluded[a]	0	.0
	Total	262	100.0

a. Listwise deletion based on all variables in the procedure.

Reliability Statistics

Cronbach's Alpha	N of Items
.794	4

RELIABILITY

/VARIABLES=EcP1 EcP2 EcP3 EcP4 EcP5 EcP6
/SCALE('ALL VARIABLES') ALL
/MODEL=ALPHA.

Reliability

Scale: ALL VARIABLES

Case Processing Summary

		N	%
Cases	Valid	262	100.0
	Excluded[a]	0	.0
	Total	262	100.0

a. Listwise deletion based on all variables in the procedure.

Reliability Statistics

Cronbach's Alpha	N of Items
.944	6

RELIABILITY
/VARIABLES=GEP1 GEP2 GEP3
/SCALE('ALL VARIABLES') ALL
/MODEL=ALPHA.

Reliability

Scale: ALL VARIABLES

Case Processing Summary

		N	%
Cases	Valid	262	100.0
	Excluded[a]	0	.0
	Total	262	100.0

a. Listwise deletion based on all variables in the procedure.

Reliability Statistics

Cronbach's Alpha	N of Items
.877	3

```
FACTOR
  /VARIABLES GTP1 GTP2 GTP4 GTP5 GTP6 GTP8 GWP2 GWP3 GWP4 GWP5 GWP6
GPP1 GPP3 GPP4 GPP5 GVE1 GVE3
    GVE4 GVE5 EP1 EP2 EP3 EP4 EcP1 EcP2 EcP3 EcP4 EcP5 EcP6 GEP1 GEP2 GEP3
/MISSING LISTWISE
  /ANALYSIS GTP1 GTP2 GTP4 GTP5 GTP6 GTP8 GWP2 GWP3 GWP4 GWP5 GWP6
GPP1 GPP3 GPP4 GPP5 GVE1 GVE3
    GVE4 GVE5 EP1 EP2 EP3 EP4 EcP1 EcP2 EcP3 EcP4 EcP5 EcP6 GEP1 GEP2 GEP3
  /PRINT INITIAL KMO EXTRACTION ROTATION
  /FORMAT BLANK(.5)
  /CRITERIA FACTORS(7) ITERATE(25)
  /EXTRACTION PC
  /CRITERIA ITERATE(25)
  /ROTATION VARIMAX   /METHOD=CORRELATION.
```

Factor Analysis

KMO and Bartlett's Test

Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		.852
Bartlett's Test of Sphericity	Approx. Chi-Square	6623.700
	df	496
	Sig.	.000

Communalities

	Initial	Extraction
GTP1	1.000	.837
GTP2	1.000	.802
GTP4	1.000	.734
GTP5	1.000	.714
GTP6	1.000	.643
GTP8	1.000	.628
GWP2	1.000	.660
GWP3	1.000	.736
GWP4	1.000	.690

GWP5	1.000	.726
GWP6	1.000	.719
GPP1	1.000	.752
GPP3	1.000	.733
GPP4	1.000	.620
GPP5	1.000	.794
GVE1	1.000	.778
GVE3	1.000	.679
GVE4	1.000	.812
GVE5	1.000	.762
EP1	1.000	.945
EP2	1.000	.938
EP3	1.000	.640
EP4	1.000	.663
EcP1	1.000	.896
EcP2	1.000	.840
EcP3	1.000	.725
EcP4	1.000	.758
EcP5	1.000	.739
EcP6	1.000	.773
GEP1	1.000	.790
GEP2	1.000	.787
GEP3	1.000	.846

Extraction Method: Principal Component Analysis.

Total Variance Explained

Component	Initial Eigenvalues			Extraction Sums of Squared Loadings			Rotation Sums of Squared Loadings
	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %	Total

1	9.472	29.599	29.599	9.472	29.599	29.599	4.889
2	3.323	10.384	39.983	3.323	10.384	39.983	4.390
3	2.934	9.170	49.152	2.934	9.170	49.152	3.620
4	2.652	8.286	57.439	2.652	8.286	57.439	3.092
5	2.151	6.722	64.161	2.151	6.722	64.161	2.702
6	1.530	4.781	68.942	1.530	4.781	68.942	2.480
7	1.401	4.377	73.319	1.401	4.377	73.319	2.289
8	.985	3.079	76.399				
9	.779	2.433	78.832				
10	.664	2.076	80.908				
11	.611	1.910	82.818				
12	.532	1.663	84.481				
13	.472	1.474	85.955				
14	.440	1.374	87.329				
15	.409	1.277	88.606				
16	.394	1.233	89.839				
17	.336	1.049	90.887				
18	.334	1.044	91.931				
19	.298	.931	92.862				
20	.293	.914	93.777				
21	.268	.838	94.615				
22	.253	.792	95.407				
23	.242	.757	96.164				
24	.231	.722	96.887				
25	.201	.629	97.515				
26	.173	.539	98.055				
27	.159	.495	98.550				
28	.140	.436	98.986				
29	.133	.415	99.401				
30	.109	.339	99.740				
31	.066	.205	99.945				
32	.017	.055	100.000				

Total Variance Explained

Rotation Sums of Squared Loadings

Component	% of Variance	Cumulative %
1	15.278	15.278
2	13.720	28.998
3	11.312	40.309
4	9.663	49.972
5	8.443	58.415
6	7.751	66.166
7	7.153	73.319
8		
9		
10		
11		
12		
13		
14		
15		
16		
17		
18		
19		
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21		
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31		
32		

Extraction Method: Principal Component Analysis.

Component Matrix[a]

	Component						
	1	2	3	4	5	6	7
GTP1	.600		.626				
GTP2	.552		.635				
GTP4	.597		.553				
GTP5	.567		.570				
GTP6	.562		.523				
GTP8	.582		.508				
GWP2		.617					
GWP3		.627					
GWP4		.601					
GWP5		.602					
GWP6		.603					
GPP1		.539					
GPP3		.529					
GPP4							
GPP5							
GVE1				.637			
GVE3				.571			
GVE4				.609			
GVE5				.604			
EP1	.599						-.508
EP2	.608						
EP3	.517						
EP4	.530						
EcP1	.768						
EcP2	.765						
EcP3	.678						
EcP4	.653						
EcP5	.682						
EcP6	.753						
GEP1	.522						
GEP2					.559		
GEP3	.562				.502		

Extraction Method: Principal Component Analysis.[a] a.
7 components extracted.

Rotated Component Matrix[a]

	Component						
	1	2	3	4	5	6	7
GTP1		.888					
GTP2		.880					
GTP4		.821					
GTP5		.800					
GTP6		.762					
GTP8		.729					
GWP2			.778				
GWP3			.820				
GWP4			.803				
GWP5			.821				
GWP6			.814				
GPP1					.826		
GPP3					.804		
GPP4					.739		
GPP5					.750		
GVE1				.855			
GVE3				.770			
GVE4				.869			
GVE5				.851			
EP1							.905
EP2							.895
EP3							.728
EP4							.715
EcP1	.892						
EcP2	.840						
EcP3	.811						
EcP4	.842						
EcP5	.801						
EcP6	.798						
GEP1						.832	
GEP2						.846	

GEP3						.852	

Extraction Method: Principal Component Analysis.
Rotation Method: Varimax with Kaiser Normalization.[a] a.
Rotation converged in 6 iterations.

Component Transformation Matrix

Component	1	2	3	4	5	6	7
1	.583	.472	.336	.296	.241	.293	.304
2	-.276	-.287	.759	-.109	.491	-.104	-.048
3	-.491	.815	.021	-.172	.078	-.243	-.008
4	-.396	-.088	-.307	.753	.395	.070	.120
5	-.146	-.050	-.304	-.523	.400	.592	.316
6	.364	.072	-.305	-.113	.585	-.237	-.599
7	-.179	.125	.175	.136	-.193	.658	-.658

Extraction Method: Principal Component Analysis.
Rotation Method: Varimax with Kaiser Normalization.

