FRAMEWORK FOR MULTI OBJECTIVE OPTIMISATION IN SECONDARY LOGISTICS OF MOTOR SPIRIT AND HIGH-SPEED DIESEL IN NORTH INDIA

A Thesis Submitted to the
University of Petroleum and Energy Studies

For the Award of
Doctor of Philosophy
in
Supply Chain Management

BY
Bhuwan Chandra Joshi

May 2021

Supervisors

Dr Binod Kumar Singh

Dr S K Singh

College of Management & Economic Studies
University of Petroleum & Energy Studies
Dehradun-348007: Uttarakhand

FRAMEWORK FOR MULTI OBJECTIVE OPTIMISATION IN SECONDARY LOGISTICS OF MOTOR SPIRIT AND HIGH-SPEED DIESEL IN NORTH INDIA

A Thesis Submitted to the
University of Petroleum and Energy Studies

For the Award of Doctor of Philosophy
In
Supply Chain Management

BY
Bhuwan Chandra Joshi
(SAP ID 500024817)

May 2021

Internal Supervisor
Dr Binod Kumar Singh
Assistant Professor(SG),
University of Petroleum & Energy Studies

External Supervisor
Dr S K Singh
General Manager (HSE) (Retd) Indian Oil Corporation Ltd

College of Management & Economic Studies
University of Petroleum & Energy Studies
Dehradun-348007: Uttarakhand

Declaration

I declare that the thesis entitled "Framework for Multi-Objective Optimisation in Secondary Logistics of Motor Spirit and High-Speed Diesel in North India" has been prepared by me under Dr Binod Kumar Singh's guidance Assistant Professor(SG), University of Petroleum & Energy Studies.

No part of this thesis has formed the basis for the award of any degree or fellowship previously.

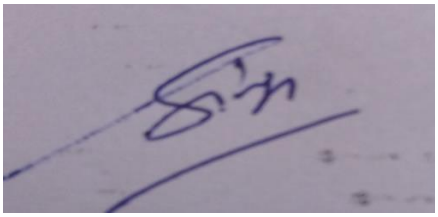
Bhuwan Chandra Joshi

UPES
UNIVERSITY WITH A PURPOSE

Great Place To Work. Certified APR 2019–MAR 2020 INDIA

CERTIFICATE

I certify that Bhuwan Chandra Joshi has prepared his thesis entitled "Multi-Objective Optimisation in Secondary Logistics of Motor Spirit and High-Speed Diesel in North India" to award the PhD degree of the University of Petroleum & Energy Studies, under my guidance. He has carried out work at the Department of College of Management & Economic Studies, University of Petroleum & Energy Studies.

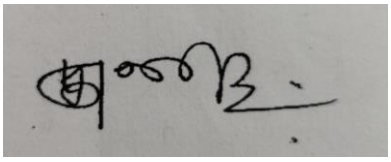


Binod Kumar Singh
Assistant Professor (SG)
Department of General Management
University of Petroleum & Energy Studies

May'2021

CERTIFICATE

I certify that Bhuwan Chandra Joshi has prepared his thesis entitled "Multi-Objective Optimisation in Secondary Logistics of Motor Spirit and High-Speed Diesel in North India" to award the PhD degree of the University of Petroleum & Energy Studies, under my guidance. He has carried out work at the Department of College of Management & Economic Studies, University of Petroleum & Energy Studies.



Dr S K Singh
GM (HSE) (Retired)
Indian Oil Corporation Ltd

May' 2021

ABSTRACT

The petroleum industry has vast spatial separation between demand and supply areas, making logistics a vital value chain element. The industry has been categorised as upstream, midstream, and downstream and the supply chains are highly complex and inflexible. The industry is facing increasingly stringent environmental regulations all over the world. There have been significant efforts to improve the quality of petroleum products and find alternatives to having more environmentally friendly credentials from renewable sources. However, the predictions are that petroleum oils will retain a significant share in the energy mix for at least two decades. In India, the per capita energy consumption is meagre compared to the world average and is expected to grow exponentially, although the energy intensity is decreasing. The Oil Marketing Companies in India incur high logistics costs without a corresponding increase in sales, thereby significantly denting their margins. The downstream supply chain from refineries to the storage points is called primary logistics, and the product remains in the custody of the oil marketing company. Since various modes of transportation are available and volumes are largely predictable,

The optimisation is extensively used in primary logistics using Linear Programming methods. The secondary logistics part covers product and services movement from storage point to the retailer or end-user has not received due attention. This part of the supply chain has been hyphenated with primary logistics. Cost optimisation is applied without considering its impact on the other channel partners and service to the customers. This is a customer-facing part of the supply chain and involves multiple stakeholders. The single objective of cost minimisation is not appropriate for this customer-facing part of the supply chain. However, the literature does not consider the need for a separate model of optimisation for secondary logistics. There is a requirement of studying this part of the inflexible supply chain involving multiple stakeholders having multiple objectives.

The present study aims to find the factors of optimisation in the secondary logistics of the downstream petroleum industry, determine the relative importance of factors in optimising secondary logistics of MS and HSD in North India, and develop a framework for the optimisation of secondary logistics and validating it.

An exploratory survey was carried out to identify the optimisation factors in the secondary logistics of automotive fuels in North India by sending a questionnaire to Subject Matter Experts (SMEs) of a leading oil marketing company. The variables were first identified through a literature survey of other industries. The questionnaire, validated through a pilot survey, was administered to the Experts with experience in supplies and operations. The responses collected from the Experts through google-forms were analysed using SPSS. The four underlying factors, namely Cost, Performance, Service, and Value, were identified using factor analysis. After that, a survey was carried out from the Experts having experience in supplies function, using a pair-wise comparison questionnaire to determine the relative weight of these factors. The Analytical Hierarchical Process was used for the analysis. The results were analysed using Super decisions software, and the results showed that the service has the highest weightage, followed by Cost, Performance, and Value in that order. This observation contrasts with the general view of applying primary logistics optimisation methods to this part of the supply chain where cost is considered a single objective and other parameters are defined as constraints.

The survey results were provided to the senior managers of the supplies, sales, and finance functions to arrange them sequentially and develop a framework for optimisation using the Delphi method. The initial poll was repeatedly placed before the group to arrive at a consensus. The service level was used as the starting point, cost function definition, performance measurement, and deriving Value in that order. The framework was applied to a test market using the Genetic Algorithm method for solving the Multi-Objective Optimisation problem for demonstration purposes.

This study has defined secondary logistics and clearly distinguished it from the primary logistics requiring an entirely different approach towards optimisation. A methodological contribution has been made by using AHP in decision making in secondary logistics of petroleum products and the Evolutionary Genetic Algorithm to solve the multi-objective optimisation problems. The present study shows that the current obsession with optimisation theories with cost optimisation throughout the supply chain does not address their overall purpose of optimisation, be it manufacturing or logistics operations. The simplicity of linear programming has led to its extensive use in literature and industry. This research has discussed the limitations of this approach

and the importance of using multi-objective optimisation methods. The concepts of optimisation and decision theories have been merged as the purpose of both is to make the supply chain efficient and provide value to the customer in a cost-effective and timely manner.

Genetic Algorithms are appropriate for the secondary logistics of petroleum products as the method does not require any derivative information and is more efficient when compared to the traditional methods. These can optimise both continuous and discrete functions. Hence these are best suited to the complex secondary logistics problem where the objectives functions are varied and subjective. It provides a decision-maker with the flexibility of choosing the results based on the preferences of the organisation.

This study has defined secondary logistics and clearly distinguished it from the primary logistics requiring an entirely different optimisation approach. It makes a methodological contribution by using AHP in decision making in secondary logistics of petroleum products and the Evolutionary Genetic Algorithm to solve the multi-objective optimisation problem. A survey was carried out to identify the various factors in optimising secondary logistics using 360 respondents with more than five years of experience in the operations and supplies function. AHP method was used to determine the relative weight of the factors identified from factor analysis. The responses of 356 experts having more than ten years of experience in supplies function in North India were analysed. The Delphi method was used for the present study, with ten experts from various disciplines having at least 30 years of experience in their respective fields.

ACKNOWLEDGEMENT

I express my sincere gratitude to my guide Dr Binod Kumar Singh, for his continuous encouragement and motivation to complete my research work. My external guide Dr S. K. Singh, kept on encouraging me throughout the journey. I feel a profound sense of gratitude and indebtedness to my colleagues in the office. They have always been cooperative and helped me in administering the survey and pursuing academic work. S/Shri Shyam Bohra, Harsh Sachdev, Sajjan Kumar, T S Khwaja, Pravesh Hooda, Dinesh Goel, KS Rao, M M Kapoor, Rishabh Bhatia, Sanjay Sharma are some of the names who supported me during this 8-year long journey.

My friends Naresh Kumar Bhola and Rajeev Sharma have been my pillars of support and always kept my spirits high even when the sheer uncertainty and confusion of research work bogged me down.

My family has always been by my side throughout the long years of research. My mother, Smt Saraswati Joshi, wife Smt Saroj Joshi, and daughters Shreya and Vanya enthusiastically sacrificed their share of time and helped me in my academic pursuit.

I dedicate the thesis to my beloved mother, who left for her heavenly abode this year. She had been and still is my constant source of inspiration.

Bhuwan Chandra Joshi

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

LIST OF ABBREVIATIONS

Abbreviation	Full-Form
3PL	Third-Party Logistics
ADC	Additional Customs Duty
AHP	Analytical Hierarchical Process
ANN	Artificial Neural Network
ANP	Analytical Network Process
APM	Administered Pricing Mechanism
ATF	Aviation Turbine Fuel
AVE	Average Value Extracted
BPCL	Bharat Petroleum Corporation Limited
BSC	Balanced Score Card
BS-VI	Bharat Stage VI
CAGR	Cumulative Annual Growth Rate
CIF	Cost, Insurance and Freight
COCO	Company Owned Company Operated
CODO	Company Owned Dealer Operated

Abbreviation	Full-Form
CR	Composite Reliability
CRM	Customer Relationship Management
CVD	Countervailing Duty
DBT	Direct Benefit Transfer
DEA	Data Envelopment Analysis
DESSCOM	Decision Support for Supply Chains through Object Modelling
DODO	Dealer Owned Dealer Operated
DSCPSC	Dynamic Sustainable Competitive Petroleum Supply Chain
DT	Decision Theory
EBMS	Ethanol Blended Motor Spirit
EBP	Ethanol Blending Program
EDI	Electronic Data Exchange
ERP	Enterprise Resource Planning
EV	Electric Vehicle
EVPI	Expected Value of Perfect Information
FAME	Faster Adoption and Manufacturing of Electric Vehicles

Abbreviation	Full-Form
FO	Furnace Oil
FOB	Free on Board
GA	Genetic Algorithm
GDP	Gross Domestic Product
GIS	Global Information System
GP	Goal Programming
GST	Goods and Services Tax
GWh	Giga Watt Hour
HPCL	Hindustan Petroleum Corporation Limited
HSD	High-Speed Diesel
IEA	International Energy Agency
IOCL	Indian Oil Corporation Limited
ISPRL	Indian Strategic Petroleum Reserves Limited
IT	Information Technology
JIT	Just in Time
KM	Knowledge Management

Abbreviation	Full-Form
LDO	Light Diesel Oil
LP	Linear Programming
LPG	Liquified Petroleum Gas
LPO	Lean Planning and Operations
MCDA	Multi-Criteria Decision Analysis
MCDM	Multi-Criteria Decision Making
MDI	Management Development Institute
MILP	Mixed Integer Linear Programming
MINLP	Mixed Integer Non-Linear Programming
MMT	Million Metric Ton
MNC	Multinational Company
MOO	Multi-Objective Optimisation
MoPNG	Ministry of Petroleum and Natural Gas
MS	Motor Spirit
MT	Metric Ton
MTO	Multimodal Transport Operation

Abbreviation	Full Form
NCCD	National Calamity Contingent Duty
NCR	National Capital Region
NEL	Nayara Energy Limited
NGT	National Green Tribunal
NLP	Non-Linear Programming
NSO	National Statistical Office
OMC	Oil Marketing Company
OR	Operations Research
PC	Personal Computer
PGDBM	Post Graduate Diploma in Business Management
PMIS	Performance Management and Improvement System
PNGRB	Petroleum and Natural Gas Regulatory Board
PPAC	Petroleum Planning and Analysis Cell
PSC	Petroleum Supply Chain
PSO	Particle Swarm Optimisation
PSU	Public Sector Unit

Abbreviation	Full Form
QFD	Quality Function Deployment
RFID	Radio Frequency Identification Device
RIC	Road and Infrastructure Cess
RIL	Reliance Industries Limited
RO	Retail Outlet
RPMS	Refinery and Petrochemical Modelling
RTD	Round Trip Distance
S&D	Supply and Distribution
SC	Supply Chain
SCM	Supply Chain Management
SCPM	Supply Chain Performance Management
SKO	Superior Kerosene Oil
SME	Subject Matter Expert
SPSS	Statistical Package for the Social Sciences
SSCM	Sustainable Supply Chain Mechanism
STD	Supply, Transformation, and Distribution

Abbreviation	Full Form
SUV	Sport Utility Vehicle
TOC	Theory of Constraints
TOPSIS	A technique for Order of Preference by Similarity to Ideal Solution
UAE	United Arab Emirate
UCO	Used Cooking Oil
UGC	University Grants Commission
USA	United States of America
VAT	Value Added Tax
VSS	Value of Stochastic Solution
WS	Weighted Sum

List of Appendices

Appendix I - Questionnaire and response statistics.

Appendix II - Questionnaire for pairwise comparison in AHP

CHAPTER 1
INTRODUCTION

1.1 OVERVIEW OF PETROLEUM INDUSTRY

There are enormous demand and supply gaps in Petroleum Industry (GoI, 2019). Crude is the raw material for the entire spectrum of petroleum products and is found in large quantities in countries where the demand is not so high, so it must be transported to long distances. It goes through a complex refining process and is converted into finished products ready for consumption. In this case, crude oil logistics becomes vital due to the spatial separation between the demand and locations of supply.

The geographical distribution of total world production in the major regions for 2017-18 shows that the Middle East has the largest share (33.75%), North America (20.88%), Europe and Eurasia (19.68%), Africa (8.74%), and Asia (Pacific Ocean). 8.56%), and South and Central America (8.39%). Gross world production distribution shows that the USA and Saudi Arabia were the 1st and 2nd highest producers with 13.01% and 12.60%. It is followed by Russian (12.63%), Canada (5.39%), Iran (5.34%), Iraq (5.06%), China (4.37%), United Arab Emirates (4.02%), Brazil (3.35%), and Kuwait (3.34). %), Mexico (2.98%), Venezuela (2.48%) and Nigeria (2.18%). India accounts for only 0.92% of world production.

The region-wise consumer pattern shows that the Asia Pacific has the highest global consumption (35.75%), North America (23.63%), and Europe and Eurasia the least (20.25%). African countries had the lowest share worldwide (4.24%). The distribution of country-wise consumption shows that the US was the largest consumer of crude oil, consuming 19.47% worldwide in 2011. (GoI, 2019)

Vertically integrated supply chain marketing involves a push system because the cost of shutting down production is so steep that it drives product sales efforts in the petroleum industry (Hall, 2002). Following the supply chain strategy argument (Fisher, 1997), a push supply chain focused on low-cost productions. (Hall, 2002) & (Gainsborough, 2006)stands as a primary goal in maximising cost efficiency gains.

The last mile of petroleum product logistics involves transportation of products, e.g. MS (Petrol) and HSD (Diesel), from the storage terminals to the Retail Outlets (Petrol Pumps or Petrol Bunks) and is called Secondary logistics.

The industry is facing severe challenges due to stringent environmental norms worldwide and in India. National Green Tribunal (NGT) orders to ban all vehicles more than 10-year-old within NCR have impacted the secondary logistics as the finished products. These vehicles have to enter the city where retail outlets are situated. While the world is making progress on low carbon emissions, oil and gas will continue to be the leading energy source for decades to come, according to the International Energy Agency (being available in large quantities, accessible and less expensive).

The petroleum industry in India has used innovative methods to optimise its logistics. One such practice is swapping the products, which has not attracted attention in the journal publications. Optimising the oil supply chain involves substantial cost savings for oil companies. Therefore, optimisation in oil supply chain management is at the centre of attention (Gainsborough, 2006) (Hussain, 2006). With increasing competition, each company trying to optimise production and transportation costs. Logistics costs play a significant role.

GoI (Government of India) has formulated 'Auto Fuel Policy' to cause movement of the country from BS-IV to BS-VI standards from 1st April 2020. The same has become effective on all India basis. The Government of India has reduced the capital investment requirements for the businesses willing to retail MS and HSD. Many foreign companies have shown interest in investing in the area of automotive fuels' retailing. Petroleum-based fuels are being threatened by the growing competitiveness of alternate energy sources. In India, auto fuels are lying primarily in the domain of public sector oil companies. The private companies tried entry into the business but could not compete due to the government subsidies necessitated by the volatility of crude oil in the international market. The support was available to the public OMC only and not to the private retailers. The phenomenon of oil production from shale in the US changed the oil price scenario and cushioned the steep hike in crude prices. The advent of shale oil companies requiring

low capital requirements and flexibility in production, rising sustainability awareness, and consequent policy changes have necessitated the OMCs in India to rethink and optimise their SCs.

1.2 LOGISTICS IN PETROLEUM INDUSTRY

The logistics of the downstream petroleum industry starts from production centres, i.e. Refineries where finished products are produced and certified as per prescribed specifications.

The custody of these products is transferred to the marketing wing of the firms. This part of the SC linking refineries with the storage terminals of marketing is called primary logistics and is effected through Railway Wagons, Cross Country Pipelines, or Tankers. The OMCs resort to inter-company swapping product and apply least-cost models to optimise the primary logistics. The segment of the SC, from Terminals to Retail Outlets and Institutional Consumers, has been termed secondary logistics, which is the subject of this study. (Sear, 1993) As it is the last mile of the SC of petroleum products, various stakeholders are involved. OMC, Logistics Providers, Retail Outlet Dealers and Institutional Consumers are all stakeholders. The auto fuels move from storage terminals of OMCs to the Retail Outlet or End Consumers on a delivered basis. The custody is transferred from the terminal to the transporter, which forwards it to the customer. IOCL, BPCL and HPCL are three OMCs operating in the public sector. Nayara Energy Ltd (NEL formerly Essar Oil Ltd) and Reliance Industries Ltd (RIL), with Shell India Markets Pvt Ltd having a nominal presence, are significant private sector players. (PPAC, 2021)

India imports 85% of its crude requirements and processes it in its refineries. The total consumption in the year 2019-20 was 32.2 MMT against the consumption of 213.7 MMT. The figures for consumption and crude oil production in 2018-19 were 34.2 MMT and 213.2 MMT. Since the last three financial years, the production and demand figures show that the gap between the two is increasing (Fig1.1).

India's current refining capacity stands at 249 MMTPA, comprising 23 refineries—18 under the public sector, three under the private sector, and 2 in a joint venture. Indian Oil Corporation (IOC) is the largest domestic refiner with a capacity of 80.7 MMTPA. The top three companies – IOCL, Bharat Petroleum Corporation (BPCL) and Reliance Industries (RIL) - contribute around 66.7% of India's total refining production from FY 2018 – 19. (GOI,

2021). The government of India has formulated a Biofuel policy to reduce dependence on crude oil imports. (GOI, 2021)

Consumption and Production of Crude Oil and Petroleum Products in India

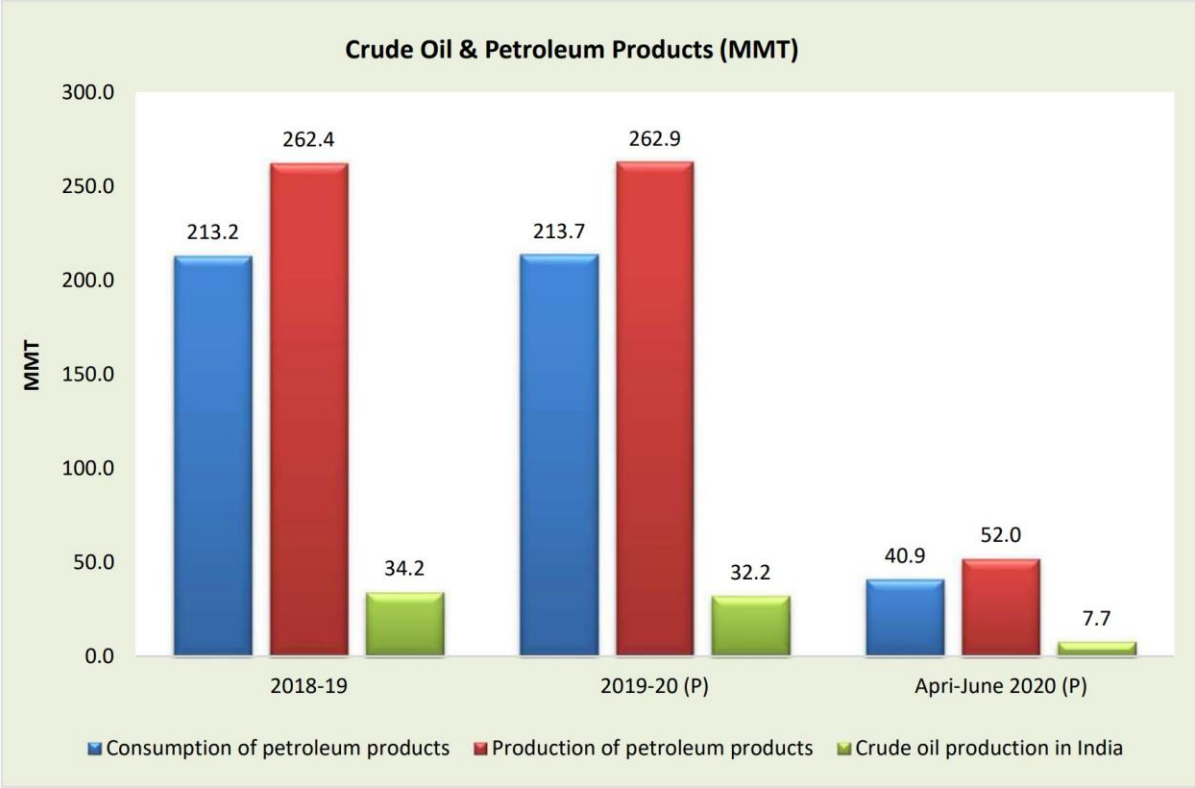
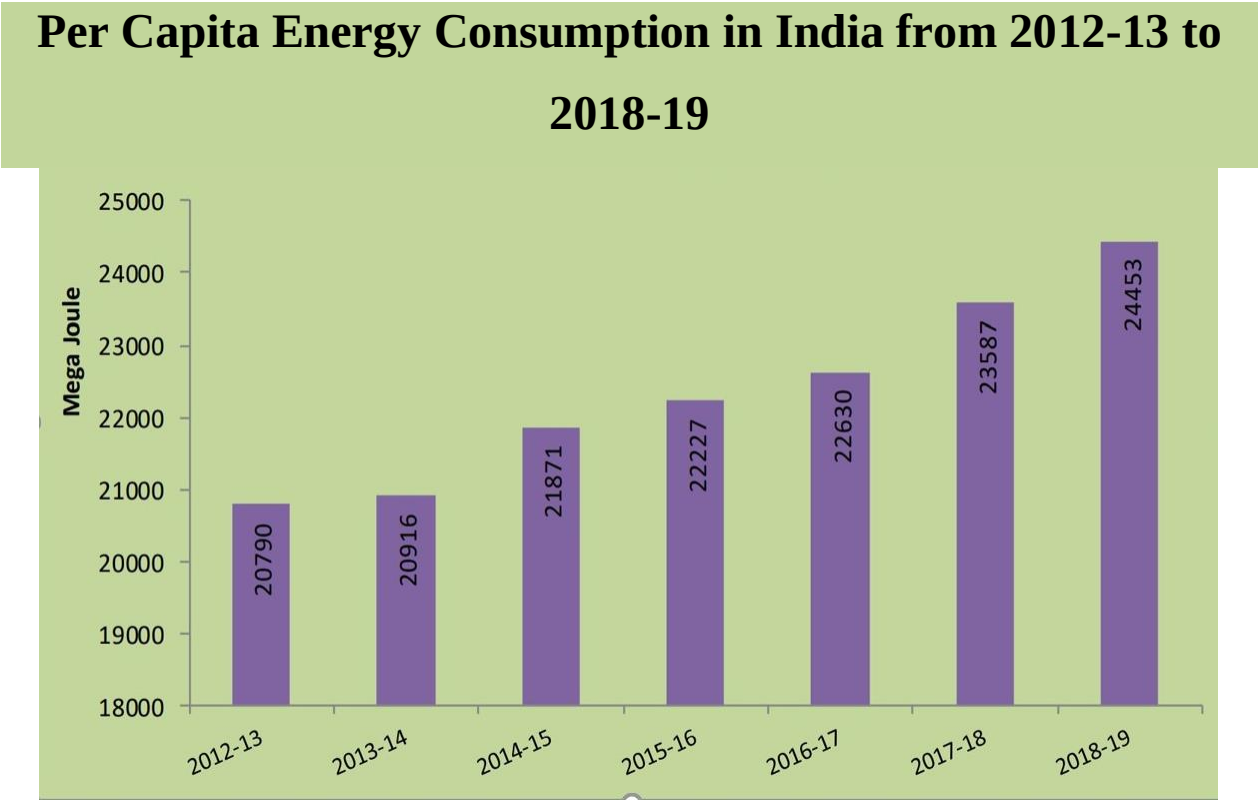