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Analysis Summary

Groups

Group number 1 (Group number 1)

Notes for Group (Group number 1)

The model is recursive.
Sample size = 262

Variable Summary (Group number 1)

Your model contains the following variables (Group number 1)

Observed, endogenous variables

GTP1
GTP2
GTP4
GTP5
GTP6
GTP8
GWP2
GWP3
GWP4
GWP5
GWP6
GPP1
GPP3
GPP4
GPP5
GVE1
GVE3
GVE4
GVE5
EP1
EP2
EP3
EP4
EcP1
EcP2
EcP3
EcP4
EcP5
EcP6
GEP1
GEP2

GEP3

Unobserved, exogenous variables

GLTP
e1
e2
e4
e5
e6
e8
e10
GLWP
e11
e12
e13
e14
GLPP
e15
e17
e18
e19
GLVP
e20
e22
e23
e24
EP
e25
e26
e27
e28
ECP
e29
e30
e31
e32
e33
e34
GEP
e35
e36
e37

Variable counts (Group number 1)

Number of variables in your model: 71
Number of observed variables: 32
Number of unobserved variables: 39
Number of exogenous variables: 39 **Number of endogenous variables:** 32

Parameter Summary (Group number 1)

	Weights	Covariances	Variances	Means	Intercepts	Total
Fixed	39	0	0	0	0	39
Labeled	0	0	0	0	0	0
Unlabeled	25	28	39	0	0	92
Total	64	28	39	0	0	131

Models

Default model (Default model)

Notes for Model (Default model)

Computation of degrees of freedom (Default model)

Number of distinct sample moments:	528
Number of distinct parameters to be estimated:	92
Degrees of freedom (528 - 92):	436

Result (Default model)

Minimum was achieved
Chi-square = 944.014
Degrees of freedom = 436
Probability level = .000

Group number 1 (Group number 1 - Default model)

Estimates (Group number 1 - Default model)

Scalar Estimates (Group number 1 - Default model)

Maximum Likelihood Estimates

Regression Weights: (Group number 1 - Default model)

			Estimate	S.E.	C.R.	P	Label
GTP1	<---	GLTP	1.000				
GTP2	<---	GLTP	.971	.045	21.680	***	
GTP4	<---	GLTP	.942	.062	15.316	***	
GTP5	<---	GLTP	.933	.057	16.258	***	
GTP6	<---	GLTP	.923	.061	15.243	***	
GTP8	<---	GLTP	.782	.063	12.326	***	
GWP3	<---	GLWP	1.027	.081	12.696	***	
GWP4	<---	GLWP	1.018	.082	12.474	***	
			Estimate	**S.E.**	**C.R.**	**P**	**Label**
GWP5	<---	GLWP	1.018	.078	13.078	***	
GWP6	<---	GLWP	1.043	.081	12.868	***	
GPP1	<---	GLPP	1.000				
GPP3	<---	GLPP	.920	.061	15.047	***	
GPP4	<---	GLPP	.665	.065	10.288	***	

GPP5	<---	GLPP	.604	.071	8.557	***
GVE1	<---	GLVP	1.000			
GVE3	<---	GLVP	.929	.071	13.084	***
GVE4	<---	GLVP	1.038	.072	14.332	***
GVE5	<---	GLVP	.932	.072	12.965	***
EP1	<---	EP	1.000			
EP2	<---	EP	1.000	.019	52.282	***
EP3	<---	EP	.424	.051	8.239	***
EP4	<---	EP	.375	.059	6.374	***
EcP1	<---	ECP	1.000			
EcP2	<---	ECP	.964	.032	30.272	***
EcP3	<---	ECP	.791	.043	18.507	***
EcP4	<---	ECP	.817	.043	18.867	***
EcP5	<---	ECP	.849	.042	20.369	***
EcP6	<---	ECP	.887	.037	23.662	***
GEP1	<---	GEP	1.000			
GEP2	<---	GEP	.929	.066	14.108	***
GEP3	<---	GEP	1.135	.072	15.840	***
GWP2	<---	GLWP	1.000			

Standardized Regression Weights: (Group number 1 - Default model)

			Estimate
GTP1	<---	GLTP	.881
GTP2	<---	GLTP	.830
GTP4	<---	GLTP	.818
GTP5	<---	GLTP	.814
GTP6	<---	GLTP	.792
GTP8	<---	GLTP	.682
GWP3	<---	GLWP	.794
GWP4	<---	GLWP	.781
GWP5	<---	GLWP	.817
GWP6	<---	GLWP	.804
GPP1	<---	GLPP	.890
GPP3	<---	GLPP	.868
GPP4	<---	GLPP	.607
GPP5	<---	GLPP	.721
GVE1	<---	GLVP	.839
GVE3	<---	GLVP	.744
			Estimate
GVE4	<---	GLVP	.859
GVE5	<---	GLVP	.796
EP1	<---	EP	.989
EP2	<---	EP	.989
EP3	<---	EP	.698
EP4	<---	EP	.670
EcP1	<---	ECP	.960

EcP2	<---	ECP	.925
EcP3	<---	ECP	.783
EcP4	<---	ECP	.790
EcP5	<---	ECP	.815
EcP6	<---	ECP	.862
GEP1	<---	GEP	.807
GEP2	<---	GEP	.793
GEP3	<---	GEP	.921
GWP2	<---	GLWP	.747

Covariances: (Group number 1 - Default model)

			Estimate	S.E.	C.R.	P	Label
GLTP	<-->	GLWP	.204	.060	3.384	***	
GLTP	<-->	GLPP	.190	.070	2.729	.006	
GLTP	<-->	GLVP	.225	.067	3.364	***	
GLTP	<-->	EP	.422	.080	5.257	***	
GLTP	<-->	ECP	.485	.082	5.883	***	
GLTP	<-->	GEP	.255	.067	3.792	***	
GLWP	<-->	GLPP	.351	.066	5.338	***	
GLWP	<-->	GLVP	.122	.056	2.189	.029	
GLWP	<-->	EP	.194	.065	2.969	.003	
GLWP	<-->	ECP	.305	.069	4.451	***	
GLWP	<-->	GEP	.148	.056	2.643	.008	
GLPP	<-->	GLVP	.189	.067	2.844	.004	
GLPP	<-->	EP	.342	.079	4.341	***	
GLPP	<-->	ECP	.155	.076	2.042	.041	
GLPP	<-->	GEP	.216	.067	3.250	.001	
GLVP	<-->	EP	.324	.075	4.322	***	
GLVP	<-->	ECP	.378	.077	4.924	***	
GLVP	<-->	GEP	.216	.063	3.407	***	
EP	<-->	ECP	.526	.089	5.902	***	
EP	<-->	GEP	.424	.078	5.462	***	
ECP	<-->	GEP	.498	.081	6.179	***	
e1	<-->	e2	.134	.039	3.434	***	
e31	<-->	e32	.155	.036	4.302	***	
e23	<-->	e24	.066	.047	1.409	.159	
			Estimate	**S.E.**	**C.R.**	**P**	**Label**
e18	<-->	e19	.264	.059	4.443	***	
e4	<-->	e8	.198	.049	4.033	***	
e4	<-->	e6	-.099	.037	-2.680	.007	
e1	<-->	e4	-.040	.028	-1.462	.144	

Correlations: (Group number 1 - Default model)

			Estimate
GLTP	<-->	GLWP	.242
GLTP	<-->	GLPP	.191
GLTP	<-->	GLVP	.240
GLTP	<-->	EP	.367
GLTP	<-->	ECP	.426

GLTP	<-->	GEP	.272
GLWP	<-->	GLPP	.422
GLWP	<-->	GLVP	.156
GLWP	<-->	EP	.202
GLWP	<-->	ECP	.320
GLWP	<-->	GEP	.188
GLPP	<-->	GLVP	.205
GLPP	<-->	EP	.302
GLPP	<-->	ECP	.139
GLPP	<-->	GEP	.234
GLVP	<-->	EP	.303
GLVP	<-->	ECP	.357
GLVP	<-->	GEP	.248
EP	<-->	ECP	.405
EP	<-->	GEP	.396
ECP	<-->	GEP	.471
e1	<-->	e2	.378
e31	<-->	e32	.303
e23	<-->	e24	.172
e18	<-->	e19	.312
e4	<-->	e8	.353
e4	<-->	e6	-.208
e1	<-->	e4	-.112

Variances: (Group number 1 - Default model)

	Estimate	**S.E.**	**C.R.**	**P**	**Label**
GLTP	1.007	.116	8.665	***	
GLWP	.706	.104	6.800	***	
GLPP	.980	.117	8.404	***	
GLVP	.874	.112	7.822	***	
	Estimate	**S.E.**	**C.R.**	**P**	**Label**
EP	1.314	.119	11.044	***	
ECP	1.284	.123	10.466	***	
GEP	.871	.115	7.557	***	
e1	.290	.044	6.605	***	
e2	.429	.051	8.368	***	
e4	.443	.057	7.772	***	
e5	.447	.048	9.243	***	
e6	.510	.056	9.116	***	
e8	.707	.069	10.277	***	
e10	.559	.057	9.727	***	
e11	.437	.048	9.121	***	
e12	.469	.050	9.318	***	
e13	.365	.042	8.708	***	
e14	.420	.047	8.948	***	
e15	.257	.054	4.796	***	

e17	.272	.048	5.702	***
e18	.743	.071	10.533	***
e19	.959	.088	10.844	***
e20	.369	.052	7.053	***
e22	.608	.065	9.400	***
e23	.335	.056	5.974	***
e24	.439	.059	7.450	***
e25	.029	.019	1.520	.129
e26	.028	.019	1.494	.135
e27	.890	.078	11.391	***
e28	1.166	.102	11.404	***
e29	.110	.019	5.952	***
e30	.201	.024	8.482	***
e31	.507	.048	10.670	***
e32	.518	.049	10.638	***
e33	.467	.044	10.512	***
e34	.350	.035	10.078	***
e35	.465	.054	8.606	***
e36	.444	.050	8.935	***
e37	.200	.047	4.211	***

Modification Indices (Group number 1 - Default model)

Covariances: (Group number 1 - Default model)

			M.I.	Par Change
e36	<-->	GLPP	7.029	.112
e34	<-->	GLWP	5.661	.073
e33	<-->	GLVP	11.461	-.137

			M.I.	Par Change
e32	<-->	EP	5.309	-.097
e29	<-->	GLWP	5.648	-.051
e28	<-->	GEP	10.651	.186
e28	<-->	ECP	9.392	.188
e28	<-->	EP	9.317	-.199
e27	<-->	GLWP	13.798	.172
e27	<-->	e37	4.488	.081
e27	<-->	e32	6.572	.105
e27	<-->	e28	9.240	.192
e26	<-->	e32	5.621	-.024
e26	<-->	e31	6.516	.026
e25	<-->	e31	5.790	-.024
e22	<-->	ECP	7.045	.127
e22	<-->	GLPP	6.934	.128
e22	<-->	GLWP	4.378	-.086
e20	<-->	ECP	5.624	-.096
e19	<-->	e37	6.598	.097
e19	<-->	e33	4.885	.091

e19	<-->	e30	8.836	-.088
e19	<-->	e28	23.357	.303
e18	<-->	GLVP	6.185	.118
e18	<-->	e27	21.231	.225
e17	<-->	e28	5.427	-.100
e17	<-->	e22	6.462	.085
e15	<-->	e27	11.927	-.135
e14	<-->	e34	14.177	.105
e14	<-->	e32	6.604	-.080
e14	<-->	e28	6.007	-.118
e14	<-->	e27	5.482	-.099
e14	<-->	e26	15.596	.042
e14	<-->	e25	11.505	-.036
e14	<-->	e20	11.647	.108
e14	<-->	e17	5.270	-.066
e14	<-->	e15	5.491	.070
e13	<-->	e33	10.141	.095
e13	<-->	e31	8.156	-.083
e13	<-->	e24	4.146	-.060
e13	<-->	e17	6.182	-.067
e13	<-->	e14	5.964	.072
e12	<-->	e32	9.231	.098
e12	<-->	e27	4.302	.091
e12	<-->	e26	5.158	-.025
e11	<-->	ECP	4.211	.085
e11	<-->	EP	5.314	-.101
			M.I.	**Par Change**
e11	<-->	e31	16.145	.125
e11	<-->	e27	5.946	.104
e11	<-->	e26	5.973	-.026
e11	<-->	e20	6.024	-.079
e11	<-->	e17	7.401	.079
e11	<-->	e14	4.785	-.069
e11	<-->	e13	5.119	-.067
e11	<-->	e12	8.289	.095
e10	<-->	e30	11.023	.084
e10	<-->	e29	5.834	-.053
e10	<-->	e12	5.665	-.087
e10	<-->	e11	4.820	.078
e8	<-->	GLVP	9.243	.136
e8	<-->	e37	4.183	-.065
e8	<-->	e34	9.034	.092
e8	<-->	e33	5.909	-.084
e8	<-->	e17	9.946	.099
e6	<-->	e32	39.718	.213
e5	<-->	EP	8.748	.130
e5	<-->	e32	7.942	-.088

e5	<-->	e31	37.817	.191
e5	<-->	e6	7.893	.097
e4	<-->	e30	5.874	.052
e4	<-->	e29	4.961	-.042
e2	<-->	GLVP	4.358	.073
e2	<-->	e34	7.811	-.067
e2	<-->	e33	5.398	-.063
e2	<-->	e30	22.991	.094
e2	<-->	e19	6.033	-.088
e2	<-->	e18	4.863	.071
e1	<-->	ECP	5.757	.075
e1	<-->	GLVP	9.178	-.095
e1	<-->	e32	4.336	-.050
e1	<-->	e31	7.191	-.063
e1	<-->	e30	10.809	-.057
e1	<-->	e29	24.704	.075
e1	<-->	e27	4.063	-.065
e1	<-->	e15	4.241	.047
e1	<-->	e11	4.994	-.056

Variances: (Group number 1 - Default model)

	M.I.	Par Change

Regression Weights: (Group number 1 - Default model)

			M.I.	Par Change
GEP3	<---	GPP5	6.584	.090
GEP2	<---	GLPP	4.137	.098
GEP2	<---	GPP3	4.451	.090
GEP2	<---	GPP1	5.096	.091
EcP6	<---	GLWP	5.988	.119
EcP6	<---	GWP6	15.043	.138
EcP6	<---	GTP8	6.357	.085
EcP5	<---	GLVP	8.323	-.144
EcP5	<---	GVE5	4.850	-.088
EcP5	<---	GVE4	6.828	-.102
EcP5	<---	GVE3	6.413	-.095
EcP5	<---	GVE1	8.277	-.114
EcP5	<---	GWP5	7.839	.118
EcP4	<---	EP	6.184	-.094
EcP4	<---	EP2	7.245	-.100
EcP4	<---	EP1	5.293	-.086
EcP4	<---	GWP4	5.753	.095
EcP4	<---	GTP6	8.427	.107
EcP3	<---	GWP3	6.326	.099
EcP3	<---	GTP5	10.041	.118
EcP2	<---	GPP5	7.493	-.075
EcP2	<---	GTP4	4.495	.058
EcP2	<---	GTP2	8.319	.077

EcP1	<---	GWP6	6.230	-.063
EcP1	<---	GWP2	8.443	-.071
EP4	<---	GEP	21.623	.350
EP4	<---	ECP	22.618	.286
EP4	<---	GLVP	4.122	.154
EP4	<---	GLTP	7.087	.185
EP4	<---	GEP3	20.003	.260
EP4	<---	GEP2	14.552	.233
EP4	<---	GEP1	14.403	.220
EP4	<---	EcP6	13.442	.210
EP4	<---	EcP5	14.081	.213
EP4	<---	EcP4	25.232	.287
EP4	<---	EcP3	22.631	.278
EP4	<---	EcP2	17.856	.239
EP4	<---	EcP1	21.399	.262
EP4	<---	EP3	7.282	.170
EP4	<---	GPP5	22.197	.275
EP4	<---	GWP3	4.314	.128
EP4	<---	GTP8	11.495	.197