Fig :1.1

Source: (PPAC, 2020)

1.3 CONSUMPTION PATTERN IN INDIA

The industrial sector in India consumed 56% of total energy demand in 2018-19, whereas transport and residential sectors consumed 10% and 9%, respectively. This energy consumption was sourced 46.8% from Coal and Lignite, 33.2 % from Crude Oil, and 12.9% from Electricity. The per capita energy consumption has a consistent increase in 2012-13 to 2018-19 with a CAGR of 2.30%. Fig 1.2



(PPAC, 2020) **Fig 1.2**

Energy consumption for producing one unit of GDP has decreased during the period (CAGR (-) 1.92%). Production increase during the period 2009-10 to 2018-19 has been 0.15% for Crude Oil, (-) 3.61% for Natural Gas, and 6.49% for Electricity (Fig 1.3). The Consumption increase during the period 2009-10 to 2018-19 for Crude Oil has been 3.3% (From 186.55 MMT to 257.20 MMT), and for Natural Gas, the growth is 0.2%. Electricity growth during the period has been 6.5% (6,12,645 GWh to 11,58,310 GWh)

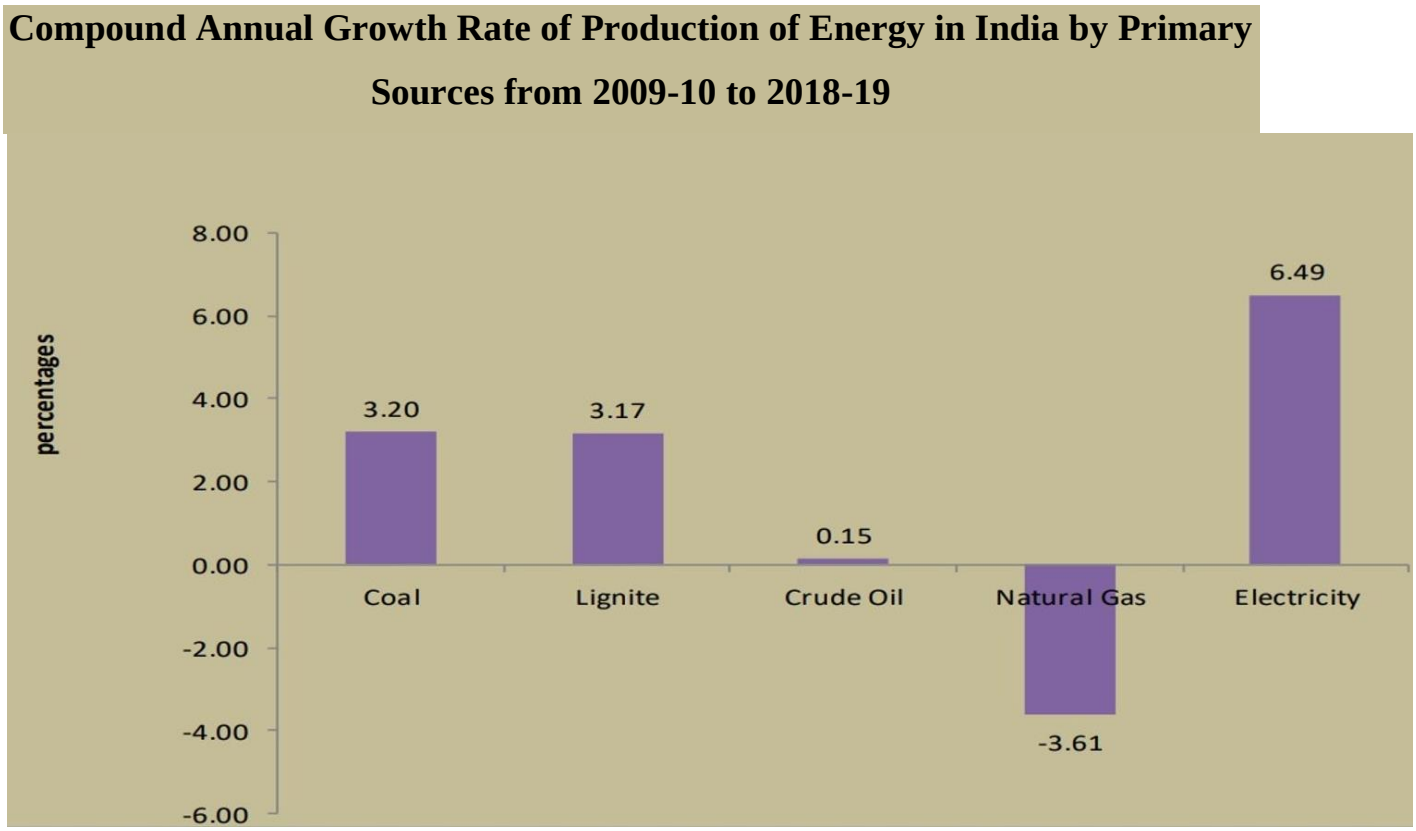


Fig: 1.3

Source: (National Statistical Office, 2020)

1.4 FUTURE OF PETROLEUM PRODUCTS IN INDIA

India is trying to improve petrol and diesel domestic production by increasing the existing brownfield refining capacity every year and building new greenfield refineries (nine metrics per year) and the West Coast (M0 metric per year). India's total refining capacity could reach 401 metric tons per year by 2025 and 443 million meters per year by 2030 (with 255% export capacity added if 554 metric tons added per year), enough to meet India's domestic demand by 2025. Purification capacity (including 25% capacity for export) up to 667 MMT per year.

India's net oil imports are expected to more than double by 2040. Currently, ISPRL with a 40 MMT storage capacity can cover ten days of the current ten days of net import. However, the same volume will cover only four days of net imports in 2040

The intensity of energy will be reduced by more than 30% by 2030 and by about 50% by 2040. The announced policy will improve the power efficiency of energy by 3.3% per annum by 2030.

In 2018, MOPNG introduced a new biofuel policy covering both conventional and advanced biofuels, which transcends the pre-2008 biofuel policy. (IEA, 2020). The planning commission of India, in 2011, predicted a share of energy supply till 2024-25 as given in Table 1.1. The actual source wise consumption up to 2018-19 is shown in Fig 1.4. One can easily decipher that the share of petroleum products, i.e. Oil and Gas is 45% in 2024-25 as per the forecast, whereas it was 40% in 2018-19.

Table 1.1

Share of future energy supply in India (%)

Year	Coal	Oil	Gas	Hydel	Nuclear
1997-98	55	35	7	2	1
2001-02	50	32	15	2	1
2006-07	50	32	15	2	1
2010-11	53	30	14	2	1
2024-25	50	25	20	2	3

Source: Upto 2011 from Technical Note on Energy, Planning Commission, Govt. of India (1998-99). Beyond this period the figures have been extrapolated.

(GoI, 2011)

The actual pattern in 2018-19 is as under:

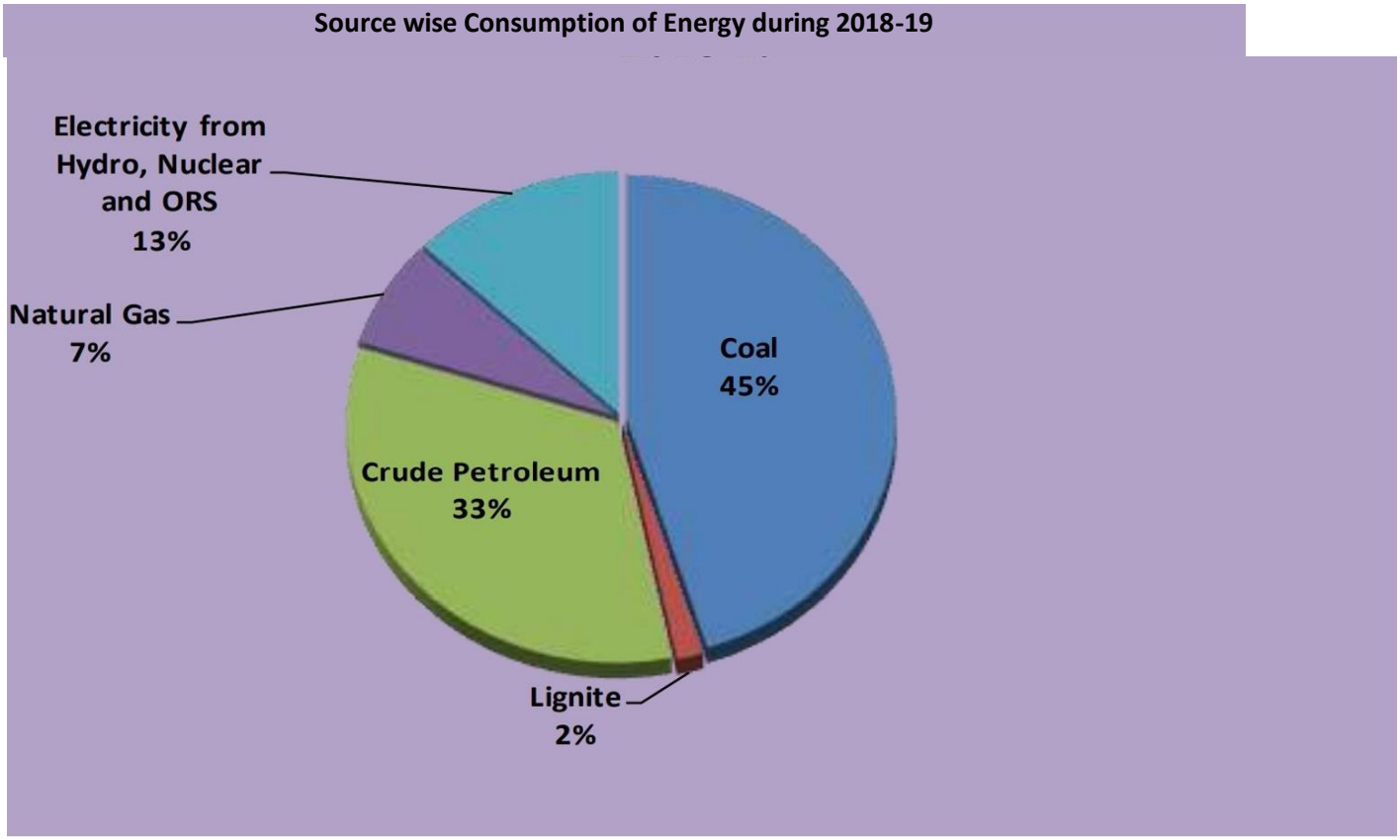


Fig 1.4

Source: (PPAC, 2020)

This table clearly shows that the role of petroleum oils has increased at a higher rate than the predictions.

1.5 THE ENERGY MIX

The energy mix of India in 2018-19 can be represented through Sankey's Diagram, where the energy from various sources has been converted to oil equivalents for easy comparison.

Energy Balance of India 2018-19

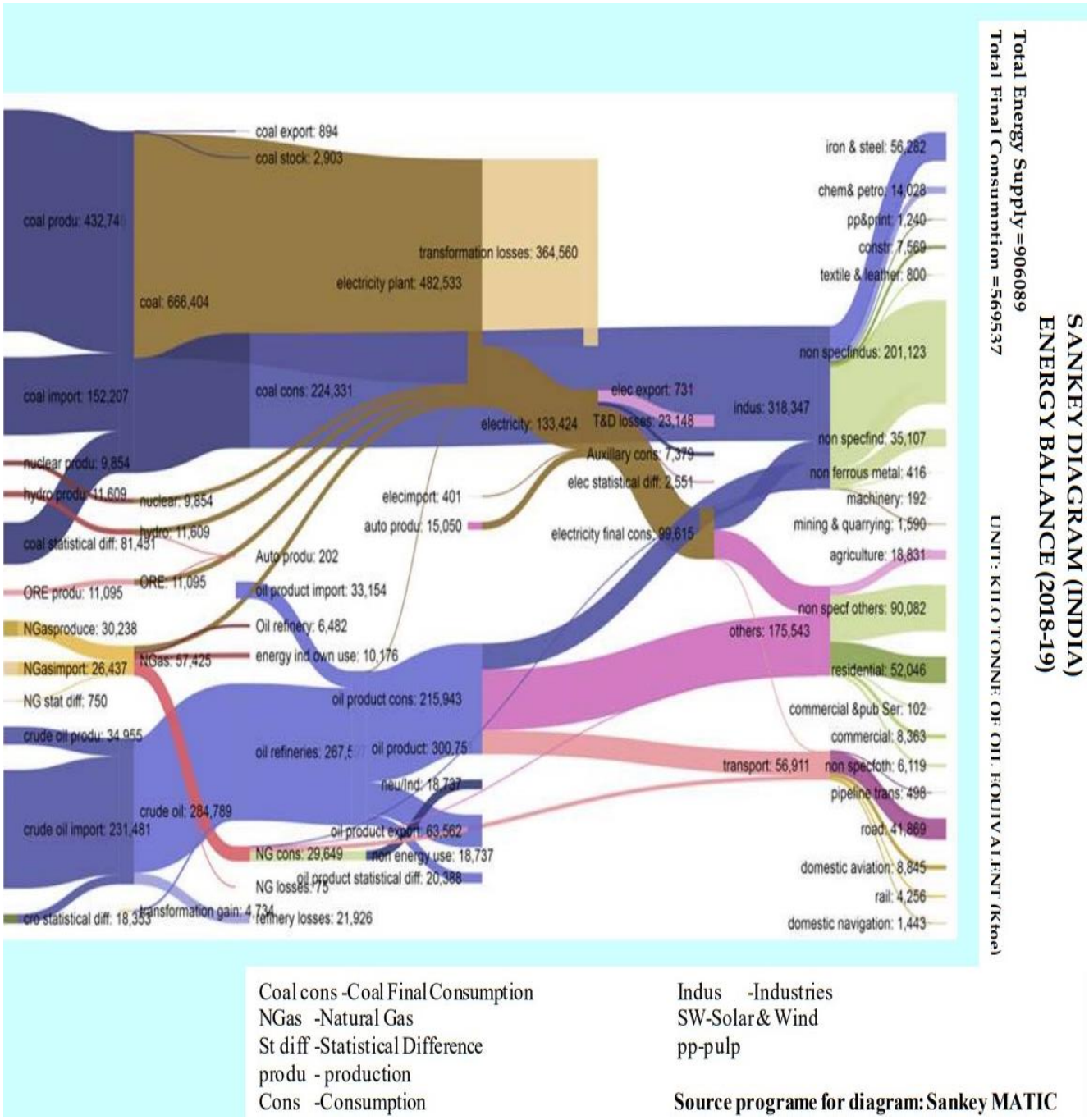


Fig 1.5

Source: (National Statistical Office, 2020)

The distribution of domestic production of petroleum products is given in Fig 1.5. The SANKEY diagram for the year 2018-19 shows that the petroleum products to the extent of 231 MMT are imported, and 35 MMT are produced indigenously. The refineries processed 267 MMT of crude, out of which 216 MMT was consumed, and 64 MMT exported. The transport sector consumed 57 MMT of the oil products, which is 26% of the total consumption of petroleum products. We can conclude that a sizable portion of petroleum products is consumed in the transport sector, and this will continue in the next decade until alternatives emerge more economical.

Distribution of Domestic Production of Petroleum Products in India during 2018-19

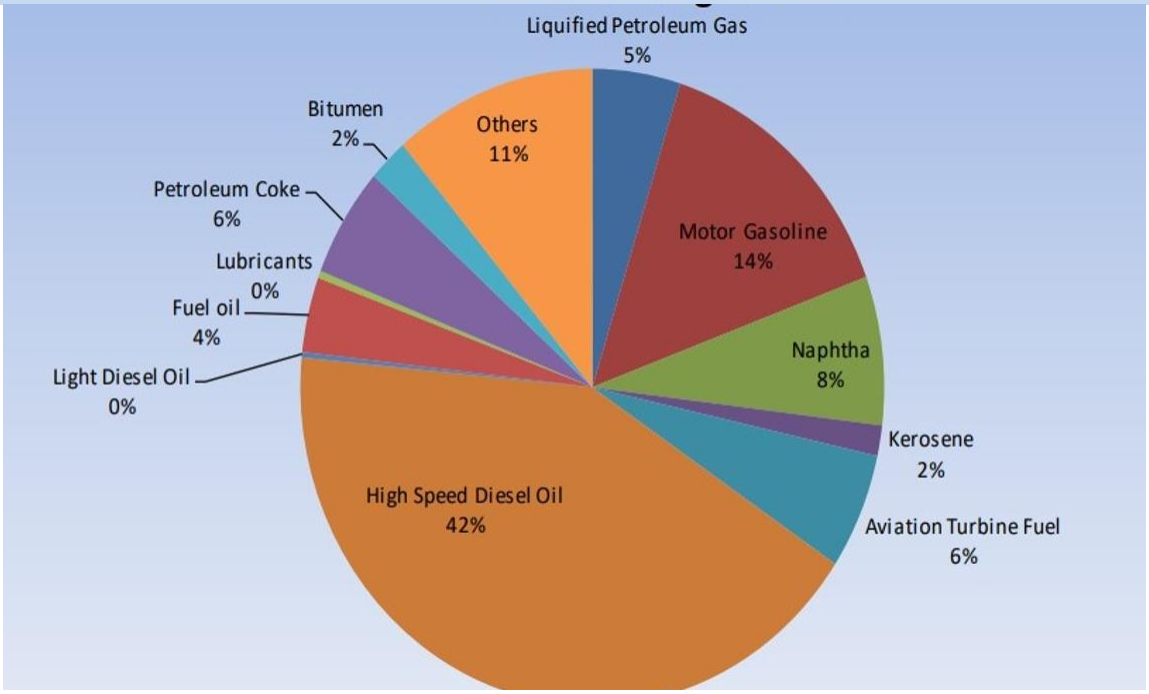


Fig 1.6

Source: (PPAC, 2020)

Figure 1.6 shows the domestic production distribution of petroleum products in India in the year 2018-19. It is noticeable that the auto fuels, i.e. MS and HSD constitute a significant part of it at 14 and 42 per cent respectively.

1.6 REGULATORY AND LEGAL ISSUES

The legislation in India and the world are increasingly becoming stringent towards emission norms, thereby causing disruptions in the product mix of Oil Marketing Companies (OMCs). The Supreme Court of India announced a ban on petroleum coke imports in 2018 as the fuel was considered highly polluting when burned. (GOI, 2021)

The same fuel is used by cement manufacturers, lime kilns, calcium carbide makers, and gasification plant operators, so these were exempted from the ban. This situation has forced the refineries to change their product mix. Over the years, the refineries have constructed and commissioned Coker plants which increase the yield of lighter distillates at the cost of bitumen which is increasingly being replaced by cement concrete in road construction. However, with the reduced demand for pet coke, bitumen marketing became competitive. The supply chain of downstream petroleum products must be flexible to accommodate regulatory and legal disruptions, especially in high emission fuels.

The Supreme Court of India banned petroleum coke and Fuel Oil (FO) by Haryana, Rajasthan, and Uttar Pradesh. Petroleum coke and fuel oil had been banned in Delhi since 1996 to limit pollution, as it has more than 4% Sulphur, thereby increasing the critical pollutant Sulfur dioxide (SO_2) in emissions. The Sulphur content in fuels was limited to 1% in these states.

The refineries had to produce alternate fuels to meet the demand of the industry in these states. The ban was subsequently relaxed for producers of cement and limestone, where petroleum coke is used as a feedstock and not a fuel. Relaxation was also given to power generation companies as they use negligible volume.

The demand for petroleum coke was growing for many years. Most of the supplies were coming from imports. Initially, the import duty on petroleum coke raised to 10% from 2.5%. The industries which use cheap fuels, such as garment factories, paper mills, brick kilns, and ceramic manufacturers, were affected by this ban. This relaxation to heavy users like cement manufacturers, who account for about 75% of demand, gave substantial relief to the refineries as otherwise the market could have been eliminated.

1.7 ENERGY SUBSTITUTION

India has plans to shift its road transport sector towards an electric vehicle (EV) fleet by 2030. A target of 30% EV fleet by 2030 has been set up. This shift will certainly affect the long-term growth of auto fuels. The policies offer incentives to achieve the target through subsidies, tax holidays, Hardware standards, and building regulations. FAME II dedicates 10% of the budget to install charges at public places in cities and highways. Heavy investments will be needed in the auto-industry chain and power supply chain to achieve the target for EVs. According to the IEA, to meet a 100% EV target, India would need to have 46 million light-duty vehicles in its fleet by 2030, compared with the 5 million in the global fleet of EVs in 2018. If trucks, buses, and motorcycles are also included, the total for India rises to about 127 million EVs. (Sharma S. S., 2019)

India had about 300 community vehicle charging stations across the country compared to about 65,000 retail fuel stations by mid of 2019. This data shows that the infrastructure to support an electric fleet is minuscule and needs to ramp up in a big way. The setting up of a power distribution system for EVs is a challenge for power companies. The early adoption of home charging or public charging stations can draw an enormous amount of electricity at a given time since there will be a move towards faster charging. Car manufacturers have moved quickly to meet the government's initial 2030 targets. Maruti Suzuki, Honda, Toyota, Kia, and Ford are building lithium-ion battery factories and EV manufacturing plants. However, the charging infrastructure and reliable electricity supply remains a challenge, but the general sentiment is that they want to see more action from the government to make electricity supply reliable and charging stations available

It can be concluded from the above discussion that petroleum fuels will remain significant components of the energy mix for the next two decades.

1.8 POLICY FRAMEWORK

India has vast reserves of coal, which are the world's fifth-largest, but sustainability concerns restrict their use in the energy mix. The government plans to produce methanol from coal, stranded gas, and biomass. There is a proposal for introducing a 15% (M15) methanol blend with gasoline and a 100% (M100) use of methanol for large vehicles to reduce pollution and fuel costs. Domestic methanol capacity needs to be augmented to further the proposal. Methanol processing plants are

in the pipeline for this purpose. There will be a need to modify the country's entire fleet. Hence it can be carried out in a phased manner. (GOI, 2021)

1.9 BIOFUEL POLICY

The ethanol blending in Motor Spirit (MS) has been practised in India since 2013. The blend ratio was 5% which has since been increased to 10% without needing a change in the vehicle engines. The Oil Marketing Companies have been mandated to sell ethanol-blended MS (EBMS). With a target to achieve an average 5% ethanol blend rate across India. Ethanol availability has been a challenge due to competing demand for ethanol from the potable alcohol industry. The ethanol blending has shown marked improvement in the last three years. The program has been extended to the whole of India except the Union Territories of Andaman & Nicobar Islands and Lakshadweep. Table 1.2

A new Biofuel Policy has been formulated in 2018, which increased the feedstock scope of the distilleries. Earlier the ethanol was produced mainly from sugarcane molasses. With the new biofuels policy, they can use sugarcane juice, sugar beet, Corn, Cassava, and damaged food grains. This dependence on molasses. The Government of India has fixed the prices of ethanol from various sources to increase the blend ratio. This step will encourage the distilleries to increase their production volume and supply more ethanol to Oil Marketing companies. Imports of ethanol imports for fuel blending are not allowed. However, in the new policy, the import allowed for non-fuel purposes. (GOI, 2021)

OMCs have been allowed to blend up to 5% biodiesel with high-speed diesel (HSD) since 2005. The actual blend rates have remained very low due to various economic and agricultural constraints. Various issues like land availability competing with edible grains and high plantation costs can be attributed to the low offtake. The new biofuels policy used cooking oil (UCO), tree oils, and partly animal fats have been allowed along with non-edible oilseeds. India's government has an indicative target of 20% blending of ethanol with gasoline and 5% blending of biodiesel with diesel by 2030.

Table 1.2

Ethanol Blending in India from 2016-17 to 2018-19

Particulars	Ethanol Supply Year *			
	2016-17	2017-18	2018-19 (P)	2019-20 (P) (Dec 2019-June 2020)
Ethanol received by PSU OMCs under EBP Program (in Cr. Litrs)	66.5	150.5	188.6	96.9
Average Percentage of Blending Sales (EBP%)	2.0%	4.2%	5.0%	5.1%

***Ethanol Supply Year :** Ethanol supplies take place between 1st December of the present year to 30th November of the following year.

Note: With effect from 01.04.2019, EBP Programme has been extended to whole of India except UTs of Andaman and Nicobar Islands and Lakshadweep.

Source: (PPAC, 2020)

1.10 GST IMPACT

The introduction of the universal Goods and Services Tax (GST) across India in 2017 revamped the tax structure on many oil products. The national GST rates of 0%, 5%, 12%, 18%, and 28% were applied to products and services, replacing all the central and state taxes. However, crude oil, MS, HSD, and ATF were kept outside the scope of the GST for the time being. The previous customs and excise tax structures for these petroleum products remained unaltered. The central government has exempted these oil products from the GST to protect state governments' revenues, as the VAT on the fuel accounts for 30-40% of state tax revenues. The oil products shifted under the GST regime were kept at an 18% slab except for subsidised SKO and LPG, which enjoyed a lower tax rate of 5%. (Haripriya, 2017)

The significant issues with the OMCs regarding the non-availability of credits on inputs, thereby increasing the input costs. The central government retains the right to eventually bring all oil products under the GST and set aside a GST schedule for these fuels. The dual tax structure will increase the costs of compliance for the OMCs. The case of non-GST oil products that include auto fuels is such that the oil company pays GST on procurement of goods and services procured but cannot get the credit on the sale of finished products.

1.11 AUTOMOBILE MARKET

Vehicle sales performance has witnessed double-digit contractions observed across the car, motorcycle, and trucks. The slowdown in sales began in mid-2018, following an increase in insurance premiums, tax on vehicle components, and the rising cost of loans from interest rate

adjustments. The situation worsened in 2019 due to the slow growth of the corporate and manufacturing sectors, financing issues and migration to Bharat Stage VI (BS-VI). The introduction of BS-VI auto fuels required a change in the engine design to keep the emissions within norms. However, the sale of utility vehicles grew despite a slowdown in all other automobile segments. The COVID-19 pandemic has marred the revival of the automobile sector.

1.12 REGULATIONS IN DOWNSTREAM PETROLEUM INDUSTRY

MOPNG has powers to regulate the downstream market monopolistic behaviour, ensure access to distribution infrastructure, regulate prices and standards as per the rules set by the MOPNG. (MoPNG, 2021). The government maintains control over private participation in SKO and LPG markets, LDO imports, foreign investment limits in state-owned refineries, and subsidies on domestic LPG and kerosene.

Public Sector Oil Marketing Companies retain overwhelming retail fuels market share despite waiver of HSD subsidies in 2014. Private sector companies could not compete with them before 2014 as they were not eligible for subsidies. The deregulation of diesel prices in 2014 has allowed private retailers to revive their retailing operations.

The import of MS, HSD, ATF, and SKO was restricted to public sector oil companies or licensed retailers. However, the refining capacity of private retailers is more than their fuel sale, so they do not exercise this option. Some industries beyond the petroleum sector are also permitted to import fuels directly on discretional government approval. Civil airline carriers can import ATF. Companies in the automobile industry can import small volumes for research and development purposes. The government of India has reduced the entry barrier for automotive fuel retailing in India. (MoPNG, 2021)FO and Naphtha can be imported in certain volumes without the custom duty to support the fertiliser plants and, in turn, the farmers. There is no customs duty on crude oil, LPG, and lubricants.

1.13 PRICING OF AUTO FUELS

There are no official price controls on most major oil products. However, the prices of OMCs in the public sector are set using a pricing formula. Private retailers are free to set their prices. OMCs

include IOCL, BPCL, HPCL, and their subsidiaries. The pricing formula is linked to regional market spot prices on an import parity basis on the moving average of the last 15 days. The formula includes import cost components, such as ocean freight and customs taxes-despite nearly all demand for oil products. Pricing of auto fuels, MS, and HSD has been changing daily since 2017. (PPAC, 2021)

This pricing mechanism led to reflect better changes in international crude oil price movements and costs. This method allowed OMCs to avoid any possible distortions in retail margins caused by delayed price adjustments or inventory management practices by retail fuel pump owners. Before this, the prices were changed on a fortnightly basis. The retailers could manage their inventory expecting price rise or fall, which was evident from the crude oil prices in the international market.

Before deregulation, the HSD subsidies were the cause of under-recoveries. The central government and state-owned upstream companies used to share the losses. The government now extends subsidies to only SKO and LPG. The subsidies in LPG are given through the Direct Benefit Transfer (DBT) scheme. The DBT scheme transfers the fuel subsidies directly to the bank accounts of the beneficiaries. The LPG consumers purchase LPG at the market rate, and the government subsequently transfers the subsidy amount directly to their bank account. The DBT for LPG was launched nationwide in 2015. India's Automotive Fuel Policies: Evolution and Challenges (Bhatt & Roychoudhary, 2021).his has limited the petroleum subsidy diversion to non-target markets and has also reduced government expenditure.

1.14 TAX STRUCTURE

Auto fuels are subject to customs, central, and state taxes. These have not been included in the GST regime. Customs and central taxes are set and collected by the central government, while state taxes are determined and collected by the state or municipality governments. The customs duties are Basic Custom Duty, CVD, Additional Duty of Customs (SAD), Additional Customs Duty instead of Sales Tax/ Value-Added Tax (ADC), Basic Excise Duty, Road, and Infrastructure Cess (RIC), Special Additional Excise Duty (SAE) (GoI, 2021). The state taxes include Value Added Tax (VAT), Toll Charges, Permit charges. State taxes are charged on top of central taxes and can vary among the states. The tax is set either on an ad valorem basis or a mix of ad valorem

and fixed-rate bases and can amount to a fifth of retail pump prices. With state taxes generally set on a percentage basis and charged after central taxes, any increases in central taxes will also affect state taxes.

The customs duties on oil products mostly move along with the excise duties so that the government can collect equal taxes on an imported oil product as in the locally produced counterpart. The CVD, SAD, and Additional Customs on MS and HSD are equal to the sum of their Basic Excise, SAE, and RIC tax counterparts. However, the Basic Customs Duty adds cost to imported oil products. This duty reflects the government's desire to limit oil product imports to rein in its already high dependence on crude oil imports and a devaluation of the Indian rupee. National Calamity Contingent Duty (NCCD) is levied on the crude oil imports to support India's National Disaster Response Fund and a cess tax of 20% to support the Consolidated Fund of India and the Oil Industry Development Fund. (GoI, 2021). The current rates of excise duty & GST in various petroleum products are given in Table 1.3

Table 1.3

Customs, excise duty & GST rates			
Product	**Basic customs duty #**	**Excise duty**	**GST rates**
Petrol	2.50%	Rs 32.98/Ltr^	**
Diesel	2.50%	Rs 31.83/Ltr^	**
PDS SKO	Nil	Not Applicable	5.00%
Non-PDS SKO	5.00%		18.00%
Domestic LPG	Nil***		5.00%
Non Domestic LPG	5.00%		18.00%
Furnace Oil (Non-Fert)	5.00%		18.00%
Naphtha (Non-Fert)	4.00%		18.00%
ATF	5.00%	11% *	**
Crude Oil	Rs.1/MT+ Rs.50/-MT as NCCD	Rs.1/MT+ Cess@20% + Rs.50 /-MT NCCD	**

Source: (PPAC, 2020)

1.15 SECONDARY LOGISTICS:

The last mile of the PSC is Secondary Logistics, and in North India, it is carried out by the road. The tank trucks can deliver products to the remotest part of the country wherever the motorable roads are available. However, the tank trucks are dedicated and are contracted to a specific OMC. The tank trucks used in white oil, i.e. MS and HSD, cannot be used for black oils (LDO, FO, LSHS). These tank trucks ply under a long term contract (3 to 5 years) with OMCs and are attached to a specific terminal for daily supplies to the linked markets. Auto Fuels are measured on a volume basis, and the tank trucks have fixed capacity. The Legal Metrology Department calibrated and certified the capacity of each tank truck, and PESO (Petroleum and Explosives Safety Organization) approves the safety and design features to ensure the safety of hazardous goods carried by them. (Singh & Joshi, 2020) The secondary logistics is inflexible as the count of tank trucks engaged are fixed under long term contracts, and their carrying capacity is fixed. Hence, these cannot cater to the highly fluctuating seasonal and daily market demands of auto fuels. The demand increases exponentially during harvesting or festival seasons and dips drastically during monsoon. The transporters are paid on a round trip basis as they have to return empty after delivery to the source terminal.

The strategic decisions during the secondary logistics include the location of Terminals for storage of product, choice of transporters, the count of tank trucks to be hired and their capacities. The operational level decisions of planning and scheduling are taken on day to day basis. The contract between OMC and transporter has provisions of eliminating malpractices like adulteration and fast delivery, tampering with fittings, deviations from the prescribed routes and others. The custody of the product shifts from OMC to the transporter. The transporter delivers it to the customer in the correct quantity and quality. (Singh & Joshi, 2020) .The performance parameter for the transporter is to deliver the right quantity with a reasonable time limit while maintaining the safety of handlers and the public. The selection of secondary logistics framework first requires identifying factors for optimisation and determining the relative weight of the specified elements. Hence the problem here is essentially multi-objective so that the logistics delivers the objectives as per company strategy and brings competitive advantage to the supply chain.

Logistics costs are controllable and significantly contribute to expenses in the oil industry running on low margins. The Oil Marketing Companies (OMCs) are using various models for optimising primary logistics. Till recently, the secondary logistics optimisation has been limited to supplies from the nearest available source having the least cost. Secondary logistics optimisation shall be a key distinguisher in the service delivery of OMCs.

The objectives of the channel partners have to be considered and balanced while constructing optimisation models for secondary logistics and aligned with the company's strategy. The study has been limited to the automotive fuels, MS and HSD, sold through retail channels of OMCs, which affect the day-to-day life of the Indian consumers. North India is farthest from the sea, so it is more dependent on surface transport. It has high volume sales and high complexity, so the model developed here may be applied to other areas with suitable modifications.

1.16 SUPPLY CHAIN MANAGEMENT

SCM is a network of infrastructure and distribution options that perform procuring raw materials, transforming these materials into finished products, and ending up distributing these products to customers. SC is in service as well as product producing companies. The complexity of SC varies from industry to industry (Hugos, 2018).

Definitions of SC are more common than the definition of SCM (La Londe, 1997). The SC is a chain of firms that carries the items from source to manufacturing to customers. Many independent companies are involved in the production of products and bring them to the end-user. The component manufacturers, importers, retailers, wholesalers, and transportation companies are all part of the supply chain. (La Londe, 1997).

SC includes all the functions related to the forward movement and conversion of goods and information from SC partners to the end-user. Strong relationships among the partnering firms are required to achieve a competitive advantage for the SC. The SC is prevalent from the customer to their customer and from supplier to their supplier, including service providers. The business environment is changing rapidly and increasingly in the business world to provide quality products and fast service. The SCs have to offer higher value and deliver the services and goods at the right

place. It consists of all the events that start from raw materials and spare components until the final product reaches the customer. The functions of the firms involved have to work towards the overall benefits of all the stakeholders. The activities have to be integrated and synchronised so that higher value is delivered to the end customer.

SCM partners require building solid bonds and maintaining these for an extended period to garner higher value for the customers. There should not be too many partners to make the SC unmanageable. The information, money and material flow must be well planned, designed and controlled for the ultimate objective of providing superior value to the customer. The small number of partners lead to increased cooperation among the organisations (Cooper, 1997)

1.17 EVOLUTION OF SUPPLY CHAIN MANAGEMENT

SCM has evolved gradually over the last century. There have been three significant transformations in the study of SCM. These have been contextualised because of technological and economical changes in the world. SCM has become increasingly popular over the past decade (Cooper, 1997). The number of sessions with the same terminology in 1997 reached 22.4%. from 13.5% in 1995 in the Conference of Council of Logistics Management. (La Londe, 1997). SCM has become so ubiquitous that at any given time, there will be an article on SCM topics or SCM related topics in all the journals on design, distribution, marketing, customer management, or travel (Ross, 1998)

Consider the official statement of one car company CEO: Our target is always to organise items and machine to make the operation easier so that there are no orders. Our finished goods stock is on its way, and our raw materials are also in transit. Henry Ford once said that their production process was about 81 hours from the mine site to the finished product, i.e. the freight car. From this statement, it is clear that this company has a well-integrated SC that reduces the cost to a minimum and increases efficiency to the maximum. The change was astonishing as a company could achieve this 100 year ago. The result sets standards for managers for the entire world. There have been three significant transformations in the SCM.

First Improvements (1910-1920): Ford's SC was the first transformation by the Ford Motor Company as they managed to maintain a good SC network. Ford owned every piece of SC from

wood to the railways. They managed the journey from mine to the car completed within 81 hours with their all-encompassing SC. There is a saying, "Ford could offer any colour, as long as it is black."

Ford Motor Company manufactured and managed to build a large SC having high productivity but was characterised by inflexibility. SC could not provide different products, and such a model could not last for a long time. On the other hand, General Motors could understand the market's needs and offer a wide range of vehicles in various colours. Ford's supply chain did require a long time to set up and, once set up, needed considerable effort to change. It worked with a large stock in the SC. All the firms in Detroit were vertically integrated. Even in India, all the organisations did all the products within their ownership. (Toyota, 2021)

Toyota Supply Chain led the second transformation (1960-1970). The manufacturing industry had seen several changes, including progress in customisation as per the customers' requirements. To cope with these changes, companies needed to reshape their SCs to make them more flexible and efficient. The SCs required to handle different types of products without extensive product holdings. Toyota had successfully addressed all of these concerns, thus leading to the second transformation in SCM. Toyota Motor Company came up with the idea that allows the final assembly done in the factory, whereas most parts were procured from outside. Most of the features came from a large number of partners called Kireitsu. Keiretsu is a system by which companies hold long-term business partnerships and shares. Toyota Motor Company had a long-term relationship with all part supplying companies. These companies were stationed in the vicinity and provided to the Toyota factory where the pieces were assembled. The manufacturing process time was significantly reduced, and relations with the suppliers played a key role, and the meagre stock was required to be maintained. It was a marked shift from the Ford SC, where all the manufacturing, transportation activities were carried out in-house.

The Toyota system had some problems at the end of the century. Gradually, when Toyota and other Japanese companies tried to establish a plant in various places of the world, they found out that they required their supply partners to move with them. Some of them had become less cost-effective. With the information technology available, the exchange of data became fast and easy among the firms. It was now possible to exchange the electronic data among firms, and companies

could connect suppliers without forcing them to relocate. In practice, Toyota SC had inflexibility in their systems, such as a permanent relationship with the supply partners., which became a drag on the company over time. (Toyota, 2021)

Dell Computers led the third transformation. It made such changes in the SC, which gave its customers the luxury of choice by using flexible supply partners. The transformation took place in 1995-2000. The customer of Dell could choose their components in computers. Each of the computers of Dell was tailor-made for the customer, and its partners were not in a long term relationship with Dell. Dell believes that it and its global service providers will also leverage their technology and have affordable prices in their region. Dell maintains customer relationships with their customers wherever they are. Due to advances in IT, Dell can interact with its suppliers electronically, even if only temporary partners.

The product in the market is made to order of the customers at Dell. The process is not based on forecasting. This concept helped Dell to reduce inventory and allow them to respond more quickly to any changes in the market.

Since their suppliers in contact by electronic means, they do not want inflexibility in SC. Dell did not find any benefit in finding suppliers close to their assembly plant. (Toyota, 2021)

Information Technology made it possible to integrate the partners who were not in long term association with the firm. The firm could move from a single product to several products customised as per the customers' needs. The ownership pattern has migrated from wholly-owned SCs to SCs of partners having long term relationships. Then it moved to short term networks enabled by IT. Information technology led to the Third Revolution, and the exact nature of the Third Revolution is still being defined. It will probably take a few years before the process is fully understood and applied in practice. As mentioned in this discussion, these three major transformations in SCM have resulted in vibrant economic and marketing progress. Rapid advances in technology, the process of economic transformation, and its paradigms have encouraged growth and expansion. This system has forced companies to find the best and most efficient way to manage the supply chain. (Varma & Khan, 2014)

Companies around the world are looking to use an innovative approach as a strategy for high growth. The output is the high level of performance, which is adding value to the customers.

Quality: the quality of products and services should be fit to use, and the quality of the product is measured in quality failure per million of products manufactured. More than half of the defects are due to the procured items.

Cost: The firm aims to optimise the cost of factors of production. The inventory and transportation are major cost elements and need to be optimised.

Time: All non-value-added for the total cycle time needs review. Every aspect of the firm's activities needs to be examined by eliminating time-consuming and wasteful activities from the process.

Technology: There are two primary responsibilities of technology SCM. It has to provide the right technology and provide in such a way that makes the firm unique. These are carefully handled and monitored when dealing with outside suppliers and customers.

Reliability of SC: The supplier network has to be developed and overseen to reduce the chances of disruptions.

The organisations need to understand the need for SCM policies to impact the success of companies positively. SCM is one of the main tasks of an organisation: SCM's overall goal is to affect the company's profits positively. Although it involves a lot, the purpose of SCM is briefed hereunder :

1. Provide an uninterrupted flow of material and service needed to manage the company.
2. Keep inventory to the lowest.
3. Maintain quality and improve. Find and develop a competent supplier. Buy the necessary materials and services at a meagre overall cost.
4. Improve the competitive position of the organisation.
5. Achieve a harmonious and productive relationship within an organisation.
6. Reduce administrative costs in purchasing and marketing.

Based on the functions of sales, distribution, planning, manufacturing, and procurement, companies across the supply chain worked independently with bare essential communication.

These had their performance objectives, which were, conflicting. For example, high customer service and the highest sales intent are the opposite of its production and distribution intent for obtaining the lowest price. The production function is designed to maximise output at minimum expenditure. The stock levels and logistics capabilities were not taken into account while designing infrastructure for production. The buying process was not having enough information about the previous record of such deals. There was no overall view of the firm as a whole. These conflicting goals were that there was no integration among various activities involved in an SC. There are several reasons for the popularity of the supply chain concept. The drivers are

1. Global sourcing
2. Time and quality-based competition
3. Environmental uncertainty

   The firms get their raw material and components from all over the world. This global SC has forced companies to look for more efficient ways to manage physical goods and data. The relationships with raw material and component sourcing firms play a critical role in the SC. These SCs are competitive based on time and quality. The aim is flawless production; delivering faster and more reliable than the competition is not seen as a competitive advantage, but something essential for the firms to exist in the market. Customers now expect the product to be always shipped quickly, on time, and without any damage. Fulfilling customer expectations requires integration among firms sourcing goods and components and distributors. This output and performance-oriented market and transformation in finance and technology functions have resulted in higher risk in the market. The higher risk does not augur well with the inflexible SCs. The changeability is the key to SC integration and relations (Mentzer D. K., 2001)

Information Technology (IT) makes it possible to have this type of coordination among the SC partners :

The below are the components for SCM:

1. Plan: This is the first step in SCM. One needs a plan to manage all the resources and reach out to meet consumers' needs. The planning includes building a system to evaluate the

supply chain to make it more efficient and cost-effective to deliver quality products with efficiency at a minimum cost.

2. Source: The choice of suppliers is an important decision, who can be relied upon to provide the products and services necessary to create the final product or service. The decision process includes setting up the parameters for pricing, delivery system, and payment method with the suppliers and the procedure to check and improve the relationship. The decision also includes the integration process for product management and services from product suppliers, including receipt, inspection, delivery to the manufacturing company, and payment to source firms.
3. Make: Conversion of raw goods or components to finished products includes scheduling, testing, packaging, and preparing for delivery. This part of SC is a critical part of the chain, as it requires quality control, volume measurement, industrial relations and asset management.
4. Delivery: This part is referred to as "logistic", which involves the coordination of receipt of the order from the customer and set up an invoice system to take payment.
5. Return/Reverse Flow: A portion of the goods or packages, or containers must move back to the manufacturer. Feedback is also required regarding improvement in manufacturing or logistics functions. (Mentzer & al, 2001)

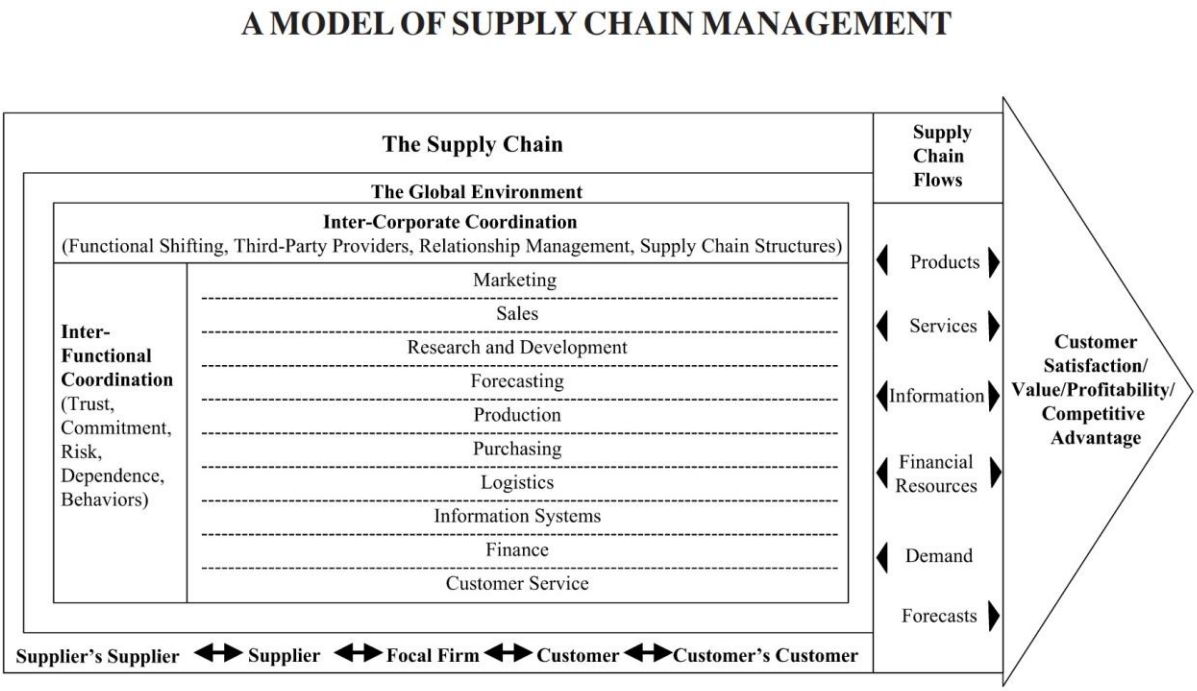


Fig 1.7

Source: (Mentzer & al, 2001)

Important for SC in the past was not so pronounced as customers demand was more than the supply. The competition was less. In other words, companies could ignore supply chain issues. The focus was on production, and customers would fight for everything available in the market. Today, companies that do not articulate their SC well will lead to higher product prices and eventually dissuade many customers from buying. The right product will not be found in the right place. Instead of companies, the SCs are competitive and determine the fate of firms involved in them. (Lambert, 2008) A typical model of Supply Chain Management is given in figure 1.7. This model depicts that the supply chains have to operate in the global environment and have to co-ordinate with the channel partners based on Trust, Commitment, Risk, Dependence, and Behaviours in functions of Market, Sale, Research & Development, etc. (Shsh, 2009)

The major trends in supply chain management are as under:

1. Product variety: The company is increasingly recognising that customers need customised products to meet the growing customer needs, especially young people. Each time a customer

enters a storeroom, he or she will notice some of the items on the shelf which were not present during his or her last visit. There are many options to choose from when visiting any neighbour's store. One is not to be surprised to find everyday products like toilet soap comes in 50 different shades. The number of Stock Keeping Units (SKUs) determine the level of customisation offered by the firms. Big multinationals such as HUL keep an average of 1,200 SKUs in self-care products. The retailers are bound to keep variety or face loss of business. (Lambert, 2008)

2. Shorter life cycles: In fierce competition, the product lifecycle becomes shorter as competitors compete to add additional characteristics to their product and appearance. A company PC is a perfect example of a product portfolio where it is like six months. In other words, Dell only has seven days of stock in the industry, where the industry standard is 35 days. Its competitors have a high cost of unsold inventories. Earlier, in developing countries where growth rates and consequent inflation was high, these stocks were the source of profit. However, with the rise in management and short-term product life, companies will have to organise their product portfolios, accounting for the shorter product life cycle. Half of the money comes from the items launched within the last three years in the IT industry. (Shah, 2009)

3. Outsourcing: The companies focus on the core activities. The other functions are delegated to other firms who are more competent and cost-effective to carry out those functions. Michael Dell once said that if his company had to be carrying out all the tasks in the house, it would need five times as many employees. The telecom companies in India are also working on a model where the Network, IT and CRM (Customer Relationship Management) have been outsourced to other organisations. (Shah, 2009)

4. The shift in power structure: Companies that are close to the customers are getting stronger. There is jostling among brands for the shelf space as organised retailing has become a power centre in the entire SC. There have been times when marketers have asked for an opportunity to introduce new products to the market, and retailers have asked for shelf allowance. There is an apparent change in power inside the supply line. The retailers have realised their potential and expect manufacturers to respond to their needs. A business leader in retailing like Wal-Mart can source the products at competitive rates. Manufacturers are forced to adapt and react quickly to customer requirements due to changes in power within the chain. (Lambert, 2008)

5. Globalisation of manufacturing: Tariffs have been reduced, and many companies are rebuilding their manufacturing facilities to meet world standards. Traditional firms often use their local ingredients, produced locally and sold locally. The SCs are not worldwide, sourcing the goods or components globally, e.g. in Telecom, the chips are from Taiwan, tested in Europe, and assembled in the US to sell in international markets. This global sourcing has led to a complex management link in the supply chain. Unlike information and budget systems, which can be controlled by electricity, goods and products will move physically. Since this movement can cross the continent, managing the supply chain is a critical issue right now. (Chopra & Meindel, 2002)

1.18 DECISION MAKING IN SUPPLY CHAIN MANAGEMENT

Strategic decision-making in the SCM is associated with a long-term impact. The selection of time, place, and level of new construction are long-term decisions. These decisions require information on forecasting for manufactured products. Dynamics of sales, differences in demographics and raw material or component location have to be considered. The SC plan has to take into account the time frame and chances of failure. The timeline needs to be identified for the implementation of the plan and the risks involved. The decisions may be categorised into strategic, tactical and operational. The decision-making process, which is usually as long as three years or more, is strategic. These are closely linked to the organisation's organisational structure, which thinks and directs drawing the policy through the design concept. (Mentzer D. K., 2001)

The decisions, which are short-term and focus on day-to-day works, are termed operational decisions. At the same time, the tactical decisions are placed between the two. These decisions are to keep things in perspective and facilitate the movement of goods and data as per the approved SC plan. The SC strategy emanates from the overall business strategy of the organisation. The decisions regarding the site of facilities, manufacturing, stock levels and logistics are strategic. The spatial statement of SC infrastructure. e.g. the factory, stock points, etc., is a strategic decision.