			M.I.	**Par Change**
EP4	<---	GTP4	13.004	.209
EP3	<---	ECP	8.622	.154
EP3	<---	GLWP	16.047	.294
EP3	<---	GLTP	4.484	.128
EP3	<---	GEP3	4.899	.113
EP3	<---	EcP6	5.087	.113
EP3	<---	EcP5	7.582	.136
EP3	<---	EcP4	14.709	.191
EP3	<---	EcP3	6.490	.130
EP3	<---	EcP2	7.777	.138
EP3	<---	EcP1	6.461	.126
EP3	<---	EP4	7.965	.142
EP3	<---	GPP4	14.984	.209
EP3	<---	GWP5	8.414	.162
EP3	<---	GWP4	17.207	.221
EP3	<---	GWP3	18.982	.234
EP3	<---	GWP2	16.232	.209
EP3	<---	GTP4	5.711	.121
EP1	<---	GWP6	4.104	-.027
GVE3	<---	EcP1	4.074	.089
GVE3	<---	GPP3	5.639	.118
GVE1	<---	EcP5	4.053	-.075
GVE1	<---	GWP6	6.361	.102
GPP5	<---	EP4	17.227	.207
GPP4	<---	GEP	4.107	.118
GPP4	<---	GLVP	7.163	.158

GPP4 <---	GEP3	5.270	.103
GPP4 <---	EP3	17.941	.207
GPP4 <---	GVE5	5.935	.115
GPP4 <---	GVE4	4.292	.095
GPP4 <---	GVE3	4.501	.094
GPP4 <---	GVE1	7.228	.125
GPP4 <---	GTP2	5.331	.102
GPP3 <---	GTP8	4.426	.073
GPP1 <---	EP3	11.079	-.130
GWP6 <---	GVE1	9.078	.120
GWP6 <---	GTP2	4.226	.078
GWP6 <---	GTP1	4.588	.084
GWP5 <---	EcP5	4.484	.075
GWP4 <---	EcP4	4.262	.081
GWP3 <---	EP	6.464	-.101
GWP3 <---	GEP2	4.186	-.084
GWP3 <---	EcP3	8.366	.114
GWP3 <---	EP2	7.585	-.107
		M.I.	**Par Change**
GWP3 <---	EP1	5.499	-.091
GWP3 <---	GTP1	5.501	-.093
GWP2 <---	EP3	4.449	.099
GTP8 <---	GLVP	10.778	.182
GTP8 <---	GLPP	8.139	.149
GTP8 <---	GVE5	8.215	.127
GTP8 <---	GVE4	8.566	.126
GTP8 <---	GVE3	5.865	.101
GTP8 <---	GVE1	9.475	.134
GTP8 <---	GPP3	12.987	.167
GTP8 <---	GWP6	4.564	.095
GTP8 <---	GWP4	4.615	.095
GTP6 <---	EcP4	11.344	.139
GTP5 <---	EP	4.753	.086
GTP5 <---	EcP3	7.650	.109
GTP5 <---	EP2	4.729	.084
GTP5 <---	EP1	4.798	.085
GTP2 <---	EcP6	5.757	-.079
GTP2 <---	EcP5	5.278	-.075
GTP2 <---	GWP4	4.252	-.072
GTP1 <---	GLVP	5.934	-.095
GTP1 <---	EcP1	5.048	.065
GTP1 <---	EP3	4.981	-.072
GTP1 <---	GVE5	5.335	-.072
GTP1 <---	GVE4	6.329	-.076
GTP1 <---	GVE3	5.014	-.066

Minimization History (Default model)

Iteration		Negative eigenvalues	Condition #	Smallest eigenvalue	Diameter	F	NTries	Ratio
0	e	24		-1.310	9999.000	6807.189	0	9999.000
1	e	26		-.614	3.174	4296.743	20	.441
2	e*	12		-.575	1.226	3064.195	5	.931
3	e*	7		-.862	.711	2463.606	4	.895
4	e	4		-7.310	.767	1768.629	5	1.046
5	e*	3		-6.227	.213	1537.331	6	.711
Iteration		**Negative eigenvalues**	**Condition #**	**Smallest eigenvalue**	**Diameter**	**F**	**NTries**	**Ratio**
6	e	1		-.051	.215	1389.753	5	.573
7	e	0	7503.273		.649	1086.857	6	.898
8	e	0	3555.521		1.077	999.577	2	.000
9	e	0	3493.213		.417	949.365	1	1.120
10	e	0	3694.555		.148	944.181	1	1.101
11	e	0	3874.369		.032	944.015	1	1.030
12	e	0	3904.207		.001	944.014	1	1.002
13	e	0	3896.770		.000	944.014	1	1.000

Execution time summary

Minimization: .032
Miscellaneous: 1.026
Bootstrap: .000
Total: 1.058

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Analysis Summary

Groups

Group number 1 (Group number 1)

Notes for Group (Group number 1)

The model is recursive.
Sample size = 262

Variable Summary (Group number 1)

Your model contains the following variables (Group number 1)

Observed, endogenous variables

EcP
EP

Observed, exogenous variables

GLTP
GLWP
GLPP
GLVP

Unobserved, exogenous variables

e1 e2

Variable counts (Group number 1)

Number of variables in your model: 8
Number of observed variables: 6
Number of unobserved variables: 2
Number of exogenous variables: 6
Number of endogenous variables: 2

Parameter Summary (Group number 1)

	Weights	Covariances	Variances	Means	Intercepts	Total
Fixed	2	0	0	0	0	2
Labeled	0	0	0	0	0	0
Unlabeled	9	6	6	0	0	21
Total	11	6	6	0	0	23

Models
Default model (Default model)

Notes for Model (Default model)

Computation of degrees of freedom (Default model)

Number of distinct sample moments: 21
Number of distinct parameters to be estimated: 21
Degrees of freedom (21 - 21): 0

Result (Default model)

Minimum was achieved
Chi-square = .000
Degrees of freedom = 0
Probability level cannot be computed

Group number 1 (Group number 1 - Default model)

Estimates (Group number 1 - Default model)

Scalar Estimates (Group number 1 - Default model)

Maximum Likelihood Estimates

Regression Weights: (Group number 1 - Default model)

			Estimate	S.E.	C.R.	P	Label
EP	<---	GLTP	.280	.052	5.423	***	par_5
EP	<---	GLWP	.114	.057	2.004	.045	par_6
EP	<---	GLPP	.147	.059	2.508	.012	par_7
EP	<---	GLVP	.175	.051	3.411	***	par_8
EcP	<---	GLTP	.188	.059	3.174	.002	par_1
EcP	<---	GLWP	.223	.063	3.561	***	par_2
EcP	<---	GLPP	-.102	.065	-1.583	.113	par_3
EcP	<---	GLVP	.177	.057	3.089	.002	par_4
EcP	<---	EP	.402	.068	5.954	***	par_9

Standardized Regression Weights: (Group number 1 - Default model)

			Estimate
EP	<---	GLTP	.305
EP	<---	GLWP	.116
EP	<---	GLPP	.147
EP	<---	GLVP	.191
EcP	<---	GLTP	.177
EcP	<---	GLWP	.196
			Estimate
EcP	<---	GLPP	-.088
EcP	<---	GLVP	.166
EcP	<---	EP	.347

Covariances: (Group number 1 - Default model)

			Estimate	S.E.	C.R.	P	Label
GLPP	<-->	GLVP	.197	.055	3.579	***	par_10
GLWP	<-->	GLVP	.117	.055	2.111	.035	par_11
GLTP	<-->	GLVP	.227	.060	3.761	***	par_12
GLWP	<-->	GLPP	.291	.053	5.462	***	par_13

GLTP <-->	GLPP	.170	.055	3.096	.002	par_14
GLTP <-->	GLWP	.201	.056	3.570	***	par_15

Correlations: (Group number 1 - Default model)

		Estimate
GLPP <-->	GLVP	.227
GLWP <-->	GLVP	.132
GLTP <-->	GLVP	.239
GLWP <-->	GLPP	.359
GLTP <-->	GLPP	.195
GLTP <-->	GLWP	.227