Stock levels are to be decided all along with the SC. The logistics mode is to be ascertained for the movement of materials, information and finished products. These decisions cannot be taken in isolation as these are interdependent. Various techniques are used to analyse the data and to arrive at such strategic decisions. The models used for diagnosing have to be selected meticulously as

per the industry. Weekly predictions, distribution and movement, manufacturing planning, and inputs planning are some of the decisions made at a tactical level. These decisions are taken for the medium term.

The operational decisions are short-term decisions made on a daily workday. The boundary between these levels is not precisely defined. The design process of SC strategy will be based on and will fit into the overall business strategy. The firms have to follow the same goals and objectives as described in the business plan. The misalignment is detrimental to the organisation. (Sunil Chopra, 2013)

The primary decision areas in SCM:

Location decisions: The spatial distribution of production stock points and raw material input infrastructure are the first steps in the making of SCM. The statement and construction of the infrastructure have significant capital requirements over a substantial period. Once the capacity, number, and location of the infrastructure are decided, the distribution channel will be determined to be delivered to the end customer. These decisions are crucial for the company as they represent an essential strategy for evaluating customers and clients. These have a considerable impact on their income, value, and level of service. Hence the optimisation is widely used in these decisions. The various cost elements like manufacturing expenses, capacity limitations, demand uncertainty are factored into the models. (Sunil Chopra, 2013)

Operational Decisions: This decision-making process answers questions such as what to do, which plant to create, which providers to choose, and where to send the product. These decisions have a high impact and decide the route for the movement of goods and services. (Sunil Chopra, 2013)

Inventory Decisions: These refer to the organisational policy as to how the stocks will be managed. The reserves are existing at every stage of procurement, manufacturing and distribution. The primary purpose of the stocking is to improve the reliability of supplies to the next step and

cater to the fluctuations in supply and demand. Variations are present at each supply level, such as equipment spares, ongoing work, or finished goods. The inventories constitute 20-40 per cent of the cost of production and are very significant. These decisions are crucial and determine the level of customer service. (Altekar, 2008)

Business strategy: Managers can rethink their approach to marketing strategies. This process involves identifying the customers that need to be focused on and displays the performance and manufacturing functionality to benefit the customers. The development of this first-of-its-kind ability to work in the first place must be developed and empowered. Differentiation is defined as a way for a company to build a sustainable advantage over the competition. Performance objectives need to be fixed, and time-critical needs are identified so that managers can monitor the company's progress to achieve its objectives. The process of giving is something that needs to change as you want and implement these goals.

Effective management and supply chain strategy performs the following:

1. To ensure that the firm's operation and chain of supply excel invaluable performance parameters by the firm's target customer segment.
2. To ensure that decisions regarding the firm's operation and chain of supply are strategically integrated with the firm's business strategy.

(Larson & Halldorsson, 2004)

Planning: Teams should develop strategies or approaches that will help them guide what they want to achieve in their marketing efforts. These strategies are not the same as having a plan, and having a marketing plan is not enough to sure success.

The pattern of actions is essential to have an SCM plan, but it is also important to implement one in practice. What is done on the ground will determine whether the plan will be successful or not. The company's code of conduct reveals the company's good intentions, but the execution is the key.

Portfolio of supply chain capabilities: A company's unique ability to manage its supply chains and achieve the performance levels envisaged in terms of cost optimisation, quality management, and performance management determine its competitiveness. The administration has to identify

and emphasise those core competencies unique to it and cannot be replicated by the competitors. The company may have the capability to produce cheaper products or differentiated ones.

Programs of improvement: These are the programs for goal-setting. The company wants to find technologies to reduce manufacturing costs if competitors can offer products at lower prices.

Performance measurement: Managers need procedures to monitor how their company is performing to achieve its objectives. For example, if the business has developed a fast delivery system within the company, they need to measure delivery time. It is essential to look at the supply chain performance as a whole. Companies are developing this type of thinking that will be successful in the market. SC makes it attractive to companies that offer products or services to customers faster and add more value for the customer depending upon their usage.

There are four functional areas to provide value addition to the customer :

Quality: The concept of quality should be subdivided into the following categories:

Confirmation: Was the product created, or was the service performed for standard specifications? Combination qualities include the degree of purity, the weight, amount of a product.

Reliability: How long will the product work without failure or maintenance requirements? Does the service perform consistently over time?

Durability: Does a product like a temperature level or rough management prevent adverse conditions? What is its "expected life"?

Safety: Was the product or service safely designed? Safety is paramount when handling hazardous products such as petroleum. The whole supply chain is built around strict safety standards as the products are combustible and explosive.

The importance of these parameters will vary from customer to customer and from team to team. The key is to determine the right mix according to the needs of its customers. A customer base can be more interested in the reliability of the service. Another segment may be using the goods or services for a short time and may not be looking for high durability. The toy industry may be one such example where the product's safety is more important than its durability, and the child using it will, anyway, outgrow the product. The company management has to think beyond customer expectations or requirements.

Delivery: The fast delivery speed is measured from the time of order and until the product's final custody transfer to the customer. The firm with faster delivery performance will indeed be having an advantage over its competitors. The ease of placing an order, availability of stock, quick mode of movement, ease of making payments are all contributors towards faster delivery services. Various strategies to speed up the transfer process include keeping track of the delivery system, retaining goods and supplies in the supply chain, maintaining the total capacity to enforce "speed" rules, and using fast transportation.

Ability-based reliability of delivery refers to the availability of a product or service at or before the deadline. The firm may have a long run but still has a higher level of reliability on delivery. The order of delivery of acceptance includes the percentage of the order issued and the time given, and the delay time in the late order policy. The ability to build trust is essential for companies integrated into the supply chain.

Flexibility: Many in the supply chain compete by responding quickly to the unique need of various customers. Product companies and users may indicate changes. The types of variables are given under :

1. Transformation cycle: defined as the ability to produce many different things from the body.
2. Be flexible or able to start creating new products in the same time-efficient process,
3. Make changes or change the design of the product to accommodate named customers.
4. Adjust the volume or be able to produce any volume that the customer wants.

The level of flexibility required varies with the type of industry and product requirement. This flexibility is a significant parameter in the performance of the supply chain. The firms determine the kind of change necessary for their clients and plan their work and efforts accordingly. The firms have to recognize that the new product (Mentzer & al, 2001)

Cost: Cost has always been considered the most crucial performance criterion, even for businesses that are not competing on cost and have other unique selling propositions. In the case of differentiated products, with time, the competition develops choices for the customer, and price becomes a critical criterion for the customer to choose the product. Most of the cost an organization incurs is on the operation and supply chain part. Hence, efficiency and flexible SCs are in high demand, which uses the plants' potential to the maximum, keeps the stocks to the minimum, and optimizes operating costs. Mass production of similar products is one of the most commonly used methods to reduce cost per product unit. However, this sacrifices flexibility. SC has to have adequate spare potential and stock to take care of

the fluctuations in the market. The lead time from the order to its fulfilment has to be short, and the product is available in different volumes as per the customer's choice. These flexibility requirements will undoubtedly affect operational efficiency. A flexible chain will conserve storage capacity and save resources to speed up for expected changes—this must have compromised performance to a certain degree. The organizations have to have a calibrated decision in balancing efficiency against flexibility to cater to the customer segment it has chosen to operate in. (Sunil Chopra, 2013)

There is always a debate within firms about resource allocation towards customization. The companies which operate and compete based on low price have to allocate resources for re-engineering of their operation and logistics processes to have higher efficiency. The other companies, which want more significant differentiation, will be dedicating their resources to making their operations more flexible to adapt to the customers' changing needs. The products that have reached the mature stage of their life cycle have lower uncertainty in their demand and require efficient chains to keep the prices competitive. On the other hand, new and innovative products will need flexible SCs for producing and supplying them. Different companies have different SC needs depending on the products they want to sell and target customer segments. Differentiated products use flexible SCs to manage uncertainty. Mature marketers can predict the demand and use efficient SCs to reduce costs.
(Sunil Chopra, 2013)

1.19 TRANSPORTATION MANAGEMENT:

The physical movement of the product is ensured by transportation. The design of the system and selection of transportation mode decides the market penetration of the organization. The firm's strategy may be for broader or deeper distribution of their products, and the transportation systems are designed accordingly. The cost per unit of the finished products depends on the volume, and larger volumes of the same product to be transported to the same destinations will lower the cost of logistics. Product positioning becomes competitive with efficient transportation, and the selling price is reduced by holding costs down. (Ketchen Jr. & Hult, 2006)

Transportation provides essential information concerning products, the marketplace, logistics costs. The steps involved are as under :

1. The 1st step in transport management is finding out the cost efficiency of private carriers and searching and selecting public pages. The cost and customer service levels must be balanced to obtain the desired service level at the lowest cost.
2. The 2nd step is the selection of the mode to meet the daily logistics needs. The type is selected to perform the functions that provide the customer's service levels and differentiation. The method has to be safe and secure so that the customer receives the product in intact condition without any unexpected delays.
3. The third step is to work with the carriers to establish a proper system regarding the time schedules and the appropriate routes to ensure on-time delivery to the customer.
4. The 4th step of the process is to prepare and complete the necessary documents.
5. The final step is to formulate the parameter for effective monitoring of the entire system. The performance assessment has to be objective and linked to incentives to enhance logistics' efficiency continuously. The whole exercise is to be carried out to maximize its market value of the goods and services.

(Wisner, G., & Keah-Choon Tan, 2005)

The movement of goods has to be effective, and the critical issues involved are the movement of information and collaboration among the partners of SC. The SC designed is not to pit one carrier against another or negotiate the lowest possible rates. The system needs the ability to react to market uncertainties. The SC must include the continuous and efficient flow of goods from the supplier to the production centres, distribution centres, and customers.

A good logistics strategy will reflect and fulfil the needs of the customers. The timing and efficiency of transportation services are essential. The packing must be adequate to avoid damage to the goods and depend on how fragile the product is. The transport plan can substantially contribute to customer satisfaction and give a unique selling proposition to the organizations and differentiate their services compared to competitors.

Mode Selection :

1. How to move a product, i.e., from the air or road?
2. What role does time play in the supply chain?
3. How to measure product and service performance?

(Wisner, G., & Keah-Choon Tan, 2005) (Bone & Ganesha, 2005)

Carrier relationships: The carrier's interest in having a more prominent business pie will create its competitive interest in business, and it should be part of the SC plan process. Trust among SC partners is key to its success. It is advisable not to divide the work among various carriers. In such a case, their position in the SC gets impacted. The work is to be entrusted to a carrier alliance having the capability to fulfil the SC requirements.

Performance Metrics: There has to be a continuous evaluation of the performance of the entire SC. Benchmarks and standards are defined, and the parameters of performance are compared. There has a suitable incentive for continuous improvement and performing better than competitors.

1. SC's actual performance in terms of customer delivery at the right time is to be evaluated.
2. The cost of each activity of SC has to be evaluated. The expenses in fuels, financing, spare parts change with time, and the data regarding these will help in price discovery for the transportation services. Benchmarking may help in this matter. Competitors may not share information. The best practices in logistics may be found in other industries, and these may be adopted with suitable modifications.
3. Regulatory impact: Policy may change, for better or for worse, and affect the transport system configuration. Delhi's recent regulation (now in Mumbai) regarding CNG transport has significantly affected the transport situation. The ban on the use of certain fuels due to environmental concerns has affected the transporters significantly.

   Flexibility: The transport options selected should have the ability to change as per the need of customers, products, businesses, business models, and partners. Corporate purposes may change with time, and SC should mould itself to a changing market environment. The logistics strategy is not based only on cost optimization but also on the degree of flexibility offered in the dynamic business environment. The relationships with the material providers, traders, freight carriers have to be maintained, and their efforts are to be coordinated for an optimized SC. The partnering firms may have to adjust the management systems to support other organizations' functions in the supply chain. (Larson & Halldorsson, 2004)

4. Response: Due to the onset of time-based competition in today's JIT stock levels, quickly responding to customer needs has led to eliminating the traditional trade-off with the service cost. An agile approach is gaining a great deal of respect - examining the supply chain from a customer's perspective, delivering feedback and information to the decision-makers at all levels. Similarly, SCM is accepting the concept of "customized" logistics. This concept means that a different customer group has other requirements, so they need a different approach to fulfil their requirements. Transportation is a critical component of agile logistics, as it is the link between the factory and the customer. The factory output can be more consistent when the data is available before the actual movement of materials. It is the overall production, which reduces the cost and not only the speed. The response enables the trouble-free flow of material in SC.

Reliability: The compression of transport time leads to the requirement of lower stock levels. However, reliability leads to a reduction of stockout costs. The customer is required to keep higher stocks if the time of transit is not consistent. If the time of transit is high, the supplier will have to adapt to the faster and expensive mode of transportation, which is a better option than increasing the stock costs and reduced revenue due to market share decrease.
(Mentzer D. K., 2001)

The various transport modes have different speeds ranging from five to ten Km/Hr to 1200 Km/ Hr. The size of consignments maybe 150 MT in railways to 10
MT on the road. Several modes and vehicles are available to ferry the consignments of various types and sizes. The SC manager's task is to choose an appropriate method most suited to the kind of consignment required to be transported. The following are matters of concern :

1. Negotiating rate and route.
2. Selecting route and carrier.
3. Appearing before regulatory agencies
4. Evaluating carrier performance.
5. Analyzing transportation cost and service.
6. Deciding on the use of shared or owned vehicles.
7. Demurrage policy and claims

8. Maintaining timely payments to the carriers.

(Bone & Ganesha, 2005)

Carriers can be grouped into the following major categories:

1. Common carrier- which holds out their services to all who wish to use them.
2. Contract carrier- who are dedicated to a company on a contract basis.
3. Private carriers tend to be the most closely regulated by public authorities, contract carriers less.

(Ketchen Jr. & Hult, 2006,)(Larson & Halldorsson, 2004)

Rail: Railways can move big consignments across the country. Modern methods and technologies have added value to this mode of transportation. The specialized trains for specific items have been introduced. The refrigerated carriages are a good example. Most of the fuels and Agri based items move on the railways. The improvement in services improves the bottom lines of the companies using the transport.

Road: The movement of goods through road has the following type of carriers:

1. Common: They are available to all and can be requisitioned by services by anybody in need of their services. The public transport companies fall under this category.
2. Contract: The carriers having contracted their fleet to a particular firm fall under this category. The carriers have to abide by the agreement and cannot use their services for others.
3. Private: The firms may own the transport equipment and thus be termed as private carriers.
4. Exempt: The government exempts some of the carriers to operate within a geographical area. This exemption is usually given for livestock and Agri products.
5. Agents: These operators do not have any vehicles but collaborate with owners to provide transport services.
6. Pipelines: These are used to move liquids, and petroleum pipelines are excellent examples. These cross country pipelines move the fluids efficiently and sustainably. These may not be very fast but are economical in the long run, although the initial capital deployed is enormous.

7. Water Transportation: The speed through waterways is slow, but the mode is very economical for big consignments and long distances. The risks involved are bad weather and storms.
8. Air Transportation: The mode is fast and safe. However, it is not considered as the cost per unit weight of the consignment is very high.

(Mentzer D. K., 2001)

1.20 Information Technology in Supply Chain

IT has transformed the way business is conducted. Before the advent of IT, the organizations assessed the demand and manufactured products at the least cost. The firms aimed to produce large volumes of goods at the lowest possible costs. In the 1980s, the customers demanded differentiation and were no longer satisfied with the 'fit to use' perception about quality. (Sanders & Premus, 2002)

They demanded that customized products having durability and customer satisfaction became the buzzword. The businesses responded by enhancing by adopting TQM or the "Total Quality Management" approach. The management of firms became complicated as the number of similar competing products entered the market. Competition increased, and the life cycle of products got shorter and shorter. Sharing information in real-time became necessary and crucial to managing a complicated business. Inflexible and unresponsive firms were driven out of the market by the innovative service and goods offerings. Transformation and response became drivers forcing firms to focus their attention on the system rather than on performance. It became mandatory for the management to use information technology to think critically and manage the supply chain. (Fawcett, Osterhaus, Magnan, Brau, & McCarter., 2008)

A combination of advances in technology and business capabilities to leverage information tools can be used to address the following business concerns:

The organizations had to change focus and become more amenable to change according to market and demand dynamics. The SCs were focused on processes instead of functions. (Koh, 2004). The use of information systems to suit the business requirements became a competitive advantage for organizations competing in the same space. The agility of the firm became imperative to edge out the competition in the ever-changing market scenario.

The ability to change, customize products, quick response and real-time information increased the performance parameters in terms of efficiency. (Bayraktar, M Demirbag, Lenny, E Tatoglu, & Zam, 2009)

Information Technology played a significant role along with the network of telecommunications. The technology cost is reduced exponentially. The computers are available at low cost, and the proliferation of computing power to mobile phones has opened an entirely new paradigm of businesses. (Sevkli, Koh, Zaim, & al, 2007)

The information is democratically available, and this has given enormous power to the customers who are now well aware of the qualities of products and services provided by competing organizations. IT has made it easy to process and communicate data, which could be analyzed. The computing power makes it possible to organize resources and schedule the tasks to get optimized results. The computers can create business situations and help managers devise the strategies to be adopted in different scenarios. (Chiu, Chen, & Tzeng, 2006)

The organization and improvement in storage capacities of computers have allowed forecasting using the available data. The monitoring and control of business functions have become easy, thanks to the advancement in IT services. (Liou & Tzeng, 2007). These functions used to be very labour-intensive. The organizations could restructure themselves and become flatter as IT enabled the managers to analyze the data and use the computer-based models to aid them in decision-making. Barcoding of articles made the movement and billing of the products and materials less labour-intensive.

Continuous monitoring of teams' performance is essential to see the direction of the parameters vis-à-vis the already defined objectives of the firm. The management of the firms needs to evaluate the actual execution of work on the ground. This evaluation helps them to assess the performance against set standards. IT has made it possible to develop alternative solutions for monitoring and controlling the SC. (Liou & Tzeng, 2007)

IT, from automation to computers, plays an important role. The rapid development and spread of IT through computers and communications have helped make changes in various aspects of life. Impossible in the past, today it is possible because of technological advances. (Simchi-Levi, Kaminsky, & Simchi-Levi, 2003) For example, a dramatic reduction in technology costs, e.g., the low

cost of PC and frequent communication, has led to increased computer capacity in all organizations and systems to proliferation information systems. This enhanced capacity has created new opportunities for the efficient functioning of the firms to support organizational goals.

EDI has facilitated the exchange of information among partner organizations. The transaction time and cost have been reduced. The information about demand has enabled the firms to operate at optimized stocks. The various technologies in use include Data warehouse, data mining, e-commerce, e-procurement, RFID, barcoding, etc. These technologies have become ubiquitous and are an essential part of businesses. (Gunasekaran & Ngai, 2004)

Evaluation of the performance of individuals or groups against objectives and values has already been established. The EDI network of business documents reduces business costs over time. Making the right decisions, being more accurate, and providing better customer service is good SCM. (Brooks & Davenport, 2004). Textual Advertising is between customers, employees, customers, and suppliers. The use of bar codes has reduced the consumption of paper, thereby saving the environment. This practice reduces errors in stock accounting. The use of the smart card has made payments more manageable. The mistakes in accounts are eliminated, and ledgers are automatically created. The need for reconciliation is minimized as all the records are available and visible to the payee and payer. RFID has made tracking of objects easy. RFID has been extensively used in toll collection, thereby avoiding long queues, which delay the consignment delivery time.

The benefits of various IT and knowledge technologies have helped provide a fast, flexible, and responsive supply chain. An organization needs to invest in IT carefully to make its infrastructure more responsive. Stocks can be better managed, and accounts can be controlled by IT. Overall the decision-making process can be expedited. The data collected as feedback from customers can increase customer satisfaction and save money simultaneously - a perfect win-win situation.

1.21 Supply Chain strategy and performance measures

The supply chain of any firm has to ensure that it provides better value to its customers than its competitors. This competitive edge is possible if its processes are efficient and its workforce is productive. The finished products and the firm's services have to be priced reasonably so that the

target customer segment can afford them. The customers want more customization and faster delivery of goods and services and want better values for them. Organizations increasingly decide to balance the level of service to the customer and the cost to arrive at that service level. The optimality of the decision will be the key to the acceptability of the goods and services. Several activities are to be aligned to meet the strategic requirements of the supply chain. The exact process may not remain competitive in the long run. The organizations must understand that their decisions for the supply chain and their strategy should be in synergy. There is uncertainty in the market that must be monitored, and the plan for meeting future challenges has to be formulated and executed in a dynamic environment. There is an ever-increasing demand for a higher level of services at lower prices to be delivered faster.

Innovative methods are required to be adopted by organizations to be able to meet customer expectations. The firms' performance is intimately related to the performance of the supply chains they are operating. The supply chains have to respond to the cost and customer service requirements together and continuously. The supply chains have to be flexible enough to handle the variability of market demand. (Chan, 2003) Indeed, the lead time of delivery is essential, but the nature of the marketplace's need and to account for uncertainty. (Hussain, 2006). This balancing need forces the organizations to categorize their outputs and services into functional and innovative.

The products that meet the consumers' basic needs less customization and have a stable demand, categorized under "functional products." Groceries are excellent examples of functional products that the customers need on a day to day basis. Their demands can be forecasted, and these have very long life cycles but are in the mature category of products, so their profit margins are meagre. There is competition in the market because of many sellers. These categories of goods are called commodities. (Tong, J Gong, Yue, & You, 2014)

On the other hand, there are fashion products where the customer needs exclusivity. Their demand is variable, and the forecasting of the demand is challenging. These satisfy the higher needs of the customers like 'esteem' in Maslow's hierarchy. These need to be differentiated, and these products have short life cycles. However, the profit margins are high. It will be pertinent to mention that there will be significant unsold inventory, which will have to be disposed of by discounting.

(Seifert & Biçer, 2014) Most of the firms change their product categories without changing their SC configurations. The different types of products need very different supply chain infrastructure and activities. The firms operating in the innovative product distribution might fail to introduce functional products without changing their supply chain structure. (Heungjo, 2011).

The organizations have to understand that there has to be a synergy between the kind of product they intend to market and the supply chain type they are willing to adopt. The uncertainty of the demand may be in terms of quantity or the bundling of the product. There are cases where the overall quantity can be forecasted very precisely, whereas the specific product requirements become highly variable and unpredictable. This uncertainty leads to the risk of a demand-supply gap in the bundling of the product. The maturity of the product in the life cycle is also a factor contributing to uncertainty. There is high uncertainty of demand when the product is in its initial stages of growth. (French & Geldermann, 2005) However, with an increase in the maturity of the product, the demand also becomes predictable. Accordingly, the firms require a more efficient supply chain.

In the case of innovative products, the supply chains have to change with the market dynamics. This flexibility can also be seen as a mitigation strategy to counter the risk of demand uncertainty. (Seifert & Biçer, 2014)

The organizations may face the unpredictability of the supplies also. There have been many publications regarding demand uncertainty, whereas the supply side failures have not been given due importance in literature. An organization hardly influences the demand, whereas they can manage the supply risk by adopting suitable supply chain associates. Earlier, the organizations used to emphasize finding out the supplier and developing them, so they have to manage the risk of supply failures. After the incident of terrorism in 2001, the organizations realized that there is a risk of disruptions in the supply chain, and they have to deal with uncertain demand and supply-side failures have to be addressed. Such events have an infrequent occurrence, but these have severe consequences on the supply chain's performance.

Delivery reliability: The time taken by the supply chain from the placement of an order until its fulfilment is called the lead time. The firm is reliable if it is repeatedly and consistently delivering

as per the promised lead time. In mathematical terms, reliability is a fraction of customers served as per the promised delivery duration. (Tong, J Gong, Yue, & You, 2014

Benchmarking: It is the process of comparing an organization's performance vis-a-vis the other firms operating in the same industry. This process helps in finding out where the firm stands in comparison to its competitors. The lead time of delivery and the cost incurred in the supply chain are the fundamental parameters used in benchmarking. (Min, 1997) The benchmarking helps the organizations find out the processes lagging behind their competitors and need the management's attention to bring it to or exceed the industry standards. The analysis of performance gaps in the process of branch marking leads the organizations towards process benchmarking.

Supply chain performance improvement has a specific effect on business performance. Every firm and the supply chain is trying to improve the return on its assets. The optimization of cost results from the stock reduction, control of transportation expenditure, reduced cost of raw materials, the control of the amount spent on the equipment and spare parts, and reduction of the cost incurred on the return of sales. The money spent on sourcing the materials, the expenditure on day to day working, the interest cost of credits to the suppliers and customers, margins gain, improved market share and market reach, efficiency improvement are integral to the supply chain performance. (Christopher & Peck, 2013) Since the supply chains are increasing in dimensions and becoming more complex, the competition is ripe for reducing logistics costs. In developed countries like the USA, the logistics cost was 15% of their gross domestic product in the 1980s. However, now with the improvement in supply chain management, this accounts for only 8.5% of their GDP. SCM practices have optimized the logistics cost to a great extent.

The factors which have help and optimizing the supply chains are as under :

Information technology: The availability of telecommunication systems at low cost has improved the organizations' ability to collaborate with the partners of their supply chains scattered worldwide. The enterprise resource planning systems have provided the organizations with uniform business processes throughout the supply chain. Each partner can benefit from the data readily available to the entire supply chain. The Internet has freed the information and made it available democratically. The information is available to organizations and individuals. The flow

of information from one firm to another has dramatically helped in the reduction of buffer stocks. (Fox, 2000)

Earlier, it often used to have bullwhip effects, thereby increasing inventory at every level of the supply chain. It can be said that information has virtually replaced the physical inventory. Many organizations do invest in information technology without commensurate changes in their supply chain systems and processes. Such organizations cannot fully utilize the benefits of supply chain optimization with the real-time information available. The need to keep stocks at all stages can be eliminated, and safety stocks can be held any commonplace accessible to all the plants.

The orders can be handled quickly, and the tracking of transactions has become very simple. Organizations have to carry out significant transformations in the supply chain structures to utilise IT's full potential. The systems, processes, and overall strategy of the organization have to be changed to reap the benefits of technology.

The entry of third-party logistics providers: The 3PL has transformed supply chain management. Earlier, most of the organizations were having their own logistics networks internally. Now the companies have come to know that they have to nurture their core competencies and outsource the logistics activities to the 3rd party logistics service providers who can bring their expertise and manage the logistics better than their departments. They can work with professionalism and can get cost optimization using economies of scale as they can have more significant volumes to transport by collaborating with many other organizations contacting them for the services (Hyung, 2006)

Some companies have gone for fourth-party logistics, giving integrated and comprehensive supply chain solutions to the organizations. In India, third party logistics is in its nascent stage. Some old transporters are providing value-added services by collaborating with warehouses and freight forwarders. Some international 3rd party logistics companies have set foot in India along with their manufacturing MNC partners. For example, Toyota brought Mitsui and the company along with them. The services of third-party logistics providers are not well developed in India, although some mid-sized companies have started providing these services. It is expected that these companies

will improve their competencies and start functioning smoothly, and will be able to take care of the logistics of most of the industries in India as well.

Coordination among Companies: Global networking has led to enhanced inter-company collaboration. The networks are functioning efficiently, with a firm at the centre of the strategy. The companies like Nike, Nintendo, and Toyota have demonstrated their capabilities to administer complex networks where they have played central strategist roles. These have become examples of other organizations that can develop network administration as their core competencies. It is also true that there have been many failures and no synergy of interests in various organizations. In such cases, supply chain networks failed. The industry is still learning the methods of collaboration among supply chain partners. The understanding and coordination among firms can fire up the 3rd supply chain revolution in the sectors (Viswanadham, 2000) ((Tayur & Ganeshan, 1999) (Shah, 2009)

Based on the definitions, supply chain management can be classified into four major areas:

1. The flow of materials and logistics- SCM involves the movement of raw materials from natural sources or factories to the manufacturing units and from there to the storage points and customers. (Yu, 2011)
2. The flow of information- The information flows in the reverse and forward directions. The movement of goods and payments is communicated to supply chain partners in each stage of the logistics and manufacturing process to optimize its operations for maximum effectiveness. (Saini & Saini, 2014)
3. Integration- The nodal company has the responsibility to integrate the entire supply chain process so that the material and information are required to reach each partner appropriately. (Sunil Chopra, 2013)
4. Comprehensive flow- The optimization model has to oversee the comprehensive flow and final delivery of goods or services to the customers instead of optimizing the supply partners' levels. (Battini, 2008)

Variability in supply, demand, logistics, and market dynamics profoundly affects supply chains' operations. The producers, distributors, and retailers constitute the supply chain. The producers and distributors may be spatially separated and may be located across cities or nations. Even manufacturing organizations may exchange a large number of materials. SCM has the characteristic of managing the exchange of information and material among the assemblers, manufacturers, and distributors. While deciding on logistics, transportation modes, and routes requires a sufficient amount of data exchange among supply chain partners. Walmart is an outstanding example of integration in which the company has been able to integrate activities of its suppliers and transportation networks, thereby optimizing stocking and logistics costs (Sunil Chopra, 2013).

The planning on the factory shop floor and logistics of distribution are the primary functions of any supply chain. The planning for production involves sequencing activities at the production level, designing and managing the production process, handling materials, sequencing, and stock keeping. The distribution logistics includes the movement of products into and out of the production facilities and distribution centres to deliver it timely to the end customers. In dynamic markets, order delivery has to be continuously improved, and such improvements have a significant impact on the profit of the organizations involved in the supply chain. The supply chain partners have to be involved in the decision-making process. The producers and distributors have to access corporate data, which will help them re-engineer their internal supply chains and make them more efficient. Involvement in decision making improves bonding among the various supply chain partners. (N. Viswanadham, 2001).

The oil marketing companies share the margins generated in the retailing operations. The fluctuations in sales are common due to seasonal and other reasons. These variations have to be accounted for while designing retail networks and their facilities. The retail network is designed considering the sales over a long period. However, the actual demand may change, resulting in some terminals' overcapacity and short capacity in others. The models have to have retrofit design capabilities that allow for relocating and resizing the facilities based on the field's information. The variations must be factored into the stock-keeping decisions. The cost built up of petroleum

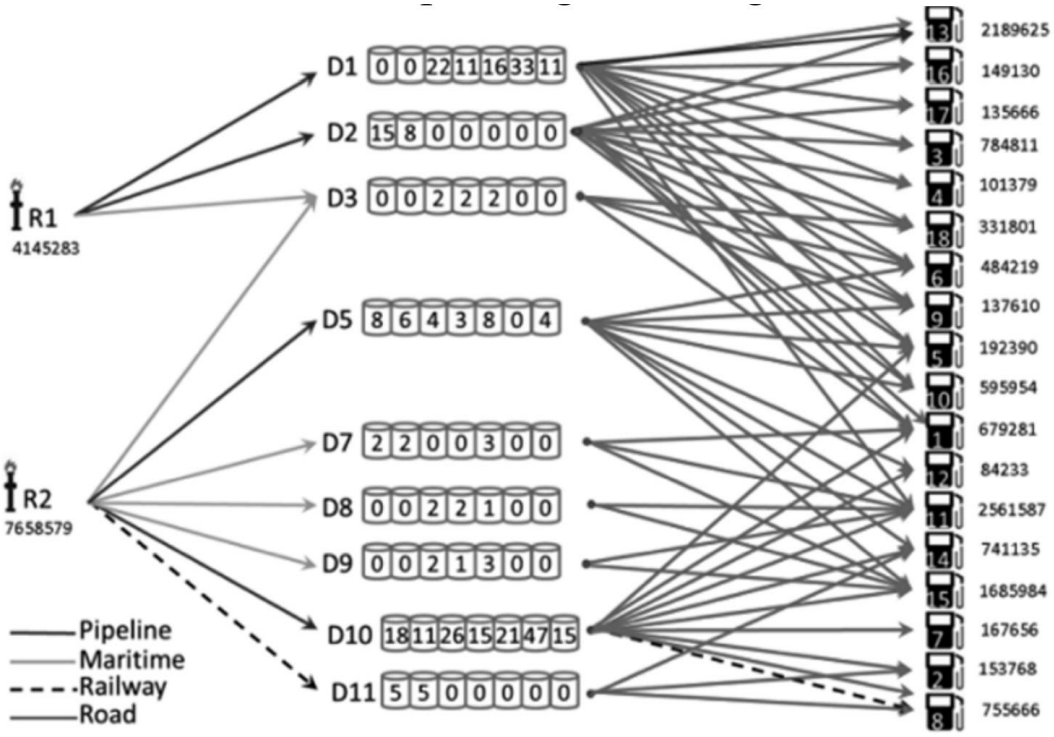
products may be summarised in figure 1.8, and a typical distribution chart of downstream petroleum logistics is given in figure 1.9

Cost Built up of Petroleum Products

Activity Stages		
 Crude Oil	Exploration costs +Production costs +Maritime transport +Production margin	=Crude Oil Spot Price
 Refinery	+Refinery costs +Refining margin	=Refinery Spot Price
 Pipeline	+Primary transport costs +Primary transport margin	=Primary Spot Price
 Storage Depot	+Storage costs +Storage margin +Petroleum excise tax	=Rack Price
 Tanker Trunk	+Secondary transport costs +Distribution margin	=Tank Wagon Price
 Petrol Station	+Retail station costs +Dealer/Operator margin +Value added tax	=Retail Price

(Fernandes, Susana Relvas, & Barbosa-Póvoab, 2013) Fig 1.8

Distribution Chart of Petroleum Product Logistics



Source (Fernandes, Relvas, & Póvoa, 2016) Fig 1.9

1.22 STRATEGIC AND TACTICAL PLANNING:

There are various optimization frameworks available for the primary logistics of petroleum products. Many models use linear programming techniques as most costs associated with primary logistics are on a per unit basis and vary linearly with the units moved. Some specific models can optimize producers and distributors together utilizing different models for each, e.g., Production on MINLP and distribution on the MILP model. The collaboration of producing refineries and delivery systems optimizes the cost of overall operations. This optimization is a valuable tool to further the overall performance (Kim, C Yun, S.B Park, & Fan, 2008) (Fernandes, Relvas, & A.P Barbosa-Póvoa, 2013). There are publications where bottom line optimization has been taken as the primary objective (Kim, C Yun, S.B Park, & Fan, 2008). In some other, the expected NPV has been sought to be maximized. (Carneiro, G P Ribas, & Hamacher, 2010).

There are works where NPV expected has been maximized whereas the risk has been minimized (Fernandes, Relvas, &Povoa, 2016

The optimization problem in petroleum supply chains, especially in secondary logistics, is complicated as there are various objectives to be achieved, and many of these objectives conflict with one another. The models have to focus on balancing the multiple purposes to create a win-win situation while taking care of sustainability and financial concerns. (Lima, Sujana & Barbosa Povoa, 2016).

In the nations where the petroleum industry is free, The critical issue is the collaboration among the various supply chain partners and synergy in their activities. It is a highly complex issue, so requires IT enabled tools for making decisions. (Barbosa, 2014) writes that the supply chains should formulate the policies so that the entire system is optimized and the firms involved in the supply chains earn a reasonable return on their investments. The author has concluded that the operations have to be based on objective and scientific criteria.

The collaborative environment among the supply chain partners has been explored (Fernandes, Relvas, & Póvoa, 2016). A combination of studies has been conducted to study collaboration strategies under risk to achieve the best results in price, weight, cost, and profit. (Fernandes, Relvas, & Póvoa, 2016). (Ghatee, 2009) has evaluated the expertise of Experts and the bias of managers deciding on the supply chain activities. He has concluded that the inventory holding capacities added at various stages of the supply chain are necessary for the network to meet the customer requirements.

The issue of reliability of supplies is vital because of petroleum products being essential commodities. These are connected with the network's resilience (Tong, J Gong, Yue, & You, 2014) but not with adverse situations and coming out of various disruptive forces. The objective and mathematics-based models use specific incentives and punitive tariffs in the equations so that the non-fulfilment of customer requirements reduces revenue for the supply chain partners. The resilience of downstream SC is an important factor and can be studied in future researches. The resilient chains mean that the supply chain network is inherently capable of handling the unforeseen circumstances that may arise and lead to supply failures. The importance of resilience has been accentuated in the COVID pandemic, which led to demand destruction, thereby leaving the entire supply chain to work at low demand. In this situation, the supply disruption could halt

essential services even during the lockdown. The OMCs in India have shown their resilience during this pandemic and have maintained the supplies.

The models are available in the literature aim at combining the tactical decisions along with operational ones. The synergy among various parts of SC has been presented to coordinate with the whole supply chain, which can meet the customer requirements by improvising the entire system's performance levels. (Neiro & Pinto, 2004) have used MINLPmodel for Brazil, where there are groups of raw material providers, refinery operators, distributors, and pipeline operators and has obtained a sequence of activities. The model has taken care of each part of the supply chain and factor in the limitations of refinery storage terminals and pipelines. The objective in the model has been accepted as turnover maximization. The model encompasses crude purchase, refinery scheduling, and planning and distribution of finished products to provide a pragmatic solution for the whole supply chain to maximize the bottom line over a period (Guyonnet, Grant, & MJ, 2009).

(Kuo & Chang, 2008) developed the MILP model for the supply chain, including production and distribution. They also included the collaboration and synergy of the shop floor plans and sequencing activities to optimize the SC results. This optimization was achieved through the integration of the MILP model. The solution provided for all critical decisions at the company level as well as at the plant level. The objective was to revamp processes to improve maintenance and operational efficiency. They also included designing and integrating a production plan and a program for optimizing the supply chain by developing an additional MILP. This optimal solution governed all critical decisions at the company level as well as the plant.

(Al-Othman, Lababidi, Alatiqi, and Al-Shayji, 2008) used an efficient MILP model where they created various scenarios to handle the customer requirements' variability and fluctuation in the prices prevailing in the market. Various dis-incentives were designed for non-fulfilment of customer requirements or delay in supplies. The whole network became complicated as it included petrochemical plants also.

(Leiras, Ribas, & Hamacher, 2013) have attempted 2 stage MILP model to synergize the tactical and operational level decisions in the supply chain network consisting of many refineries. Different

models have been used for each level of decision making. The variability in customer requirements and prices prevailing in the market get addressed at one level, whereas the issues of the petroleum supply chain and refining are handled at a very different level. The exchange of data between the two ensures that the hierarchy of the framework. Various iterations have been carried out to achieve optimization. The model also takes care of the fuel's quality by keeping the parameters of sulfur content and viscosity under a fixed range, as described by regulatory authorities.

MILP models have been extensively used in optimization. There are many research papers where various techniques have been applied to mitigate the variability and risk and return on assets. There has been an attempt to forecast future revenues and provide a decision-making tool applicable to the petroleum supply chain. Since PSCs are complex networks where mathematical and scientific instruments are required for decision-making, the need for more acceptable optimization and decision support systems and tools has been felt to cater to the industry's unique problems. Frameworks can handle the variability of demand and risk issues and models that can help develop a resilient, sustainable, and collaborative decision process.

There have been papers on single objective MLP models. In these models, the maximization of the bottom line of the entire supply chain has been considered. The research mentions the multi-objective nature of the problem and tries to balance economic, environmental, and social aspects. The performance issues by the suppliers and service level to the customers are qualitative and subject to several research papers. The quantitative parameters are returned on assets deployed and profit margins. The primary purpose is to integrate, plan, and schedule the entire downstream supply chain (Lima, Susana, & Barbosa-Póvoa, 2016).

Metrics are required to effectively evaluate operational efficiency and strategic performance in terms of reliability of the supplies and satisfaction of the customers. The various performance measuring parameters are necessary for assessing each of these dimensions (Heckmann, Comes, & Nickel, 2015)

The downstream sector is in dire need of resilient supply chains as the existing models have not paid attention to this aspect. The current models have primarily focused on cost optimization and

profit maximization. There have been adequate research papers on the sustainability of PSC. However, the quality has mostly been taken as a constraint as a regulatory requirement. Most of the refining production models are mathematical, where the quality of the finished products has been accepted as the limitations due to statutory provisions. The impact on society has not been well researched in the publication. There is a need to consider the social aspects, sustainability issues, and economics of PSCs. These issues can be addressed using multi-objective and multiple criteria frameworks. The balance among these factors is maintained in decision making at the strategic, tactical, and operational level (Lima, Susana, & Barbosa-Póvoa, 2016).

1.23 SUPPLY CHAIN NETWORK

A typical supply chain of the petroleum industry can be described as under

Product Flow in the Petroleum Industry

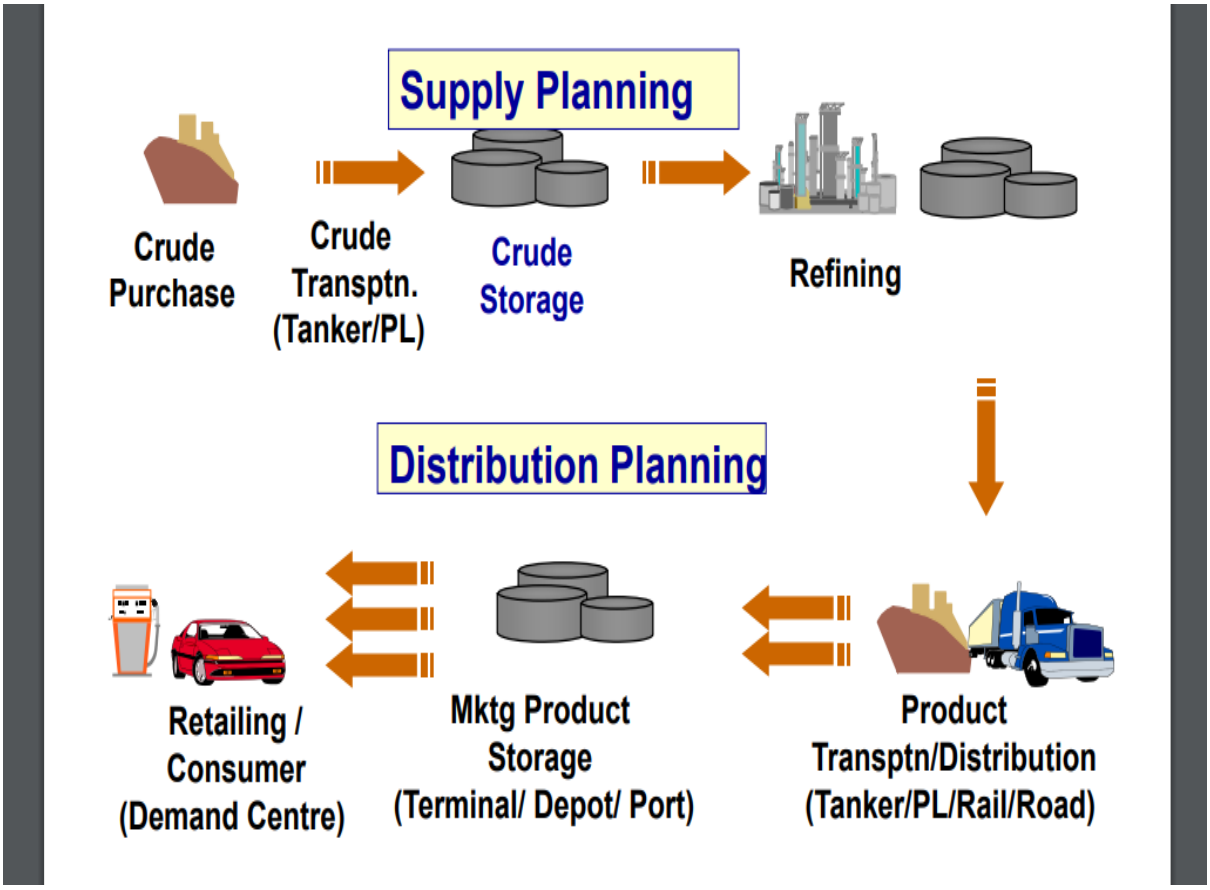


Fig 1.10

Source (Mohanty, Dhalla, & Mohapatra, 2010)

The present set up in India's petroleum industry can be represented as per the following figure:

Petroleum Industry Set up in India

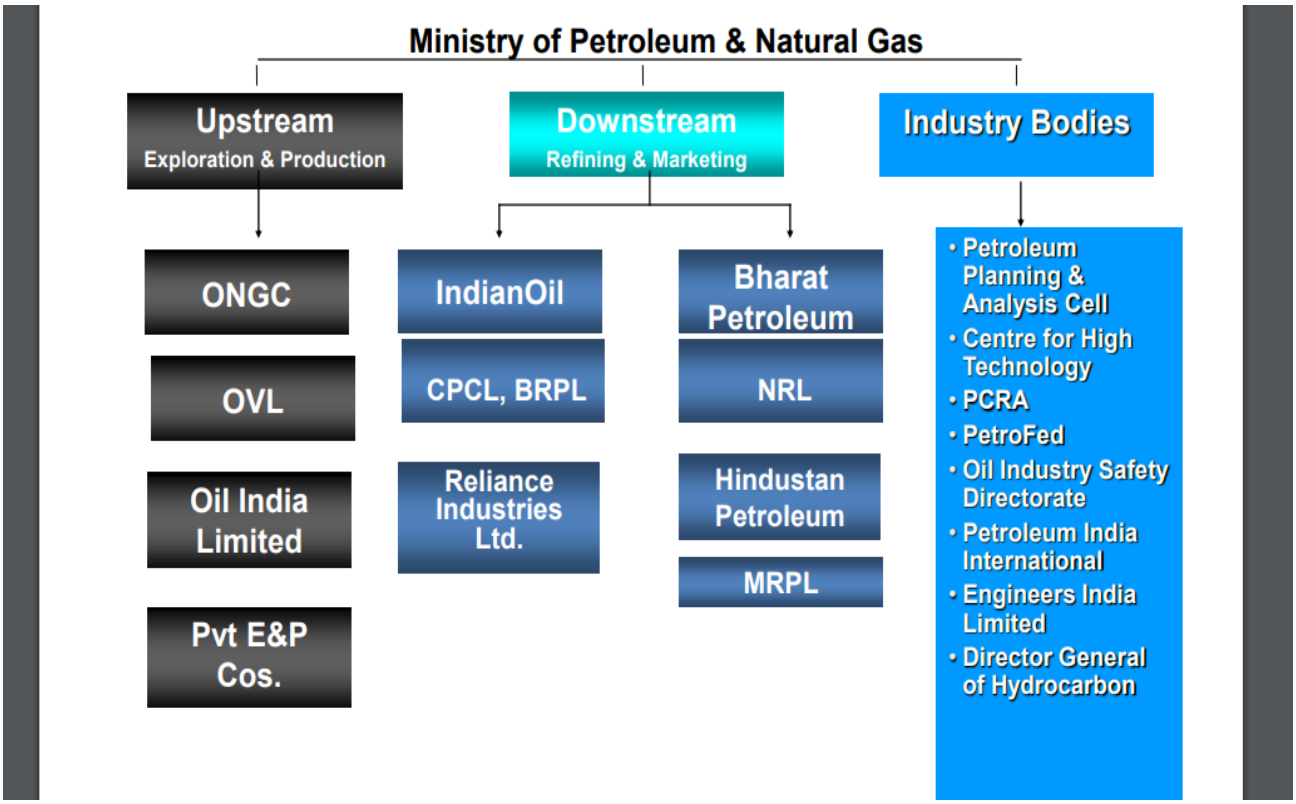


Fig 1.11

Source: (Ministry of Petroleum and Natural Gas, India, 2016)

1.24 DECISION MAKING IN SUPPLY CHAIN MANAGEMENT

The SCM can only be effective only when the decisions are appropriate and based on data from the field. It is evident that there is a forward movement of materials and reverse flow of information and feedback from the field to the supply chain partners. The decisions have to be taken at every stage of SCM. These may be policy decisions or tactical and strategic decisions based on the level at which the decisions are being taken. There are many issues needing consideration while measuring the efficacy of these decisions. Picking the right kind of suppliers, sequencing the manufacturing processes, and planning the product's distribution are typical decisions in any supply chain. This decision takes a complicated process as the business environment is dynamic and has several partnering organizations that are to be involved in each decision making level. The

kind of production and the stage in the product's life cycle profoundly impact decision-making. SC's SC's performance in the industry is primarily dependent on the type of decisions taken.