Variances: (Group number 1 - Default model)

	Estimate	S.E.	C.R.	P	Label
GLTP	.951	.083	11.424	***	par_16
GLWP	.826	.072	11.424	***	par_17
GLPP	.794	.070	11.424	***	par_18
GLVP	.947	.083	11.424	***	par_19
e1	.592	.052	11.424	***	par_20
e2	.705	.062	11.424	***	par_21

Squared Multiple Correlations: (Group number 1 - Default model)

	Estimate
EP	.257
EcP	.343

Matrices (Group number 1 - Default model)

Factor Score Weights (Group number 1 - Default model)

Total Effects (Group number 1 - Default model)

	GLVP	GLPP	GLWP	GLTP	EP
EP	.175	.147	.114	.280	.000
EcP	.247	-.043	.269	.301	.402

Standardized Total Effects (Group number 1 - Default model)

	GLVP	GLPP	GLWP	GLTP	EP
EP	.191	.147	.116	.305	.000
EcP	.232	-.037	.236	.283	.347

Direct Effects (Group number 1 - Default model)

	GLVP	GLPP	GLWP	GLTP	EP
EP	.175	.147	.114	.280	.000
EcP	.177	-.102	.223	.188	.402

Standardized Direct Effects (Group number 1 - Default model)

	GLVP	GLPP	GLWP	GLTP	EP
EP	.191	.147	.116	.305	.000
EcP	.166	-.088	.196	.177	.347

Indirect Effects (Group number 1 - Default model)

	GLVP	GLPP	GLWP	GLTP	EP

EP	.000	.000	.000	.000	.000
EcP	.070	.059	.046	.112	.000

Standardized Indirect Effects (Group number 1 - Default model)

	GLVP	**GLPP**	**GLWP**	**GLTP**	**EP**
EP	.000	.000	.000	.000	.000
EcP	.066	.051	.040	.106	.000

Bootstrap (Group number 1 - Default model)

Bootstrap standard errors (Group number 1 - Default model)

Scalar Estimates (Group number 1 - Default model)

Regression Weights: (Group number 1 - Default model)

Parameter			**SE**	**SE-SE**	**Mean**	**Bias**	**SE-Bias**
EP	<---	GLTP	.063	.003	.281	.002	.004
EP	<---	GLWP	.061	.003	.117	.003	.004
Parameter			**SE**	**SE-SE**	**Mean**	**Bias**	**SE-Bias**
EP	<---	GLPP	.063	.003	.144	-.003	.004
EP	<---	GLVP	.054	.003	.174	-.001	.004
EcP	<---	GLTP	.075	.004	.198	.010	.005
EcP	<---	GLWP	.069	.003	.225	.001	.005
EcP	<---	GLPP	.055	.003	-.102	.001	.004
EcP	<---	GLVP	.053	.003	.176	-.001	.004
EcP	<---	EP	.079	.004	.397	-.004	.006

Standardized Regression Weights: (Group number 1 - Default model)

Parameter			**SE**	**SE-SE**	**Mean**	**Bias**	**SE-Bias**
EP	<---	GLTP	.068	.003	.307	.001	.005
EP	<---	GLWP	.061	.003	.118	.002	.004
EP	<---	GLPP	.061	.003	.143	-.004	.004
EP	<---	GLVP	.057	.003	.190	-.001	.004
EcP	<---	GLTP	.069	.003	.187	.009	.005
EcP	<---	GLWP	.060	.003	.196	.000	.004
EcP	<---	GLPP	.048	.002	-.088	.000	.003
EcP	<---	GLVP	.052	.003	.167	.000	.004
EcP	<---	EP	.066	.003	.343	-.004	.005

Covariances: (Group number 1 - Default model)

Parameter			**SE**	**SE-SE**	**Mean**	**Bias**	**SE-Bias**
GLPP	<-->	GLVP	.053	.003	.203	.006	.004
GLWP	<-->	GLVP	.054	.003	.122	.006	.004
GLTP	<-->	GLVP	.062	.003	.233	.006	.004
GLWP	<-->	GLPP	.051	.003	.291	.000	.004
GLTP	<-->	GLPP	.064	.003	.171	.002	.004
GLTP	<-->	GLWP	.063	.003	.202	.001	.004

Correlations: (Group number 1 - Default model)

Parameter	**SE**	**SE-SE**	**Mean**	**Bias**	**SE-Bias**

GLPP <-->	GLVP	.056	.003	.233	.006	.004
GLWP <-->	GLVP	.059	.003	.138	.006	.004
GLTP <-->	GLVP	.060	.003	.244	.005	.004
GLWP <-->	GLPP	.058	.003	.361	.002	.004
GLTP <-->	GLPP	.072	.004	.198	.002	.005
GLTP <-->	GLWP	.070	.004	.229	.002	.005

Variances: (Group number 1 - Default model)

Parameter	SE	SE-SE	Mean	Bias	SE-Bias
GLTP	.073	.004	.952	.001	.005
Parameter	**SE**	**SE-SE**	**Mean**	**Bias**	**SE-Bias**
GLWP	.052	.003	.820	-.006	.004
GLPP	.061	.003	.793	-.002	.004
GLVP	.073	.004	.954	.007	.005
e1	.044	.002	.581	-.011	.003
e2	.066	.003	.680	-.024	.005

Squared Multiple Correlations: (Group number 1 - Default model)

Parameter	SE	SE-SE	Mean	Bias	SE-Bias
EP	.047	.002	.272	.015	.003
EcP	.056	.003	.364	.021	.004

Matrices (Group number 1 - Default model)

Total Effects - Standard Errors (Group number 1 - Default model)

	GLVP	GLPP	GLWP	GLTP	EP
EP	.054	.063	.061	.063	.000
EcP	.060	.059	.074	.076	.079

Standardized Total Effects - Standard Errors (Group number 1 - Default model)

	GLVP	GLPP	GLWP	GLTP	EP
EP	.057	.061	.061	.068	.000
EcP	.057	.051	.063	.070	.066

Direct Effects - Standard Errors (Group number 1 - Default model)

	GLVP	GLPP	GLWP	GLTP	EP
EP	.054	.063	.061	.063	.000
EcP	.053	.055	.069	.075	.079

Standardized Direct Effects - Standard Errors (Group number 1 - Default model)

	GLVP	GLPP	GLWP	GLTP	EP
EP	.057	.061	.061	.068	.000
EcP	.052	.048	.060	.069	.066

Indirect Effects - Standard Errors (Group number 1 - Default model)

	GLVP	GLPP	GLWP	GLTP	EP
EP	.000	.000	.000	.000	.000
EcP	.026	.025	.024	.036	.000

Standardized Indirect Effects - Standard Errors (Group number 1 - Default model)

	GLVP	GLPP	GLWP	GLTP	EP
EP	.000	.000	.000	.000	.000
EcP	.024	.021	.021	.034	.000

Bootstrap Confidence (Group number 1 - Default model)

Percentile method (Group number 1 - Default model)

90% confidence intervals (percentile method)

Scalar Estimates (Group number 1 - Default model)

Regression Weights: (Group number 1 - Default model)

Parameter		Estimate	Lower	Upper	P
EP <---	GLTP	.280	.170	.385	.010
EP <---	GLWP	.114	.008	.204	.078
EP <---	GLPP	.147	.040	.249	.017
EP <---	GLVP	.175	.094	.264	.010
EcP <---	GLTP	.188	.078	.318	.010
EcP <---	GLWP	.223	.119	.340	.010
EcP <---	GLPP	-.102	-.193	-.016	.070
EcP <---	GLVP	.177	.091	.268	.010
EcP <---	EP	.402	.265	.523	.010

Standardized Regression Weights: (Group number 1 - Default model)