1.25 GLOBAL OPTIMIZATION

Optimizing the supply chain at the global level is very complicated as unstable geopolitical situations lead to significant uncertainties for the organization. One of the complications is that production and distribution centres are scattered all over the world. The factory owners tend to de-risk their production processes by having stable contracts in which high volumes are committed for an extended period. They also expect that their occasional failures to meet the timelines are accommodated. These contracts allowed the factories to run for an extended period. However, the variability in the demand figures forces them to be flexible in their production operations. Many decisions regarding the production runs are taken without adequate data about market dynamics. The producers need to develop the agility to change supply volume as per the demand pattern. The distributors aspire to operate at minimum stock levels.

On the contrary, the producer’s expects the distributors to keep the stocks to cater to the variability in demand in a dynamic marketing environment. Customer demands are variable, and the firms' firms' objectives partnering in the supply chain may differ. Still, the customer's needs force the producers and suppliers to customize products and provide high quality. In the petroleum industry, the governments are under pressure to address environmental concerns. There is a trend to legislate for improving the quality of products to the increasingly stringent parameters.

The variability of demand is a significant complication while designing a supply chain network. There are seasonal fluctuations in the orders, which can be studied from the trends of previous years. The impact of the product's promotion can also be explored, and cost-benefit analysis is carried out to assess their adequacy. The variability of prices and demand volume makes it challenging to optimize the supply chain's performance. Because of these complications, optimization has become a necessity. The most common objectives are to minimize the cost function and to maximize the service delivery to the customer. The maximization of the profits is another principal objective. Hence the model has to be essentially multi-objective. The process of

decision making has to be made as objective as possible because of the involvement of multiple partners. The decision-making technique of the hierarchical analytical process (AHP) is adopted. The optimization aims to formulate alternative approaches that are more cost-effective and give a higher performance under the limitations of the resources. The objective has to be achieved so that the favourable outcomes are maximized, and the unfavourable ones are minimized.
In most cases, linear programming is used due to the simplicity of its application. Most of the PSC transportation models are for primary logistics and involve tank trucks, rails, and ocean tankers. The selection of the mode is to administer and improvise PSC.

1.26 DRIVERS OF SUPPLY CHAIN

An organization has to upgrade its SC performance for agility and operational efficiency continuously. There are drivers of logistics, and also, there are other drivers related to other functions. The prime drivers being the storage terminals, stock points, logistics information-sharing platforms, sourcing, and pricing. These drivers are not independent but interdependent and together measure SC's performance for both agility and operational efficiency.

The physical assets of SC are the storage facilities, assembly lines, and manufacturing facilities. PSC has refining complexes and storage terminals. PSC's performance is affected by the various decisions taken regarding the size, capacity, agility, and purpose of the storage terminals. In the case of efficient storage facilities, the ability for storing the product will reduce. However, this may lead to more response time if the number of terminals is reduced to improve the efficiency of operations. Hence balance needs to be maintained. Various stock points are created within the supply chain, from raw materials to intermediate materials to the finished product. Petroleum products are strategic assets and are mandated to keep a minimum level of inventory at all times. The selection of logistics providers has a massive effect on the responsiveness and efficiency of the PSC. Most of the OMCs have designed their supply chains to provide same-day service to most of their retail outlets as the transportation is rapid and reliable.

Data flow among the various partners of the supply chain is an essential aspect of SCM. The information and analysis about the stock position cost incurred, process, and demand is to be circulated throughout the supply chain. The real-time data and analytics available to the supply

chain partners go a long way in ascertaining SC's performance. It improves each of the drivers. IT has been instrumental in enhancing the suppliers' response time and has led to efficient operations. The availability of adequate data helps the organization and supply chains to strategize their functions and decide upon outsourcing non-core functions.

Sourcing decisions directly affect the responsiveness and efficiency of the supply chain. Pricing is an important determinant of customer behaviour, so it profoundly affects SC's performance. The responsiveness has a premium and can fetch a higher price. The various drivers discussed above are interdependent, and their combination determines the supply chain performance as a whole. An objective supply chain design has to realize that the interaction among these drivers has to be accounted for to get the desired results.

1.27 EVOLUTIONARY GENETIC ALGORITHM:

Genetic algorithms were introduced in the US in the 1970s by John Holland at the University of Michigan. The advancement in computing has made this optimization technique attractive for mixed combinatorial problems. The method uses a natural selection process where survival of the fittest offspring ensures that the successive solutions are nearer to the optimization objectives. This technique is common for multi-objective optimization, where there is a mix of continuous and discrete functions.

GA's concept is easy to understand, independent of application, suitable for multi-objective optimization (MOO), and is good for complex problems. The solutions get better and better with time.

1.28 BUSINESS PROBLEM

The secondary logistics of petroleum products in India has not been studied adequately. There are many innovative methods the industry practitioners have employed but have not been reported in publications. There have been attempts to optimize the various parts of the supply chain. However, the secondary logistics part has been primarily left to the judgment of field offices. The Linear Programming models used in primary logistics have been extended to this part also.

Petroleum Product Marketing is a low margin business, as is clear from the Annual reports of India's public sector oil marketing companies. IOCL, BPCL, and HPCL posted a net profit of Rs 10,399 Cr, 8,463 Cr, and 3,863 Cr at the turnover of Rs 4.1 lac Crore, Rs 2.2 lac Crore and 1.8 lac Crore, respectively, in the financial year 2015-16. The percentage of net profits to turnover is 2.6%, 3.9%, and 2.1% for IOCL, BPCL, and HPCL. (IOCL, 2016) (BPCL, 2016) (HPCL, 2016)
The various cost elements of the petroleum products are:

Crude Oil Price + Refining Cost + Refinery margin + Marketing and Storage Cost + Marketing Margin + Distribution Cost + Dealer Margin + Taxes and Duties
(http://www.theanalytic.co.in/downloadfile/CostofPetrolinIndiaBriefOverview.pdf, 2015)
According to BPCL's annual report for 2013-14, the distribution of each Rupee earned is given as per the following table:

Table 1.4

Distribution of Each Rupee Earned by an OMC

Distribution of Each Rupee Earned	Year	
	2013-14	2012-13
Raw Materials, Purchase of Product for resale and packages	87.43	87.98
Duties, Taxes, etc.	4.41	4.58
Transportation	1.64	1.52
Stores and other Operating Expenses	1.96	1.74
Employees' remuneration and other benefits	1.06	1.1
Interest on Borrowings	0.5	0.72
Depreciation	0.82	0.76
Income Tax	0.69	0.55
Dividend (including Corporate Dividend Tax)	0.52	0.37
Retained Profits	0.97	0.6

(BPCL Annual Report, 2013-14)

The data of the above table shows that material and taxes account for over nine-tenths of expenses. India, being an importer of 83% of its crude requirement, does not control the prices of raw materials. The government of India is aiming to reduce import dependence by ensuring bio-fuel

dosing in auto fuels. 10% Ethanol dosing in MS has been mandated, and Bio-Diesel dosing of 7% in HSD has been allowed. Dosing of 15% Methanol is also under consideration. However, the buyer's power of the Oil importing countries is low. The crude pricing is determined by the Oil producing companies who regulate their production to keep crude prices under their control. Also, there are no credible substitutes for petroleum products, so the market is supplier controlled.

Duties and taxes are sovereign functions, and the oil industry has no role in it. Auto fuels are heavily taxed as these are essential commodities and have very low-price elasticity of demand. The prices are supplier determined, and customers cannot bank upon the substitute products. However, the difference in the price of MS and HSD does change consumer behaviour while buying automobiles. The customers bought more Diesel vehicles when the price of Diesel was much lower as compared to MS. However, the trend reversed when the price difference was reduced. The other major expenses are Operating and transportation expenses, which are controllable and have a sizable contribution to the industry's expenses running on low margins. The transportation cost of OMCs in the last Nine years is tabulated as under:

Table 1.5

Transportation Charges of OMCs from 2010-11 to 2018-19 in Cr Rs

	2018-19	2017-18	2016-17	2015-16	2014-15	2013-14	2012-13	2011-12	2010-11
IOCL	13310	12395	11832	12157	10630	9690	8623	7509	6894
BPCL	6930	6160	5644	5349	5004	4467	3824	3320	2855
HPCL	6161	5863	5318	5391	4997	4639	3785	3255	2887
Total	26401	24418	22794	22897	20631	18796	16232	14084	12636
% increase	8.1	7.1	-0.4	11.3	9.8	15.8	15.3	11.5	

Source: Compiled by Author

Table 1.6

Product Sales of OMCs from 2010-11 to 2018-19 in Cr Rs

	2018-19	2017-18	2016-17	2015-16	2014-15	2013-14	2012-13	2011-12	2010-11
IOCL	79.97	77.13	74.11	72.6	68.47	67.14	68.62	68.1	65.31
BPCL	43.3	41.38	37.68	36.53	34.45	34	33.3	31.14	29.27
HPCL	38.71	36.87	35.23	34.19	31.95	30.96	30.32	29.48	27.03
Total	161.98	155.38	147.02	143.32	134.87	132.1	132.24	128.72	121.61
% increase	4.2	5.7	2.6	6.3	2.1	-0.1	2.7	5.8	

Source: Compiled by Author

Compiled by Author from Annual Reports of the companies.

An analysis of the annual report of all three Oil Marketing Companies (OMCs) in the public sector throws an interesting insight into the transportation expenses in the last nine years.

Indian Oil Corporation Limited (IOCL) is the largest OMC, having spent Rs 13,310 Cr on transportation for a total sale of 79.97 MMT in 2018-19, which is a 7.4% increase over the previous year against the rise in sales of 4.2%.

Bharat Petroleum Corporation Ltd (BPCL) has spent Rs 6,930 Cr in the transportation of 43.3 MMT product in 2018-19, registering a 12.5 % increase over the last year, whereas sales increase was 4.2%

Hindustan Corporation Ltd (HPCL) has shown Rs 6,161 Cr for trans-shipping, which increased 5.1% over last year for trans-shipping 38.71 MMT product, a 5% increase over last year.

Combining all three OMCs figures, the average transportation charges in 2018-19 have increased by 8.1% against a 4.2% increase in sales. In other words, the oil companies have incurred a notional loss of 4.1% on the transportation charges of Rs 26,401 Cr amounting to Rs 1,082 Cr.

A similar analysis in 2017-18 shows a 7.1% rise in transportation cost against a 5.7 % increase in product sales.

It can be concluded that the transportation cost of OMCs is increasing even after discounting for the increase in sales. This increase is despite an increase in pipeline length, which has reached 21,460 Km and 156.6 MMT (PPAC, Feb'2020) throughput of the three OMCs in the primary logistics and should have reduced overall transportation cost.

It is evident out of the three modes of transportation, i.e., Rail, Sea, and Road, the cost of transport is highest through road. The cost is high because dedicated carriers are used, and round-trip distance is paid to the transporters. The capacities of the tank trucks used are low, and their operating cost is high compared to other modes. Since the last mile connectivity from storage terminals to retailers or consumers is essentially through road, the entire secondary logistics is through road only.

North India has the most complex logistics with multiple sources, multiple modes of transportation, and higher logistics costs due to its distance from the sea. The secondary logistics framework developed for it can be easily replicated elsewhere.

BUSINESS PROBLEM STATEMENT:

Oil Marketing Companies in India incur high secondary logistics costs without increasing sales, thereby denting their margins significantly.

1.29 RESEARCH OBJECTIVES

1. To Identify the factors of optimization in secondary logistics in the downstream petroleum industry.
2. To determine the relative importance of factors in optimizing secondary logistics of MS and HSD in North India.
3. To develop a framework for optimization of secondary logistics and validating it.

1.30 ORGANISATION OF THESIS

Chapter one gives the introductory details about the Petroleum Industry, Supply Chain Management, objectives of the research, Business problem, an optimization technique.

Chapter two describes a detailed literature review done based on the objectives of the present thesis. The literature review is used for identifying the variables and components of optimization using related industries and supply chain components as direct references to secondary logistics of downstream petroleum industry optimization are not available.

Chapter three explains the research methodologies used for each of the objectives. The surveys conducted to collect the primary data have been described, and relative weights have been determined using Analytic Hierarchical Process (AHP).

Chapter four explains the methodology for factor analysis using SPSS.

Chapter five demonstrates the use of AHP to find out the relative weight of each of the factors identified.

Chapter six describes the process of construction of the framework using the Delphi Method.

Chapter seven demonstrates the Evolutionary Genetic Algorithm method for Multi-Objective Optimisation of auto fuels' test market using the framework.

Chapter eight provides a conclusion, contribution, limitations, and scope for further study.

CHAPTER 2

LITERATURE REVIEW

2.1 INTRODUCTION :

Petroleum is one of the prime sources of energy globally and is required worldwide as a prime mover to their economies (Kimani, 2013). The petroleum supply chain's logistics function starts at the oil wells and ends at the final customers. Crude is primarily shipped in ocean tankers or pipelines (Shaban & Khan, 1995).

The refinery products have two kinds of distribution in their journey to reach the end consumers. The primary distribution involves the dispatch of products from the petroleum refinery complexes to the storage terminals. The last mile of the product from storage terminals to the customers or retail outlets are secondary logistics. The modes in the primary part of the supply chain are pipelines, ocean tankers, and railways, whereas, in secondary logistics, the retail outlets are connected through road and have small volumes of supply, so they are essentially fed through tank trucks (Sahebi & Nickel, 2014)

There are five primary sources of energy: hydroelectricity, coal and lignite, renewables, compressed natural gas, and nuclear power. (Cohen, 2016). The gasoline industry is facing heat to stay competitive. In the marketplace, globally, due to the uncertain nature of demand and fluctuations in the crude oil prices. Due to this, the petroleum industry looks for every opportunity to increase its profit margins. Most major oil companies are vertically integrated because of the reason that these companies operate at low margins and try to maximize volumes to improve their bottom lines. In PSC, the refiners and transporters face many uncertainties, so they confront many risks (Yang, 2014)

A literature review about refinery planning models under uncertainty reveals that LP, NLP, MNLP, and MINLP models have been extensively used. (Leiras, Ribas, & Hamacher, 2013) uses the linear program in two stages in Brazil. The model has two stages and provides structural and temporal integration. The model is suitable for practical and operational level plans in many refineries operating within the network. Fuzzy programming has been used in literature for solving multi-objective logistics problems. The approach has a feature that the objectives can be evaluated both

at an individual and global scale. The preference of managers is accounted for by giving relative weights. The objectives are evaluated globally, and a balanced programming model is established. There are various methods covered under this model. (Li & Lai, 2000)

The business environment is dynamic. There are multiple participants in the chain, which makes it complicated to plan and design PSC. The models have to be suitable for different time horizons, have various objectives and levels, and encompass multiple products. The models have to make changes per market conditions, consider the environmental concerns, and be competitive. These should consider diverse stakeholders interests (Moradinasab et al., 2019)

Crude oil moves from exploration sites to the seaports and then from there to the refining centres. The finished products from refineries move through various stages to reach retail outlets (Chandra, 2013). Petroleum products are MS, HSD, Aviation Turbine Fuel (ATF), FO, Light Diesel Oil. Bitumens, Liquefied Petroleum Gas, Wax, Petcoke, and many others. The modes of transportation are railways, ocean tankers, tank trucks, and cross country pipelines. The ways of transport used to move these products from refinery to the storage terminals are primarily pipelines and railways Pipelines are considered to be ideal as these are environment friendly and safe, so they are used extensively (Adeleke, 2012)

(Stevens, 2017) SC requires an integrated approach for the movement of materials at the strategic, tactical, and operational levels. The company has to evaluate and measure such movements' performance, the stock levels maintained, service delivered, the vendors' performance, and cost-efficiency. In most cases, petroleum oil moves from refineries to storage terminals through pipeline and rail. In the coastal areas, ocean tankers are also used. The movement through the road is restricted to local supplies only and is prevalent during secondary logistics. It is independent of the primary logistics.

The logistics of petroleum products ends there as the customer usually moves to the retail outlet to get the product. However, recently the door delivery service of petroleum products has been permitted in India, and the OMCs and start-ups are toying with this idea.

The OMCs operate at very thin margins; therefore, the optimization of their supply chain is vital as any reduction in logistics or operational expenses results in considerable savings. Hence the optimization of PSC is the centre of attention (Gainsborough, 2006). The importance and complications involved show a need for optimization, but PSC optimization is still at the infancy level only (Hussain, 2006)

The requirements of upgraded fuel specifications and enhanced competition has led to complicate the PSC and has imparted inflexibility (Gainsborough, 2006)
In PSC, the long distances leading to high transit durations, limits on refining capacity, and limited modes are the significant causes of inflexibility. The geographical separation between the source and destination, low speed of movement results in increased lead time. The slow pace affects service levels to customers who are forced to keep expensive safety stock of these essential commodities (Hussain, 2006). The two factors which reduce the lead time and ensure product availability are the trustworthy, consistent transportation system and stock positioning as near to the consumption centres as possible. Such a design of PSC enhances customer satisfaction (Hall, 2002)

"Jenkins and Wright (1998) have suggested that the focus has to be on the tank trucks and their crew in road transportation. They believed that the trank trucks are highly flexible parts of otherwise inflexible PSC and help optimize operations and logistics. A useful SCM model has the right IT support as there are high transit time and multiple transportation modes. These models must have a vehicle scheduling package. (Jenkins & Wright, 1998).

The models optimize cost, enhance changeability, and lead to customer satisfaction besides providing more excellent monitoring and control on the SC (Jenkins P. G., 1998). The product run out situations is avoided with the use of these models (Balasubramanian, 2002). Jha and Deshmukh (2009) stress the expenses and the service standards are the core areas to be considered. In downstream PSC, the product is dispatched either from the refinery or from the storage terminal. The number of tank trucks, the definition of the path for movement of vehicles, and the volume of the products dispatched are the elements to be considered while planning for the supply and distribution of petroleum products (Jha, 2009)

The activities of PSC can be categorized into upstream, midstream, and downstream. The firms engaged in exploring activities are classified as upstream. The midstream includes refining activity and the movement of crude from oil wells to the refineries. The movement of finished products from refinery to the consuming markets is called downstream (Leira A, 2006)

The facilities associated with PSC are set up under strategic planning. The fixing of goals for production volumes and logistics decisions are referred to as tactical planning. The assignment of jobs to individual units under proper sequencing on a daily and weekly basis is carried out under short term planning. This part of the planning process is also called scheduling (Sung, 2009). Most of the Refinery planning models are Linear Programming or Mixed Integer Linear Programming as they are less complicated than NLP and MINLP. The computational power has exponentially increased, but the use of MINLP is still a challenge.
The OMCs carry out many collaboration projects, but the same is not reported in publications due to engagements' confidential nature. This confidentiality is a significant hindrance in the formulation of a framework for optimization (Qahtani &Elkamel, 2009)

PSC involves transportation of crude oil from the exploration and production sites to the seaports, from ports to the refineries. From refineries, the final products move to the consumption centres (MOPNG, 2006). MS, HSD, Aviation Turbine Fuel, FO, Bitumen, Liquified Petroleum Gas, Lubricating oils, and waxes are commonly known petroleum products. The transportation of these products from the refinery to the retailers or end consumers is through multiple modes on the surface, railroad, water, or air. The most common mode for primary logistics is the pipeline, ocean tankers, or railways. The transportation for secondary logistics is a road only as it is the last mile of the PSC. Pipelines are considered much more economical and environmentally friendly. (MOPNG, 2006).

The managers have to see that the logistics strategy is in line with its competitive strategy. The applicable incentives should be designed to aid the attainment of targets. Traditionally the logistics were assessed based on their ability to lower the cost of transportation. Hence, the managers mainly targeted cost-cutting, but this could reduce the firm's response level and adversely impact the

overall operations cost. The organizations need to assess their logistics function on the transportation cost criteria and factor in the response level attained while delivering to a customer (Chopra &Meindl, 2013). The refining complexes are now getting into synergizing their activities by not many publications are available on this subject due to confidentiality reasons.

2.2 LITERATURE SURVEY:

The assessment of the PSC of an OMC has been explained in this article. The purpose is to change the structure of the SC by re-engineering the value chain. It concludes that the customer perspective has the highest level of importance for OMC in the public sector. (Mohanty, Dhalla, & Mohapatra, 2010)

This thesis evaluates:

1. The factory stock framework with LP while the demand for the perishable article in SC is having stockouts.
2. The manufacturing model considers stockouts and perishable articles which deteriorate throughout its life.
3. Multi-echelon supply chain stock-keeping material for linearly varying demand.
4. Multiple suppliers, one distributor on and SC with several retailers
5. The stock keeping strategy of retailer for perishable commodities while part of the sale is on credit.

(Rani, 2009)

The study is about ANN for energy SC transformation. The network is self-learning and has the regular reverse flow of information and facilities to detect faults. This feature makes it flexible and valuable. (Saini & Saini, 2014)

This study discusses :

1. Development of Multi-Objective Optimization Model to capture the trade-off between the total cost and the environment influence.
2. Design and development of Sustainable Supply Chain Architecture.
3. Spatial Analysis for eradicating environmental risks at all echelons of the supply chain.

4. Development of Decision Tools and Solution Approaches. Multi-Objective Optimization Model is appropriate for Supply Chain Management in organizations as there are multiple objectives involved, and the optimization of single factors like cost is not most appropriate." (Dhingra, 2012)

This study is about :

1. Maximizing overall delivery performance (operational perspective)
2. Minimizing penalty to the entities of a supply chain by finding optimal payment and collection periods that would minimize cycle time from investment to payback.
3. Studying the effect of inventory turnover ratio on investment to payment cycle time (financial perspective)
4. Developing a framework to assess shareholder facing performance metrics (shareholders' perspective)

Data required for analysis of research objectives have been collected from a batteries manufacturing firm. A framework is needed to provide a basis for assessing the performance of a firm and its supply chain from shareholder's perspective and to develop performance indicators from various perspectives, i.e., Operational, Financial, Shareholders, Suppliers" (Rao, 2011)

The SC of an industry is handled to optimize the operation cost given limitations existing in the system. GA, PSO, and combined methods have been applied for cost optimization. (Dhanalakshmi, 2014)

"Performance measurement that links the company's strategy to operating decisions Inbound logistics have been identified as the weakest link owing to its least aggregate weight, followed by outbound logistics, etc." (Sarode, 2010)

The research presented in this thesis aims at developing a performance assessment model for the organizations having considerations of stock-keeping. There is a need to focus on flexibility, and the organizations already flexible must have high growth. This study identifies the issues the liquified petroleum gas dealers face and has made observations for the managers to adhere to. The agencies in the cities and villages are a part of PSC, where there is a forward movement of filled LPG cylinders and backward movement of empty cylinders for a refill. The study has Proposed a

model implementation strategy, which makes the business processes more effective and highly responsive by reducing both the defects and operating costs to achieve high customer satisfaction. (Sriyogi, 2014)

The paper reviews the medium- and short-term scheduling, planning and discusses practical modelling approaches to integrate scheduling, planning, and strategy. Integration leads to better solutions. (Maravelias, 2009)

The paper identifies the hierarchical components of performance measures; Strategy (top-level), Objectives (Business- Unit level), Operational level (operating system), and customer level (customer satisfaction). Considers the integrated approach, but measures of quality and delivery are not explicit. (Lynch & Cross, 1989)

The model performed the optimization and assessment of the performance. This model takes inputs such as material requirements, transit duration, requirements of customers, and service levels. It generates the inventory level at each storage point location for intermediate and finished products. This model has been used to optimize stock levels and reliable customer service. The model fails to address the dynamic requirements of demand and supply. It assumes that all orders are filled with a possible delay, which may not be accurate in actual operations. (Ettl, 2000)

The model considers the supply chain with the infrastructure sequentially arranged. This model's primary consideration is the uncertainty associated with the variation in customer requirements and the risk of delivery all through the supply chain. The fuzzy method is used to determine the optimum order in each of the stock points along the supply chain based on decentralized stock control practices and collaboration among the partners. The simulation method has been used in a dynamic environment to examine market variability and assess the supply chain's performance levels as a whole. (Petrovic, 1999)

The technique is used for the analysis of benchmarking SC using weighted scores. It uses a single score based on the perception of the user to give results. It can be used for benchmarking hotel

service supply chains. The score used for benchmarking is subjective. The rank reversal problem is challenging. (Min, 1997)

The paper identifies four issues: financial, customer, Business, innovation, and learning. Reflects on the holistic approach of SCM and nonfinancial perspective are highlighted. This model does not consider competitors' perspectives.
(Kaplan, 2009)

The proposed model helps assess supply chain performance at the top management level. It consists of the perspectives of consumers and intra-company perspectives. The focus is on reliability, responsiveness, and flexibility. Reliability has been defined as fulfilling the order as per specifications. Responsiveness is related to the time taken in order fulfilment vis-à-vis the promised delivery period. The flexibility in the supply chain is the adaptability to dynamic market situations. The internal-facing perspective consists of costs and assets. In SCM, the cost component and expenditure on the sale of goods have been considered. The asset component consists of investment to payment cycles, return on assets, and working capital. This conceptual model is suitable for manufacturing organizations, but many soft issues related to retailing are not covered. (Chan, 2003)

This paper formulates a technique for the assessment of the performance of PSC using a design approach. A combination of analytical hieratical process and BSC has been used for assessing the performance of PSC. The importance of PSC performance management factors has been listed in the hierarchical order as customer perspectives, finance perspectives, internal business perspectives, innovation perspective, and learning perspective. The most important factors have been identified as the product's quality, the market share with the OMC, reliable raw material supply, and utilization of information systems (Varma, Wadhwa, & Deshmukh, 2008).

The paper tells the success story of Honeywell SCM solution RPMS (refinery and petrochemical modelling system) adopted by IOCL in supply chain planning. The earlier method of function wise planning could not cater to the market fluctuations in a serial manner. Synergies among the various

materials purchase, production, marketing, and transportation were used to maximize the organization's bottom line. Honeywell's model applied to the whole of the PSC of IOCL from the selection of crude, transport to the ports, ports to refinery gate, and the product's movement up to the storage terminals. However, this model does not cover secondary logistics from the storage terminals to the consumer or retailers. (Honeywell, 2005)

The companies have not recognized systemic risk in the PSC and traditionally have an affinity towards efficiency improvement using LP. Organizations have realized that the supply chain strategies have to be reoriented to formulate resilient supply chains, which are the key to the organization's success. Resilience encompasses both agility and flexibility. The processes in the supply chain can be more collaborative with greater transparency of information sharing. (Christopher & Peck, 2013)

The dissertation is about SC of petroleum refineries, especially when the functions like crude procurement, shipping, terminal, refining, storing, lending, and dispatch distribution from the refinery to the distributor. Data sharing between the sales force and refineries can help meet the oil industry's coordination challenges. (Paul, 2012)

The article is about the use of RFID technology for the identity and tracking of vehicles. Use of Global Positioning Systems for intelligence gathering and computation of work and analytics and making use of extensive data. The paper simplifies the supply side of the fuel and retailers through automation. The paper proposes RFID technology for using a time management system. It works on a replenishment model for the supplies. The work done by the vehicles can also be measured through GPS. The benefits would be optimizing the fuel supply chain and imparting greater efficiency to the chain's vehicles. (Ankalikar & S, 2014)

This model aims to maximize the supply chain's bottom line by integrating the various activities under variable and uncertain demand at the tactical decision-making level. This model has two stages, and the variability has been incorporated into the price and demand. The study has been

conducted in Brazil with industry data. It has concluded that there are advantages of factoring in the risk and variability in decision-making and has demonstrated the suggested model's effectiveness. Spatial integration has been mooted for the optimization of resources in PSC. (Ribas, Leiras, & Hamacher, 2011)

The paper applies multi-agent technology to make SC faster in the petroleum industry. Such an approach has been found superior to the Gaussian approach using simulation. (Sinha, Tiwari, & Chan, 2011)

The report provides the data on the Oil and Gas Sector in India; the primary logistics in petroleum is conclusively optimized through pipeline mode. (Petroleum Planning & Analysis Cell, 2015)

The article provides a framework for improving performance, and a lean manufacturing technique has been suggested. The framework has been woven around the company's various levels using parameters for the measurement of performance. It has mooted a framework based on the structure of interrelated decisions with eight parameters and 66 sub-parameters. The improvement in the measurement of lean manufacturing parameters has been obtained as a scorecard utilizing a multidimensional performance model. (Susilawati, 2013)

HPCL co-created vision, strategy building by cross-functional teams, and BSC use in strategy execution, evaluation, and monitoring. The paper identifies the steps for organizational success and involvement of people in each corporate vision, strategy, balanced scorecard processes, and deciding routine work. (Sen, 2013)

The paper classifies various differentiated products and assigns importance to their characteristics in creating a vibrant SC strategy. Organizations are capable of setting up excellent SCs with innovative products with a policy to utilize cost optimization. The improvement in efficiency and agility in the utilization of resources helps build successful SC.(Seifert & Biçer, 2014) The paper studies the SC practices in Exxon Mobil. Analyses literature and interacts with industry experts.

Identifies issues with the downstream sector and concludes that the shift towards a holistic supply chain is slow. (Manzano, 2005)

The report provides Indian and international scenarios in the petroleum and Natural Gas Sector. The thrust areas of the Petroleum and Natural Gas Sector have been identified. (Working Group, 2006)

A comparison of measures of SC has been identified and categorized based on the literature case study. The paper describes various steps in the production function and economic aspects. The lack of coordination among the different organizations has been highlighted, leading to overlooking social and environmental considerations. (Cuthbertson & Piotrowics, 2008)

The article targets the development of customer-focused e-commerce to attain energy security in the petroleum sector. The IT adoption pattern of top oil companies has been studied. An SC based on e-commerce is critical for IT adoption in PSE. (Wei, Ende, & Lin, 2009)

"The paper studies the pricing in the downstream sector. The policies of the government are likely to achieve their objectives but at a huge fiscal cost." (Clarke, 2010)

"A comparative analysis of the most cited performance measurement systems has been undertaken A comprehensive SCPMS suitable to an organization and its and which are implementable are yet to realize." (Kurien & Qureshi, 2011)

"The thesis studies the SCM in Nagarjuna Fertilizers and Chemicals Ltd, Kakinada from sourcing to manufacturing to distribution. The study measures various performance parameters of the company." (Bondada, 2013)

"The paper studies SCC (Supply Chain Collaboration) of open and closed types of firms, the impact of uncertainty avoidance and social trust on firm-level relationships. Uncertainty avoidance and social trust harm SCC in open firms. National cultures are to be taken into account in SCM decisions." (Qu & Yang, 2014)

The article discovered the effects of the market-facing approach in supply chain management. Collaboration, commitment, confidence in each other, and innovative approach are the key parameters measuring the supply chain's market orientation. (Karami & Malekifar, 2015)

The report gives a Sales Trend analysis of the petroleum industry. The data shows high growth in MS and HSD. (Davar, 2015)

Developed metrics to help improve a firm's visibility of supply among partners and better decision-making. Product quality and variety had some differences in their importance and effect score but no difference in their total measure score. (Shashi & Singh, 2015)

Paper details the successful implementation of mathematical programming in Citgo Petroleum Corporation. The firm used the Supply Distribution Marketing (SDM) Model to achieve optimization in downstream marketing (Kingman et al., 1987)

The US food market is moving from mass to segment. The industry has to emphasize various but consistent quality levels for both upscale and downscale customer segments. (Cook, 1990)

The paper discusses ways to optimize costs in the downstream petroleum sector. The use of technology for inventory and distribution management can lead to optimization. (Keller, 2012)

The paper identifies salient factors influencing Ethiopian Export Trade Logistics Intermodal competition should be encouraged. (Kebede & Hussen, 2015)

The case study explains the Delhi Mumbai Freight Corridor Project's economic, social, and environmental impacts. This Project will significantly impact CO2 emissions. (Pangotra & Shukla, 2012)

Theories of Distribution Network Optimisation and supply network complexity analysis have been discussed. The thesis identifies the need to develop a software tool to study and control the whole distribution network. (Battini, 2008)

A mathematical model has been developed, aiming at total cost minimization and service level maximization. Ant Colony algorithm has been used and compared with heuristics. (Chan, Shekhar, & Tiwari, 2014)

Case studies have been used to identify how logistics activities among various firms will be planned and executed. Companies willing to share resources and information and risk and benefits stand to gain from working together. (Audy, Lehoux, SophieD'Amours, & Ronnqvist, 2010)

The paper investigates the critical factors of SC in the Indian Automobile Industry. Lead Time and Order Entry methods are the most dominant vital factors. (Katiyar & Barua, 2015)

A multi-objective model has been introduced for minimizing internal cost, CO2 emissions, and air pollutants MILP Model with heterogeneous fleet and time windows have been presented. (Molina, Eguia, Racero, & Guerrero, 2014)

The paper discusses the role of IT in SCM. The firms using IT gain a competitive advantage. (Manappa, 2014)

The Fuzzy AHP model is used to select maintenance policies within the petroleum industry. A sensitivity analysis validates the proposed model(Abdel & SAD, 2016)

The Chemical logistics sector in Germany has been studied in this article. The logistics activities in the chemical industry in Germany are frequently outsourced. (Schwenner & Kubler, 2016)

The meaning of value has not been defined due to theoretical, definitional rigour. The word value should be dropped, and Money, cash, or profit should be used. (Francis, Fisher, Thomas, & Rowlands, 2014)

The case study distinguishes the SC of the petroleum industry from the regular discrete manufacturing industry. The SC performance has not been studied adequately in the Petroleum Industry. (Varma, Wadhwa, & Deshmukh, 2007)

The article details a research problem, method, organization, data collection, analysis, and making sense of the data and publishing. The article narrates the journey of a qualitative researcher. (Dasgupta, 2015)

"The authors introduce the concept of sustainability to SCM through literature review A framework formed along with the resource-based view, transaction cost economics and population ecology" (Carter & Rogers, 2008)

The paper tells about popular software packages and best practices in exploratory factor analysis Information regarding extraction, rotation, several factors, and the sample size is provided. (Costello & Osborne, 2005)

The DEA tool and its application to petroleum engineering have been discussed; the method has been hardly used in the oil industry. (Bezerra, 2017)

SCM involves objects like cost, service level, resource utilization. Through an experimental study on the plastic industry in Turkey, A new solution procedure based on a genetic algorithm to find a set of Pareto optimal solutions has been used. (Altiparmak, Gen, Lin, & Paksoy, 2006)

Multi-Criteria Decision Making has been reviewed through 90 published papers AHP is the most popular technique followed. (Phekar & Ramachandran, 2004)

Fuzzy AHP has been used in the model, and there are considerations for the cost of operations, quality of the product, transit time, and sustainability. Fuzzy multi-objective LP has been utilized, and weights have been assigned to various elements, e.g., production costs, quality failures, delivery failures, environmental concerns, and demand. (Shaw, Shankar, Yadav, & Thakur, 2012)

The paper is about the importance of assigning weights in terms of references, the Pareto optimal sets, and objective functions. The authors conclude that blind use of this method should not be encouraged. (Marler & Arora, 2009)

A trade-off between total cost and environmental influence has been studied through numerical experiments. Sensitivity Analysis shows that capacity enhancement can reduce carbon emissions. (Wang, Lai, & Shi, 2011)

AHP is a theory of measurement by a method of pair-wise comparison and based on experts' opinions. The consistency has been measured to improve judgments. (Saaty T., 2008)

With AHP and ANP, one constructs hierarchies or feedback networks to select the best alternatives. The various pillars are pair-wise comparison on a reciprocal basis, use of eigenvectors, homogeneous nature of data, synthesis, and group judgment. (Saaty & Vargas, 2012)

The modern SC is a global network of material providers, manufacturers, storage centres, distributors, and retail outlets. The materials are procured in the raw form, converted into finished products, and finally transported to the customers. In recent years, development in information technology has enabled the management of SC at both tactical and operational levels. The software used to have agents that control and monitor the activities and have interlocks with other agents while formulating plans and execution. This paper describes a framework for agent-oriented software architecture for SCM. (Fox, Barbuceanu, Mihai, & Teigen, 2000)

This paper deals with the requirement of SCM methods to give practical solutions. The tools used in the study are pretty trendy. Distribution network design and activity-based management have been used to cut the cost and increase the value proposition to a considerable extent. The achievement of any SCM design depends on the information systems available and deployed. The study emphasizes the competence of the handling persons. These systems have been highlighted to reduce the expenses and increase the firms' brand value in SC (Vasant, 2000).

The firms used traditional trade practices and policies for organized SC. While the jobs are given to various firms across SC, the ultimate aim is to improve the supply chain's long-term value. (Mentzeret, 2001)

SCM has become a potent tool in the hands of organizations. This paper gives SC networks a framework with increased data flow and visibility of activities to all the supply chain members. The model provides for the distribution network, which can acquire and purchase the goods. The technique offers certainty to the supply chain activities and views various issues during this technique's usage.
(Kumar, 2002)

The primary differentiation between analyzing a distribution system and supply chain is that we consider the clashing objectives from the two different departments or firms while analyzing a supply chain, e.g., we reduce the manufacturing cost at the producer end by considering the cost of delivery at the distributor's end. Similarly, reducing delivery expenses on the distributors' end, we may have to alter the package size affecting the delivery cost, and the performance on the lead time may also change. Sending large shipments may increase the delivery cost but may reduce the production cost due to more units produced in a single set up of machines at the production centre. Production scheduling has been researched widely, but almost no publication is available to combine the supply chain's two operations. Decision-making in the supply chain is hugely crucial for most of the organizations which exist today. (Pundoor, 2005)

Knowledge Management is an efficient technique that is being widely used worldwide. The fundamental difficulties in SCM include maintaining efficient SCs in a global context. International SCs are most difficult as they have many interdependent organizations with different policies, administrative environments, and SCM exposures. The emerging international outsourcing SCs have to depend on enterprises' necessary skills to get the best price for the clients. KM has a great capacity to usher new opportunities and provide more value. The use of KM tools leads to improved SCM. (Wadhwa, 2005)

There are various devices available for interaction among the suppliers. Innovation and strategy are the cornerstones of SCM in all industries. It is an essential tool for building the competitive advantages of organizations. This study uses the use of sustainability as a differentiating factor by the firms. SC has been used as a powerful technique for environmental strategies. The firms are devising various methods to interact with suppliers on sustainability issues. The performance of devices has been assessed for sustainability policy and carrying out a SWOT analysis of organizations. A general method of the criterion for sustainable SCM has been devised, which uses a strategy for the whole system. (Fitzgerald, 2007)

The change in market conditions decreases the performance of SC as the earlier created capacities are unutilized, and there is a higher level of inventories in the system. This change leads to a reduction in customer service and an increase in cost. Organizations are increasingly turning into lean production methods where the production is demand-driven, and the strategy is to create material pull. This strategy leads to flexible SCM, where the needs of the customers have been analyzed. This method allows production to be flexible as per the needs of the customers. The final customer and the demand focus on the entire production line, thereby reducing wastage and losses. SAP LPO provides a solution for levelling production. (Chakraborty, 2008)

Each of the organizations of the value chain has a distinct responsibility in SC e,g. If a customer requires to change its purchase method, the supply chain has to take the product designers and engineering groups of the suppliers into confidence to fulfil the demand. This paper discusses many issues relating to poor supply chain performance. The performance of the suppliers and the business strategies of the competitors has to be considered. The individual organizations in the SCM may have different targets and strategies. The SCM has to focus on client service while considering the goals of the particular organization (Lee, 1992)

This paper gives a brief of the pre-requisites of effective supply chain management. The study has been put in an Indian perspective and carries out strength. Weakness. Opportunities and threat analysis of logistics issues. It has emphasized the use of IT and telecommunications in improving supply chain management. Several case studies have been narrated from the SCM perspective, and operations research methods have been widely used for logistics systems design. The issues

involved in perishable commodities logistics have been widely discussed, emphasizing fruits and vegetables. Methods have been recommended for improvement in their supply chain. The problems have been discussed at length, and the approach needed to overcome these challenges has been proposed. There is an assumption that the issues involved in India's perishable commodities trade are available in the literature, so the various problems have been categorized, and multiple factors have been identified, which are influencing the supply chain of perishable commodities (Vrat, 1999).

The business power structure has transformed, and the competition has risen to astronomical levels. A supply chain's performance has to be measured continuously, and analysis must be carried out regularly to maintain the organization's competitive advantage. This paper has proposed an enhanced performance measurement system for a soft drink stockist's supply chain in India. The parameters have been classified, and a method has been submitted to measure improvement and growth. The objectives of the supply chain have been calculated and validated through a matrix. (Deshpande, 2009)

The paper explains the various techniques of integrated logistics and considers the significance and functions of transportation. The multiple issues encountered by the suppliers, shipping companies, governments, industries, regulatory authorities, and consumers have been described in the paper. The pros and cons of various administrative measures have been examined, and the benefits of using information technology have been emphasized (Vijayaraghavan, 1999)

This paper discusses the commoditization of transportation networks where buyers use their bargaining power to reduce their logistics costs. The transporters have to be flexible to meet the challenges. While cutting the cost of transportation, the SC has to remain responsive; otherwise, the customer's service is significantly reduced (Bask, 2001).

The organizations have become global, and the logistics cost has great significance. Organizations face significant challenges in deciding upon an adequate transportation mode within their budgets and customer service requirements. Road transport is commonly used for short distances and smaller delivery parcels. Waterways are very cost-effective for long hauls and big consignments.

However, the logistics cost is to be optimized by considering various factors. The firms have to be clear about the duration and logistics cost issues. The demand forecasts have to be accurate for designing an effective transportation system. (Smyk, 2010).

This study explains the process in the logistics industry. It provides the various techniques for selecting transportation modes and considers various constraints while optimizing the transportation system. The process and advantages of outsourcing have been explained in this study. The process begins when the transporter receives goods from the consigner, and the process ends when the customer has received the articles. Since the organizations and manufacturing processes have become international, the process starts with receiving the manufacturers' goods and dispatching them through multi-modal methods. The stacks are exchanged among various modes before reaching the end consumer (Marx, 1978).

The study elaborates on the potential of the use of multi-modal transportation in tropical Africa. It aims to develop an MTO (Multimodal Transportation Operations) for international shipping and transportation companies. The framework makes assumptions regarding African Government policies while creating a framework. The experience gained in developed countries has been used to develop Africa's framework, where the political and economic environment is different (Filani, 1978).

The manufacturing plant's finished goods are moved to the distributors and then finally to the customers using various transportation modes. The method of delivering to the customer is known as door-to-door service. The containerization of logistics has significantly improved the benefits as it has now become possible to use multi-model methods of transportation for a single consignment. The containerisation has dramatically enhanced SCM performance. (Alderton, 1995).

The world has recognized multi-modal transportation as an efficient means to move consignments internationally. The various modes of transportation have different advantages. The multi-modal approach has made it possible to exploit the different methods to transport goods across the

continents and nations. The service quality has improved. The travel time has reduced, and efficient logistics have improved the countries' income by adopting them. The most noticeable change had taken place when containerization came into existence. This process has acted as a catalyst in the process of transformation of logistics. Multi-modal transport across the world would not have metalized without containerization. The multi-model transportation logistics has fully utilized the benefits of containerization. It is the process that has revolutionized the logistics industry (Guibin, 1999).

Multi-model logistics have become the cutting edge for competition in international businesses. This paper describes the various patterns emerging for business transformation and strategies in international organizations. The process of globalization, shifts in the businesses' power structure, need for the organizations' agility, and change in trading practices have been observed and described in this report. The "speed has defined the supply chains' effectiveness to market," and flexibility has been used as a competitive advantage by the supply chains (Rondinelli, 2000).

This study is about the congestion of vehicles in the Netherlands, where transportation expenses increase because of traffic jams on roads. The manufacturing systems have been planned for the timely movement of materials. However, the congestion on the streets is causing inventory in the system and reducing the efficiency of SC. The transporters are motivated to use multi-modal transportation, e.g., road- water and road-rail combination. The study finds that 7% of the expenses can be attributed to traffic jams. Multi-modal solutions have been proposed as the delays are adversely affecting the logistics (Schijndel, 2000).

The supply chain approach envisages the involvement of various firms in a logistics operation. Containerization of transportation has enabled logistics providers to offer services from door-to-door services across nations and continents, requiring multiple transportation modes. Multi-modal transport and containerization have several benefits which logistics providers around the world have exploited. However, in India, this industry is still at the nascent stage, so it has not significantly reduced its logistics cost (N. Viswanadham, 2001).

This study provides an overview of the multi-model logistic system' ss progress in India. There is a need to provide uniform standards and a framework for multi-modal transportation activity to take place. The various factors of logistics optimization have been discussed (Ravi, 2001).

The supply chain has to be a collection of various organizations linked to each other and is dependent on each other for multiple technical and administrative activities. The members may be directly or indirectly involved in the activities of SC. These organizations may be in different locations but contribute towards the efficient supply chain management system by pooling their resources and competencies (Rudan, 2002).

The logistics providers are packing their products in containers and are providing services from door-to-door and office-to-office, using the modes of air, water, and surface transportation. The network of organizations is providing reliable services to customers by adopting an optimized sequence of activities. These activities are integrated using various agreements during the multiple phases of the journey of the product. These agreements are flexible to multiple members of the supply chain's responsibilities and comply with the regulations. These agreements are capable of handling a new multi-modal transportation system. The most recent of these, the UNCITRAL draft, in marine: it works to the ocean stage; however, it is applicable for door-to-door services. The unimodal law obstructs this. This study tends to the issues experienced by the determining element of this type (Malcolm, 2002).

This paper studies the railway networks used in intermodal transportation and challenges the research in the field. It proposes an alternate autonomous research field that should be established for intermodal rail transport study as it has distinguishing features from other inter-model logistics. It examines 92 publications with a specific goal to recognize the differences in characteristics of researchers in multi-modal sectors and their technical know-how. The study considers various phases of publications viewing the present state and getting some guidance for the future. As opposed to the earlier circumstances where distinctive means of transport functioned as independent elements, at this time, distinct modes are more integrated and organized. Presently, transportation by multiple modes is offered in a combined offering. It can be seen as an option of unimodal transit based on high travel duration and quantity transported (Bontekoning, 2004).