Parameter		Estimate	Lower	Upper	P
EP <---	GLTP	.305	.194	.420	.010
EP <---	GLWP	.116	.008	.205	.078
EP <---	GLPP	.147	.042	.245	.017
EP <---	GLVP	.191	.099	.281	.010
EcP <---	GLTP	.177	.071	.295	.010
EcP <---	GLWP	.196	.102	.302	.010
EcP <---	GLPP	-.088	-.169	-.014	.070
EcP <---	GLVP	.166	.086	.268	.010
EcP <---	EP	.347	.229	.448	.010

Covariances: (Group number 1 - Default model)

Parameter		Estimate	Lower	Upper	P
GLPP <-->	GLVP	.197	.120	.303	.010
GLWP <-->	GLVP	.117	.032	.212	.019
GLTP <-->	GLVP	.227	.126	.340	.010
GLWP <-->	GLPP	.291	.219	.389	.010
GLTP <-->	GLPP	.170	.076	.272	.010
Parameter		**Estimate**	**Lower**	**Upper**	**P**
GLTP <-->	GLWP	.201	.100	.303	.010

Correlations: (Group number 1 - Default model)

Parameter		Estimate	Lower	Upper	P
GLPP <-->	GLVP	.227	.138	.320	.010
GLWP <-->	GLVP	.132	.036	.237	.019
GLTP <-->	GLVP	.239	.138	.336	.010
GLWP <-->	GLPP	.359	.261	.469	.010
GLTP <-->	GLPP	.195	.084	.309	.010
GLTP <-->	GLWP	.227	.111	.336	.010

Variances: (Group number 1 - Default model)

Parameter	Estimate	Lower	Upper	P
GLTP	.951	.841	1.076	.010
GLWP	.826	.732	.911	.010
GLPP	.794	.685	.895	.010
GLVP	.947	.821	1.077	.010
e1	.592	.502	.655	.010
e2	.705	.579	.788	.010

Squared Multiple Correlations: (Group number 1 - Default model)

Parameter	Estimate	Lower	Upper	P
EP	.257	.197	.350	.010
EcP	.343	.279	.460	.010

Matrices (Group number 1 - Default model)

Total Effects (Group number 1 - Default model)

Total Effects - Lower Bounds (PC) (Group number 1 - Default model)

	GLVP	GLPP	GLWP	GLTP	EP
EP	.094	.040	.008	.170	.000
EcP	.154	-.141	.150	.191	.265

Total Effects - Upper Bounds (PC) (Group number 1 - Default model)

	GLVP	GLPP	GLWP	GLTP	EP
EP	.264	.249	.204	.385	.000
EcP	.347	.054	.379	.431	.523

Total Effects - Two Tailed Significance (PC) (Group number 1 - Default model)

	GLVP	GLPP	GLWP	GLTP	EP
EP	.010	.017	.078	.010	...
EcP	.010	.431	.010	.010	.010

Standardized Total Effects (Group number 1 - Default model)

Standardized Total Effects - Lower Bounds (PC) (Group number 1 - Default model)

	GLVP	GLPP	GLWP	GLTP	EP
EP	.099	.042	.008	.194	.000
EcP	.144	-.122	.133	.170	.229

Standardized Total Effects - Upper Bounds (PC) (Group number 1 - Default model)

	GLVP	GLPP	GLWP	GLTP	EP
EP	.281	.245	.205	.420	.000
EcP	.339	.048	.342	.397	.448

Standardized Total Effects - Two Tailed Significance (PC) (Group number 1 - Default model)

	GLVP	GLPP	GLWP	GLTP	EP
EP	.010	.017	.078	.010	...
EcP	.010	.431	.010	.010	.010

Direct Effects (Group number 1 - Default model)

Direct Effects - Lower Bounds (PC) (Group number 1 - Default model)

	GLVP	GLPP	GLWP	GLTP	EP
EP	.094	.040	.008	.170	.000
EcP	.091	-.193	.119	.078	.265

Direct Effects - Upper Bounds (PC) (Group number 1 - Default model)

	GLVP	GLPP	GLWP	GLTP	EP
EP	.264	.249	.204	.385	.000
EcP	.268	-.016	.340	.318	.523

Direct Effects - Two Tailed Significance (PC) (Group number 1 - Default model)

	GLVP	GLPP	GLWP	GLTP	EP
EP	.010	.017	.078	.010	...
EcP	.010	.070	.010	.010	.010

Standardized Direct Effects (Group number 1 - Default model)

Standardized Direct Effects - Lower Bounds (PC) (Group number 1 - Default model)

	GLVP	GLPP	GLWP	GLTP	EP
EP	.099	.042	.008	.194	.000
EcP	.086	-.169	.102	.071	.229

Standardized Direct Effects - Upper Bounds (PC) (Group number 1 - Default model)

	GLVP	GLPP	GLWP	GLTP	EP
EP	.281	.245	.205	.420	.000
EcP	.268	-.014	.302	.295	.448

Standardized Direct Effects - Two Tailed Significance (PC) (Group number 1 - Default model)

	GLVP	GLPP	GLWP	GLTP	EP
EP	.010	.017	.078	.010	...
EcP	.010	.070	.010	.010	.010

Indirect Effects (Group number 1 - Default model)

Indirect Effects - Lower Bounds (PC) (Group number 1 - Default model)

	GLVP	GLPP	GLWP	GLTP	EP
EP	.000	.000	.000	.000	.000
EcP	.030	.014	.003	.055	.000

Indirect Effects - Upper Bounds (PC) (Group number 1 - Default model)

	GLVP	GLPP	GLWP	GLTP	EP
EP	.000	.000	.000	.000	.000
EcP	.116	.095	.082	.173	.000

Indirect Effects - Two Tailed Significance (PC) (Group number 1 - Default model)

	GLVP	GLPP	GLWP	GLTP	EP
EP	...	...	...	...	...
EcP	.010	.017	.077	.010	...

Standardized Indirect Effects (Group number 1 - Default model)

Standardized Indirect Effects - Lower Bounds (PC) (Group number 1 - Default model)

	GLVP	GLPP	GLWP	GLTP	EP
EP	.000	.000	.000	.000	.000
EcP	.030	.012	.002	.054	.000

Standardized Indirect Effects - Upper Bounds (PC) (Group number 1 - Default model)

	GLVP	GLPP	GLWP	GLTP	EP
EP	.000	.000	.000	.000	.000
EcP	.109	.081	.072	.167	.000

Standardized Indirect Effects - Two Tailed Significance (PC) (Group number 1 - Default model)

	GLVP	GLPP	GLWP	GLTP	EP
EP	...	...	...	...	...
EcP	.010	.017	.077	.010	...

Bias-corrected percentile method (Group number 1 - Default model)

90% confidence intervals (bias-corrected percentile method)

Scalar Estimates (Group number 1 - Default model)

Regression Weights: (Group number 1 - Default model)

Parameter		Estimate	Lower	Upper	P
EP <---	GLTP	.280	.161	.377	.013
EP <---	GLWP	.114	-.009	.194	.130
EP <---	GLPP	.147	.048	.263	.012
EP <---	GLVP	.175	.094	.265	.009
EcP <---	GLTP	.188	.049	.286	.026
EcP <---	GLWP	.223	.118	.336	.012
EcP <---	GLPP	-.102	-.195	-.017	.063
EcP <---	GLVP	.177	.093	.271	.007
EcP <---	EP	.402	.265	.523	.010

Standardized Regression Weights: (Group number 1 - Default model)

Parameter		Estimate	Lower	Upper	P
EP <---	GLTP	.305	.191	.418	.012
EP <---	GLWP	.116	-.005	.193	.118
EP <---	GLPP	.147	.048	.248	.013
EP <---	GLVP	.191	.109	.284	.007
EcP <---	GLTP	.177	.041	.263	.034
EcP <---	GLWP	.196	.104	.306	.007
EcP <---	GLPP	-.088	-.169	-.014	.070
EcP <---	GLVP	.166	.087	.268	.009
EcP <---	EP	.347	.229	.448	.010

Covariances: (Group number 1 - Default model)

Parameter		Estimate	Lower	Upper	P
GLPP <-->	GLVP	.197	.118	.291	.012
GLWP <-->	GLVP	.117	.032	.212	.019
GLTP <-->	GLVP	.227	.103	.321	.019
GLWP <-->	GLPP	.291	.225	.392	.006
GLTP <-->	GLPP	.170	.073	.265	.013
GLTP <-->	GLWP	.201	.083	.302	.012

Correlations: (Group number 1 - Default model)

Parameter			Estimate	Lower	Upper	P
GLPP	<-->	GLVP	.227	.128	.317	.015
GLWP	<-->	GLVP	.132	.036	.237	.019
GLTP	<-->	GLVP	.239	.119	.326	.019
GLWP	<-->	GLPP	.359	.282	.480	.006
GLTP	<-->	GLPP	.195	.078	.303	.014
GLTP	<-->	GLWP	.227	.103	.334	.012

Variances: (Group number 1 - Default model)

Parameter	Estimate	Lower	Upper	P
GLTP	.951	.848	1.079	.006
GLWP	.826	.745	.922	.005
GLPP	.794	.684	.893	.011
GLVP	.947	.812	1.055	.019
e1	.592	.526	.670	.003
e2	.705	.627	.890	.001

Squared Multiple Correlations: (Group number 1 - Default model)

Parameter	Estimate	Lower	Upper	P
EP	.257	.173	.320	.046
EcP	.343	.213	.416	.056

Matrices (Group number 1 - Default model)

Total Effects (Group number 1 - Default model)

Total Effects - Lower Bounds (BC) (Group number 1 - Default model)

	GLVP	GLPP	GLWP	GLTP	EP
EP	.094	.048	-.009	.161	.000
EcP	.168	-.123	.139	.160	.265

Total Effects - Upper Bounds (BC) (Group number 1 - Default model)

	GLVP	GLPP	GLWP	GLTP	EP
EP	.265	.263	.194	.377	.000
EcP	.383	.060	.374	.410	.523

Total Effects - Two Tailed Significance (BC) (Group number 1 - Default model)

	GLVP	GLPP	GLWP	GLTP	EP
EP	.009	.012	.130	.013	...
EcP	.004	.508	.015	.020	.010

Standardized Total Effects (Group number 1 - Default model)

Standardized Total Effects - Lower Bounds (BC) (Group number 1 - Default model)

	GLVP	GLPP	GLWP	GLTP	EP
EP	.109	.048	-.005	.191	.000
EcP	.159	-.109	.138	.158	.229

Standardized Total Effects - Upper Bounds (BC) (Group number 1 - Default model)

	GLVP	GLPP	GLWP	GLTP	EP
EP	.284	.248	.193	.418	.000
EcP	.354	.051	.347	.389	.448

Standardized Total Effects - Two Tailed Significance (BC) (Group number 1 - Default model)

	GLVP	GLPP	GLWP	GLTP	EP
EP	.007	.013	.118	.012	...
EcP	.004	.541	.007	.018	.010

Direct Effects (Group number 1 - Default model)

Direct Effects - Lower Bounds (BC) (Group number 1 - Default model)

	GLVP	GLPP	GLWP	GLTP	EP
EP	.094	.048	-.009	.161	.000
EcP	.093	-.195	.118	.049	.265

Direct Effects - Upper Bounds (BC) (Group number 1 - Default model)

	GLVP	GLPP	GLWP	GLTP	EP
EP	.265	.263	.194	.377	.000
EcP	.271	-.017	.336	.286	.523

Direct Effects - Two Tailed Significance (BC) (Group number 1 - Default model)

	GLVP	GLPP	GLWP	GLTP	EP
EP	.009	.012	.130	.013	...
EcP	.007	.063	.012	.026	.010

Standardized Direct Effects (Group number 1 - Default model)

Standardized Direct Effects - Lower Bounds (BC) (Group number 1 - Default model)

	GLVP	GLPP	GLWP	GLTP	EP
EP	.109	.048	-.005	.191	.000
EcP	.087	-.169	.104	.041	.229

Standardized Direct Effects - Upper Bounds (BC) (Group number 1 - Default model)

	GLVP	GLPP	GLWP	GLTP	EP
EP	.284	.248	.193	.418	.000
EcP	.268	-.014	.306	.263	.448

Standardized Direct Effects - Two Tailed Significance (BC) (Group number 1 - Default model)

	GLVP	GLPP	GLWP	GLTP	EP
EP	.007	.013	.118	.012	...
EcP	.009	.070	.007	.034	.010

Indirect Effects (Group number 1 - Default model)

Indirect Effects - Lower Bounds (BC) (Group number 1 - Default model)

	GLVP	GLPP	GLWP	GLTP	EP
EP	.000	.000	.000	.000	.000
EcP	.034	.023	.003	.055	.000

Indirect Effects - Upper Bounds (BC) (Group number 1 - Default model)

	GLVP	GLPP	GLWP	GLTP	EP
EP	.000	.000	.000	.000	.000
EcP	.125	.109	.082	.173	.000

Indirect Effects - Two Tailed Significance (BC) (Group number 1 - Default model)

	GLVP	GLPP	GLWP	GLTP	EP

EP	...	...	...	...	...
EcP	.004	.005	.081	.010	...

Standardized Indirect Effects (Group number 1 - Default model)

Standardized Indirect Effects - Lower Bounds (BC) (Group number 1 - Default model)

	GLVP	GLPP	GLWP	GLTP	EP
EP	.000	.000	.000	.000	.000
EcP	.032	.021	.002	.054	.000

Standardized Indirect Effects - Upper Bounds (BC) (Group number 1 - Default model)

	GLVP	GLPP	GLWP	GLTP	EP
EP	.000	.000	.000	.000	.000
EcP	.114	.099	.072	.167	.000

Standardized Indirect Effects - Two Tailed Significance (BC) (Group number 1 - Default model)

	GLVP	GLPP	GLWP	GLTP	EP
EP	...	...	...	...	...
EcP	.006	.004	.077	.009	...

Minimization History (Default model)

Iteration		Negative eigenvalues	Condition #	Smallest eigenvalue	Diameter	F	NTries	Ratio
0	e	0	15.756		9999.000	156.546	0	9999.000
1	e	0	6.066		.589	51.912	3	.000
2	e	0	5.573		.357	8.401	1	1.031
3	e	0	9.071		.197	.625	1	1.148
4	e	0	11.508		.078	.008	1	1.072
5	e	0	11.955		.011	.000	1	1.010
6	e	0	11.771		.000	.000	1	1.000

Pairwise Parameter Comparisons (Default model)

Variance-covariance Matrix of Estimates (Default model)

	par_1	par_2	par_3	par_4	par_5	par_6	par_7	par_8	par_9	par_10	par_11	par_12	par_13	par_14	par_15	par_16	par_17	par_18	par_19	par_20	par_21
par_1	.004																				
par_2	.000	.004																			
par_3	.0	-.	.0																		

	par_1	par_2	par_3	par_4	par_5	par_6	par_7	par_8	par_9	par_10	par_11	par_12	par_13	par_14	par_15	par_16	par_17	par_18	par_19	par_20	par_21

	00	001	04										
par_4	.000	.000	-.001	.003									
par_5	.000	.000	.000	.000	.003								
par_6	.000	.000	.000	.000	.000	.003							
par_7	.000	.000	.000	.000	.000	-.001	.003						
par_8	.000	.000	.000	.000	-.001	.000	-.001	.003					
par_9	-.001	-.001	-.001	-.001	.000	.000	.000	.000	.005				
par_10	.000	.000	.000	.000	.000	.000	.000	.000	.000	.003			
par_11	.000	.000	.000	.000	.000	.000	.000	.000	.000	.001	.003		
par_12	.000	.000	.000	.000	.000	.000	.000	.000	.000	.001	.001	.004	
par_13	.000	.000	.000	.000	.000	.000	.000	.000	.000	.001	.001	.000	.003

	par_1	par_2	par_3	par_4	par_5	par_6	par_7	par_8	par_9	par_10	par_11	par_12	par_13	par_14	par_15	par_16	par_17	par_18	par_19	par_20	par_21
par_14	.000	.000	.000	.000	.000	.000	.000	.000	.000	.001	.000	.001	.001	.003							
par_15	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.001	.001	.001	.001	.003						
par_16	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.002	.000	.001	.001	.007					
par_17	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.001	.000	.002	.000	.001	.000	.005				
par_18	.000	.000	.000	.000	.000	.000	.000	.000	.000	.001	.000	.000	.002	.001	.000	.000	.001	.005			
par_19	.000	.000	.000	.000	.000	.000	.000	.000	.000	.001	.001	.002	.000	.000	.000	.000	.000	.000	.007		
par_20	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.003	
par_21	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.004

Correlations of Estimates (Default model)

	par_1	par_2	par_3	par_4	par_5	par_6	par_7	par_8	par_9	par_10	par_11	par_12	par_13	par_14	par_15	par_16	par_17	par_18	par_19	par_20	par_21
par_1	1.000																				
par_2	-.114	1.000																			

	par_1	par_2	par_3	par_4	par_5	par_6	par_7	par_8	par_9	par_10	par_11	par_12	par_13	par_14	par_15	par_16	par_17	par_18	par_19	par_20	par_21
par_3	-.032	-.296	1.000																		
par_4	-.118	.005	-.135	1.000																	
par_5	.000	.000	.000	.000	1.000																
par_6	.000	.000	.000	.000	-.163	1.000															
par_7	.000	.000	.000	.000	-.087	-.321	1.000														
par_8	.000	.000	.000	.000	-.198	-.021	-.173	1.000													
par_9	-.318	-.123	-.153	-.207	.000	.000	.000	.000	1.000												
par_10	.000	.000	.000	.000	.000	.000	.000	.000	.000	1.000											
par_11	.000	.000	.000	.000	.000	.000	.000	.000	.000	.376	1.000										

	par_1	par_2	par_3	par_4	par_5	par_6	par_7	par_8	par_9	par_10	par_11	par_12	par_13	par_14	par_15	par_16	par_17	par_18	par_19	par_20
par_12	.000	.000	.000	.000	.000	.000	.000	.000	.000	.237	.249	1.000								
par_13	.000	.000	.000	.000	.000	.000	.000	.000	.000	.196	.256	.071	1.000							
par_14	.000	.000	.000	.000	.000	.000	.000	.000	.000	.272	.134	.261	.274	1.000						
par_15	.000	.000	.000	.000	.000	.000	.000	.000	.000	.106	.260	.176	.254	.386	1.000					
par_16	.000	.000	.000	.000	.000	.000	.000	.000	.000	.064	.076	.329	.059	.271	.312	1.000				
par_17	.000	.000	.000	.000	.000	.000	.000	.000	.000	.065	.185	.041	.478	.113	.312	.051	1.000			
par_18	.000	.000	.000	.000	.000	.000	.000	.000	.000	.313	.114	.061	.478	.271	.097	.038	.129	1.000		
par_19	.000	.000	.000	.000	.000	.000	.000	.000	.000	.313	.185	.329	.040	.075	.044	.057	.017	.052	1.000	
par_20	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	1.000

	par_1	par_2	par_3	par_4	par_5	par_6	par_7	par_8	par_9	par_10	par_11	par_12	par_13	par_14	par_15	par_16	par_17	par_18	par_19	par_20	par_21
par_21	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	1.0
																					0 0

Bootstrap (Default model)

Summary of Bootstrap Iterations (Default model)

(Default model)

Iterations	Method 0	Method 1	Method 2
1	0	0	0
2	0	0	0
3	0	0	0
4	0	1	0
5	0	40	0
6	0	107	0
7	0	49	0
8	0	3	0
9	0	0	0
10	0	0	0
11	0	0	0
12	0	0	0
13	0	0	0
14	0	0	0
15	0	0	0
16	0	0	0
17	0	0	0
18	0	0	0
19	0	0	0
Total	0	200	0

0 bootstrap samples were unused because of a singular covariance matrix.
0 bootstrap samples were unused because a solution was not found. 200 usable bootstrap samples were obtained.

Bootstrap Distributions (Default model)

ML discrepancy (implied vs sample) (Default model)

```
     |--------------------
.000 |*******************
.000 |******
.000 |*
.000 |
.000 |
```

```
                    .000  |
                    .000  |
N = 200             .000  |
Mean = .000         .000  |
S. e. = .000        .000  |
                    .000  |
                    .000  |
                    .000  |
                    .000  |
                    .000  |
                          |--------------------
```

ML discrepancy (implied vs pop) (Default model)

```
                          |--------------------
                   8.820  |*
                  13.196  |***
                  17.573  |***********
                  21.949  |*******************
                  26.325  |******************
                  30.701  |**************
                  35.077  |**************
N = 200           39.454  |**********
Mean = 30.048     43.830  |*****
S. e. = .727      48.206  |***
                  52.582  |**
                  56.958  |**
                  61.335  |
                  65.711  |*
                  70.087  |*
                          |--------------------
```

K-L overoptimism (unstabilized) (Default model)

```
                          |--------------------
                 -92.382  |*
                 -69.770  |**
                 -47.157  |******
                 -24.544  |*******
                  -1.931  |*********
                  20.682  |*************
                  43.295  |**********
N = 200           65.907  |***************
Mean = 58.724     88.520  |****************
S. e. = 4.597    111.133  |********
                 133.746  |*******
                 156.359  |****
                 178.971  |**
                 201.584  |**
                 224.197  |**
                          |--------------------
```

K-L overoptimism (stabilized) (Default model)

```
                              |--------------------
                     24.930   |*
                     31.480   |***
                     38.031   |**********
                     44.582   |******************
                     51.132   |***************
                     57.683   |******************
                     64.233   |**********
 N = 200             70.784   |***********
 Mean = 58.088       77.335   |********
 S. e. = 1.142       83.885   |***
                     90.436   |**
                     96.986   |***
                    103.537   |*
                    110.088   |
                    116.638   |*
                              |--------------------
```

Execution time summary

Minimization: .012
Miscellaneous: .130
Bootstrap: .039
Total: .181

List of Papers Published (During Ph.D.)

1. **Chhabra, D., Garg, S.K., Singh, R.K., (2017)** 'Analyzing alternatives for Green Logistics in an Indian automotive organization: a case study', Elsevier Journal of Cleaner Production, Vol. 167, pp. 962- 969. http://dx.doi.org/10.1016/j.jclepro.2017.02.158. (SCI Impact Factor-7.0). (SCI/SCOPUS & UGC Listed) – ***Cited by 39 (Google Citation Report Attached)***

2. **Chhabra, D., Singh, R. K., (2016)** 'Justification of Green Logistic Practices in Indian Enterprises using analytic hierarchy process', International Journal of Logistics Systems and Management, Vol. 25, No. 3, pp 295-312. http://dx.doi.org/10.1504/IJLSM.2016.079828 (SCOPUS & UGC Listed) - ***Cited by 5 (Google Citation Report Attached)***

3. **Chhabra, D., Singh, R.K., Garg, S.K. (2020)** "Green Logistics Practices in the select Indian manufacturing sector: An Empirical study", Presented in the 1st International Conference on Energy, Material Sciences & Mechanical Engineering - 2020, (31st Oct – 01st Nov, 2020), NIT Delhi, India. (International Conference).

4. **Chhabra, D., Singh, R.K., Garg, S.K. (2020)** "Organizing Green Logistics Packaging Practices in Oil and Gas Industry in the Indian context", Presented in the 1st International Conference on Energy, Material Sciences & Mechanical Engineering - 2020, (31st Oct – 01st Nov, 2020), NIT Delhi, India. (International Conference)

5. **Chhabra, D., Garg, S.K., Singh, R.K., (2020)** "Analyzing barriers for green logistics in context to circular economy and Industry 4.0", International Conference on Resource Sustainability (2020), Dublin, Ireland (Submitted & Accepted). (International Conference)

6. **Chhabra, D., Singh, R. K., (2013)**, "Towards improving the production performance through green supply chain and lean manufacturing – A case study", In Proceedings of ISTE Delhi Section Convention, 2013, Delhi, India. (Conference).