This paper is about studying models used for the movement of goods within a supply chain from the perspective of emerging economies. The supply chain ensures the movement of goods and information within the partner organizations. Similarly, in multi-modal transportation, the framework's objective is to move the goods faster from the consignor to the customer with minimum expenses. The containerization of global logistics has been elaborated in this study. The pros and cons of multi-modal transportation have also been elaborated. The interaction among the partner organizations, the influence of mediators, manufacturers, and partner organizations have been discussed. The specific problems faced by the emerging economies have also been elaborated in this article. The nationalized transport system has been mainly studied in the context of Bangladesh (Dewan, 2005).

This study refers to East and West Europe's transportation companies. It provides four options for these firms. These can either provide complete service, be in container trade, do ferry operations, or be in ro-ro service. Those opting for full-service operations have to develop an international network of transporters and have excellent data management services available to them. Such an option is available to big corporates or super agents only. The container operators of the old socialist economy have an inherent advantage of being low-cost agents. They can make deliveries in Europe. The option of container feeder business is not viable. It is already saturated by the multiple agents vying for space, and it becomes challenging for the new market players in Europe (Lauri, 2006).

This paper studies supply chain event management in the multi-modal logistic context. Various associations contribute to the movement of consignment from the source to the destination. The supply chains need to have the ability to "sense and react" to quickly respond to the supply chain events. The study proposes an analysis of the behaviours of the partners handling the events using simulations. The article utilizes the "colour petre ne" to form a multi-modal logistics plan. It has also suggested that future research can be carried out to demonstrate and implement planning in the logistics area. The participating companies are expected to focus on the logistics plan implementation and provide visibility to the transportation companies to respond quickly to the supply chain events and develop competency (Qin, 2008).

The study has been made to find out the benefits of sea routes and land routes in America. Supply chain logistics has been defined as the movement of commodities to various places in an appropriate and precise manner. Logistics is a primary function within supply chain management. In recent times, multi-modal transportation has become significant, and containerization has enabled this revolution in the logistics sector. The land bridges and the road network improvement in the USA have provided surface transport as an option for transporters. The logistics providers can opt for it as a model for comparing it with other modes of transportation. This paper observes transportation routes across the USA, their price, and the time taken for the shipments to reach the customer. It establishes the USA as a bridge between Europe and Asia and explains that a very long relationship in the transportation sector may not be too beneficial (Yoon, 2008).

Multi-model logistics is considered the most cost-effective method of transportation provided an excellent communication network and payment system is available with a sound technological and financial system. The movement in multi-modal logistics typically takes place in containerized consignments. The various transporters, carriage companies, and customs brokers are involved in the entire chain (Rokhlin, 2013).

In India, the multi-modal transportation industry is still in a nascent stage. There has been an active policy of the government to improve the containerization of the packages. The amendment to the multi-modal transportation act in 1993 was a step towards this goal. The GST implementation has been a milestone in developing the single market for the entire country, thereby facilitating an integrated and coordinated transport framework. The Association of multi-modal transport operators in India has brought attention towards multi-modal transportation in India. (Vivek, 2013)

The optimization of the transportation network to improve its efficiency contributes considerably towards the development of global businesses. There is a need for the development of performance parameters of modern supply chain systems. The speed to market is measured ' ss ability to compete. The handling of the supply chain using multi-modal transportation systems is considered essential, given global supply chains. The supply chains are continuously evolving and are competing with each other in the international logistics market. The efficiency of the entire system

is based on the visibility and coordination among the components. Any disturbance in the relations is detrimental to the efficiency of the supply chain (Lespier, 2013).

This report explains multi-modal and intermodal transportation. It differentiates these based on the activities they perform. This paper focuses on the performance of the transportation networks, their approaches, and their reliability. The functions of freight forwarders in organizing and supervising the teams and supporting the whole supply chain have been explained. The purpose of the supply chain is to reduce wasteful expenditure in the system and reduce operations costs. (Vasco, 2013).

This paper is concerned with the various issues faced by transporters during the movement of goods. In comparison, the routes and the locations are fixed during the strategic planning stage. The transportation time and price has to be decided for efficient logistics. The paper uses a genetic algorithm to solve the location problem using the transportation model to minimize logistics costs. The model takes into account the guarantees regarding quality, on-time service, and reasonable price. The benefits of multi-modal transportation are factored in. The modes of railway, land, and waterways have been considered wherever applicable (Zeng, 2013).

This paper deals with the various mode of transportation and conveyance during natural calamities. In urban areas, transportation framework using different transportation modes like buses, automobiles, subways, and railways have been studied, and their trustworthiness in natural calamities has been interpreted. The route selection behaviour of the people driving various modes has been observed. The article provides different tactics to be used during calamity times and the ways to administer traffic. An example has been exhibited to give the adequateness of the proposed model (Udenta, 2013).

This study deals with multi-modal transportation and focuses on the various methods for the same. It elaborates on the different development patterns in the multi-modal transportation sector globally and observes that this is the best transportation system. The silo effect of the supply chain has been explained in detail. Rail, road, water, air, and pipeline are the various modes of the European Union discussed. Multi-modal transportation has become an essential element in

facilitating export and import among multiple nations. Numerical tools developed for unimodal transport are not appropriate for multi-modal activities (Dua, 2015).

The study aims to improvement of multi-modal transportation, freight services, and consignors. Multi-modal transportation is an important trade area across the nations; this requires economic, managerial, technical, and HR competency. Accurate forecasting of the demand is essential as speculations may become very costly for the organizations, especially in areas where the markets are not mature. This study recommends the use of information technology in multi-modal transportation systems. The study is experimental and prescribes enhancement firm' ss effort to collect data regarding the conditions of the road traffic and handling of containers (Jarasuniene, 2016)

The case of a notebook manufacturing company in China has been discussed in this paper. Multi-modal transportation has been used to sell these notebooks in Europe using Rotterdam port. The long-distance multinational transport has been observed, and the route choices for various laptops manufactured in a state of China to Rotterdam port of Netherlands have been investigated. Seven accessible routes have been identified, and the first route is secure and leading to the minimum cost. However, this route has not been found appropriate, as it is not precise for this consignment. The balance between the transportation charges and the transit time for the logistics of notebooks from China to rotor them has been established (Joon, 2017).

The coastal transport of the USA has been studied in this paper from the economic point of view. The ports have been considered where the containers are being handled. The multi-modal transportation networks are vital as they are involved in the economic prosperity of the country. The availability of the global information system and analytics tools have let two the solutions two sustainability issues and reduce cost.

Since the container trade is complex, it is difficult to forecast the demand for the containers in the USA ports. The enhanced competition and evolving policies of the partner firms contribute to the uncertainty in the system. It is presumed that consignors are interested in reducing the overall cost of transporting containers from origin to the destination. The paper gives a graphical presentation

of approximate yearly transport facility demand in the USA's main ports, handling containers. The computation procedures and software design have been pursued, the transportation system and financial variables have been explained, and the model's effectiveness has been reviewed (Marit, 2003).

This paper talks about the 3rd party logistic services and recommends optimization through an algorithm for the multi-model transportation network. The advancement in the 3rd party logistics, despite severe competition from the existing transporters, progressive globalization, and diversification, has resulted in efficient SCM. The various procedures used in international multi-modal transportation networks have been studied, and the best has been recommended. By definition, multi models network uses two or more modes of transport. The 3PL (Third Party Logistics Providers) organizations have a network planning framework, a decision support system, and container tracking software. The network is based on the traditional methods were the prices. Freight and logistics nodes can be altered as per the mode of transportation decided and utilized. The routing problem has been simplified using a heuristic procedure. The multi-objective optimization method has been used to obtain multiple Pareto optimal solutions. The paper utilizes this method to get a multi-modal transportation route from Busan in Korea to Rotterdam in Netherland and reviews' ss strength (Hyung, 2006)

The efficiency of multi-modal transportation has increased significantly due to the globalization of financial services and businesses getting online. The easy flow of data across the organizations has made it easy to trade and manage logistic services. Information technology has been a great enabler and has catalyzed the performance of multi-modal transportation networks. This paper uses Petri-Net to define and analyze multi-modal transportation using a coloured time progressive extension. Information technology can significantly reduce transit time and working hours and enhance the participating firms (Wang, 2007).

By definition, a multi-modal transportation system utilizes two or more transport modes connected back to back to move the goods and individuals from source to destination. The modes of transportation and the workstations are maximized, and the route selection is carried out using

optimization methods. The multiple objectives of reducing transit time, cost of logistics, uncertainty, and risk have been discussed in the article. The route selection in multi-modal networks has been defined as a multi-criteria decision making problem (Lili, 2008).

The paper discusses transportation through containers in a multi-model setup. The optimization of various modes of transportation has been addressed to achieve better performance for the supply chain. The speed of movement of goods and expenditure during transport has been taken as performance parameters. The various transportation modes have different cost and speed characteristics. The article considers multi-model networks the most effective transportation method when the supply chain's performance is regarded as a prime consideration. The study uses a genetic algorithm technique where the time and cost have been taken as constituting elements. The weights are assigned to these elements, and a realistic example has been taken to explain the entire optimization process in the containerized transportation network. The consequences have been added, assuming it to be a linear function. In the end, the limitations of the present study have been explained. The transport time and the cost involved have been discussed in a general manner. The weights have been assigned to each of the parameters. Flexibility has been imparted using technology interventions (Joon, 2008).

This paper analyses two different models of optimization in the logistics sector. The first one considers optimization to maximize the interests of the supply chain partners, whereas the second one uses cost minimization as its objective. The author has recommended the former model as superior, considering delivering maximum value to the customers. (Shuai, 2009).

The combination of road and rail modes has been studied in this article. The constraints of railways regarding their uptime and freight pick up time have been discussed. The logistics providers have trust issues with the railways as there are cost implications during storage at the railway stations. The distributor's storage capabilities are one of the limitations, and customers' satisfaction has been taken as a prime objective (Chen, 2011).

This article discusses multi-model transportation and suggests that the storage points become intelligent while handling the containers. The workstations running the containers have complex

issues, and it becomes challenging to write the algorithms as arithmetic models. The study uses simulation to schedule the container terminal and optimize its operations. The flow of materials and scheduling of activities have been carried out using this model. The actions performed by cranes and trains have been simultaneously scheduled. This simulation has later been integrated with a genetic algorithm leading to sequence optimization. (Yu, 2011)

The study suggests that containerized movement helps mitigate the effects of natural calamities. WTO mentions that two billion containers are operating throughout the world. The multimodal nature of transportation has made it easy to move goods under a single agreement. In contrast, the actual movement takes place using two or more modes of transportation. In legal terms, a single firm is responsible for the logistics from source to destination, although various transport modes and operators are used in actual practice. The logistics provider, liable for the consignment, is also called the multi-modal transportation operator. The use of containers has enabled the logistics providers with traceability of their consignment during transit. In this study, an analogy has been made between emergency relief and the immune system of living beings. A linear programming model has been proposed to select the supply chain during emergencies from natural calamities (Zhi-Hua, 2011).

An attempt has been made to evaluate the performance of multi-modal transport through a system of indexing. Many characteristics affect-multi-modal transportation routes, and assessment of a suitable route has been elaborated using t Index system has been created to address the appraisal based on the advantages accrued to the society, innovation and the level of satisfaction of the consignor. An example explains that the system for the use of the method in assessing a multimodal transportation corridor. (Yin, 2012)

This article discusses the optimization of logistics to improve decision making in multimodal transport organizations (MTOs). There has been a tremendous improvement in the transportation facilities globally, and the inter-modal movement has picked up drastically. The study uses a fuzzy scheduling optimization model that the MTOs can use to select the routes and modes of transportation. Both financial and technical aspects have been considered in the model. The characteristics of model transport, like transit time, risk, transfer nodes and time windows defined

by the customer, have been considered. A genetic algorithm has been suggested for building an integrated transportation system. An example has been given to validate the model and algorithm. The transport cost and the time taken to achieve delivery have been considered as primary performance parameters. Reloading and distance of travel are the other elements taken into account, which can affect the cost and time of the MTO. Utilising the respective strengths of the various modes of transportation leads to the optimum utilization of resources in the logistics network. The study can further be extended by using storage constraints in the network (Wang, 2012).

This article aims to create and improve the DSS (Decision Support System) to select routes for multi-model transportation between Thailand and Vietnam. The constraints of time, risk, budget and ecological impact have been considered. The route selection has been carried out in such a way that sustainability concerns have been factored in. In the literature review, significant gaps have been identified as most of the studies use only quantitative criteria, and the subjective criteria have been ignored. This study proposes a method where objective and subjective criteria have been merged. A new decision support system has been formulated to reduce time and cost for each route selected for the supply chain. The zero-one goal programming method has been used. The study emphasises the collaboration among the various supply chain partners even if these are belonging to two separate nations. The model is flexible regarding selecting supply chain partners and routes according to the customer's demands and uses both objective and subjective criteria for deciding minimum cost and time. The method is easy and adaptable for many situations. The outcome of DSS leads to selecting the most cost-efficient route and reduces the environmental impact of the activities in the supply chain. The optimization factors have been provided weights while arriving at the decisions regarding ways and partners (Kengpol, 2012).

This article considers that a single mode of transport is incapable of fulfilling modern times' customer demands. This is why the exponential growth of multi-modal transportation associations and objective programming in container freight. The supply chain has to analyze the cost involved in fulfilling the demands and devise ways to minimise them. The study suggests a multi-objective optimization model which balances various customer needs and the time value of the interruptions.

A process has been defined to resolve the optimization issue in multi-modal transportation associations (Wang, 2012).

This article details the multi-modal transportation system and its evolution over the period. The phenomenal growth in this system has its origin in exploiting the respective advantages of various modes of transportation. There is a need to measure the performance of multimodal systems, and this study proposes a parameter model for the same. The collaboration among the supply chain partners has been considered an essential parameter, and an evolution equation has been created. The paper develops of framework where the co-evolution equations of the cargo freight are used to select among roads, railways, and sea sub-systems. The synchronization of the various modes of transportation and the combined development structure has been studied (Feng, 2013).

The containerization of logistics has necessitated the development of several ports and container handling facilities throughout the globe. In the last twenty years, various container exchange terminals have been developed in the ports. These container stations are complicated structures where multiple suppliers and shippers collaborate to ensure secure movement of containers using the ships, road transport and railways. The railways and trucks are primarily used to move these containers from the source to the destination. The ports must have facilities for the exchange of containers of various types. The workstations available at the port must be capable of handling different kinds of consignments. It is a challenging task for the port authorities to forecast the demand in various workstations. In this paper, a simulation method has been propounded which imitates the port's operations. It displays space, security entryways, rubber-tired gantry cranes, quayside cranes, trains, and trucks, arriving and departing ships (Kotachi, 2013).

The supply chains compete with each other in the private and public sectors and vying for more cost-effective alternatives for each article being transported. Freight transport is increasingly being evaluated on various parameters. IRR (Internal Rate of Return) being one of the critical parameters. The parameterization of the performance has enabled the use of algorithms to improve the return on investments. The proposed parameterization has been assessed for a cargo transport utility in Spain (Prado, 2014).

This article envisages a combination of space, time, and capacity to optimise various transportation parts using containers. Optimization has been carried out, keeping dual objectives in mind. Reducing the time and the cost of transportation are the two objectives considered in the study. A mathematical model has been created to balance the objectives under the constraints of space and mode of transport (Yang, 2015).

This article describes the various policies to reduce carbon footprints. Modern logistics has more potential for reducing carbon emissions as compared to traditional methods. The use of multi-modal transportation can address multiple environmental issues. Recent models used for the selection of routes have used the policy constraints for addressing sustainability issues. A case study has been used to demonstrate the sustainability model utilising the impact of carbon trading and carbon tax on the business (Chen, 2015).

This article has studied the transportation of containers on railways and waterways. These modes are different in their characteristics and have their respective complications and uncertainties concerning costing and slot allocation. A framework has been designed for this two-stage transportation network where revenue management has been balanced with the multiple modes of waterways and railways. The article uses containers for big consignors where a single agreement has been used for various modes. The source to destination management has been proposed in the earlier phase of the study. The programming equations have used the stochastic number to resolve long-term agreements for allocating slots and having visibility of empty slots in container terminals. In the second phase, an NLP equation (Non-linear programming equation) has been used to control the cost in a multi-product end multi-location problem having dynamic pricing. Random features have been added regarding the demand variability. Integrated slot allocation with dynamic pricing and random demand has been used to enhance the revenue of logistics providers. The model ensures the satisfaction of the variable demand (Liu, 2015).

The globalization of economies has led to the increased significance of models used to select transportation routes. The elements of sales and distribution, transportation, logistics are gaining prominence while choosing the appropriate route for the optimization. The identity of various factors used in selecting an optimised transportation path has been studied in this article, and their

relative importance has been established. The study has been carried out among the freight forwarders between Mongolia and Korea. Delivery time, cost, service level and Freight have been suggested as significant characteristics in the optimization model. The relative weights of these characteristics have been established using an advanced analytical hierarchical process, and the survey has been carried out amongst freight forwarders of these countries. The cost factor is most important while selecting the transportation route. The study shows that shipping and air segments have to pay attention to the features established during the investigation while choosing suitable transportation routes. The study offers an insight into the present position of freight forwarders in Mongolia (Ganbat, 2015).

The logistics sector has been transformed by the use of multi-modal transportation and containerization. These two trends have helped the improvement of the national economies involved in harnessing these two features. The integration of container multi-modal transportation provides a solution that can improve the whole supply chain logistics. The collaboration among various modes of transport focuses on the price, time and nature of freight transport. Since all the industries are optimising their networks, the completion is getting tougher. The transport networks are becoming congested. The challenge for the industry is to satisfy the customers and improve the productivity of the sector and provide efficient operations. Unimodal transportation is unable to meet the requirements of global SC (Hao, 2016).

This paper talks about the biofuel supply chain logistics where MIP(mixed-integer programming) model has been used. The model uses two types of transportation modes that are road and rail. The objective is to minimize the entire cost of procurement of feedstock infrastructure warehouse and transport.

The study recognises the short term (tactical) and day-to-day (operational) decisions in the outcomes. The decisions which decide the capability, capacity and location of storage yards and biorefineries are strategic. The decisions regarding the quantity of biomass to be supplied, developed, and stored are tactical decisions. The study has been carried out in Michigan province of Midwest United States. The study's outcome is that road transportation is advantageous than

railways for short-distance deliveries, whereas for long distances, the efficiency of railways is better (Zhang F., 2016).

An organization needing to move its goods from one place to another has a transportation system choice. The use of an appropriate logistics network has a profound impact on the inventory levels of the firm. The study discusses the trade-off between transportation expenses and savings in inventory expenses of a given selection of logistics. Usually, the organizations consider the transportation expenses differently, and inventory management is handled in a different Department. A reliable transportation system helps in reducing overall delivery expenses when considered, along with stock management systems. Uncertainty in incoming logistics forces an organization to keep a high inventory of components to avoid disruption in manufacturing activities. The paper advocates a coordinated strategy for logistics and inventory management. The transportation option is defined by its transportation cost, time, fixed cost and in-transit delivery cost of consignment. The carrier has to decide the order volumes and time required to deliver each of the possible alternatives. The model then selects the transportation mode and scheduling duration (Liberatore, 1972).

The selection of transportation mode is commonly known as model split, one of the most debated logistic circles. The decision not only depends on the objective evaluation of available alternatives but also the expected improvement in service levels. The speed of delivery, geographical location and density of the network have a profound impact. The selection of transportation mode has a significant impact on logistics' performance as the various modes have entirely different features, strengths and weaknesses (McKinnon, 1989).

This report describes various factors influencing the transport decisions of manufacturing companies. In many cases, there is no choice regarding the mode of transport. The policymakers have to be aware of the intricacies involved in the logistics management of enterprises. Some of the features of a particular mode may have better qualities for a specific industry than others. The inventory management systems are evolving given the current financial environment. The organizations are becoming more and more conscious about their inventory costs and endeavour to reduce their inventories by improving inward and outward logistics. Just in time delivery

methods are in vogue, where the manufacturing process is streamlined and integrated with the logistics networks, thereby reducing the inventory to almost zero. Various logistics models are being used to ensure this. Reliability and trustworthiness of these models is a critical area of concern. Some organizations with an optimistic approach towards transportation use the tactics by altering the package size and distance of delivery while selecting various modes. Service quality is a very important but not the only variable. There are many factors like reliability, ease of operation, reduction in damages or loss. Often, transportation speed may not be that significant, whereas, in perishable commodities, the speed of delivery becomes essential. In some of the issues, certainty is more important than speed, so the organization has to balance the various factors, thereby serving the customer's needs (Jeffs, 1990).

This paper reviews the current literature regarding transportation and identifies the significance of the transport mode selection process. The cost of logistics has been defined as the central theme of supply chains. The cost becomes the main feature influencing the transport selection decisions and is balanced with the customer service level. Most of the literature gives recognition to the statistical modelling of service-related or cost-related functions. The research publications have identified the orientation towards decision methods during the selection of transport modes. Multi-stage behavioural techniques have been implemented for making decisions. However, most of these rely on the chronological performance of the organizations. (Pisharodi, 1991)

This study uses perceptual and behavioural techniques for managing the mode selection decisions. The views of the logistics providers have been taken into account while recommending the method for the general supply chain. The facilities required for an effective transportation system have been described. Mode selection is another critical decision determining the performance of the supply chain. The logistics provider has to use a wholesome valuation method considering the various advantages of different modes of transport. Distance, transit time, price factors are considered while making decisions (Gray, 2001).

The paper discusses the various elements involved in the selection of transport modes and transporter. It also provides the tools for the measurement of performance. Most of these publications are focused on transit time and cost as the main criteria. These are essential factors,

but several other measures cannot be ignored. The requirements vary from business to business and organization to organization. Even within the organization, the criteria may differ from one service to another. Inbound and outbound shipments are generally considered separate. The organizations are recommended to have a wholesome view of the logistics to arrive at optimum performance level (Monczka, 2005).

The various modes of selection of consignors and transporters have been discussed using discrete choice theory. The multiple modes of transportation have different characteristics and have their unique advantages and disadvantages. The consigner has a choice of selecting the best mode suitable for the purpose. This article examines the various parts of decision making and transportation mode selection. There are multiple types of consignments, and the study identifies the factors affecting the transport mode selection. The variables of cost, duration of transit and reliability have been identified (Zhao, 2005).

International supply chains involve the physical movement of goods across nations and continents. The multi-modal logistics providers provide the door to door services for the manufactured goods. This study identifies seven significant variables which are used in decision making towards the mode of transportation. These are described as the stage of products, geographical area, distance, volume, transit time, price and transport cost. The starting point of transportation is the packing of manufactured products. Usually, each product has a standard packing customized to it for preventing any damage during transit. These packed products are then stacked in containers capable of being loaded into multiple modes of transport. The containerization of transportation has made it possible for door-to-door delivery at the lowest possible freight under a single agreement. The multimodal transit eliminates covered storage requirements at the port locations or other shipment workstations and reduces the chance of commodities getting damaged or stolen during shipment. Such global multimodal transportation in containers is widely used for finished goods. (GangWang 2007)

Each of the transporters makes an effort to provide better services at the lowest possible cost, but the transporter choices are not always rational. They may lead to the selection of non-optimal solutions. The cost of transportation is an essential criterion while making decisions regarding

logistics partner selection. Many other factors like price, nature of the product, and the benefits accrued to the customer throughout the logistics process are worth considering. The vehicle's capacity and advantages must be matched with the goods being carried and the available time (Reis, 2009).

Usually, it is the decision of the consignors as to how they wish to transport their goods as per their business requirements. A pictorial representation of the available choices helps the consignor make a rational decision based on the criteria developed from experience. This article identifies factors of transport-mode selection using a decision support system with a survey from subject matter experts (SME). Shipping time, shipping price, accessibility, and safety have been incorporated as significant criteria. Trans-shipment cost is assumed to be a fraction of the actual shipping cost. The financial parameters get prominence during the selection process. The framework allows the consignors to select the most profitable transport mode. The criteria are obtained from the information acquired from consignors, transport specialists, and publications. This study provides the most probable option for the consignor out of the alternatives available. AHP has been used for resolving the issue, and the model has been demonstrated for rail, road and waterways combination in Turkey (Gursoy, 2010).

This paper points how towards the lack of data on multi-modal transportation. The selection of the mode impacts the frayed quality and transit time of the consignment. Financial and technological features of the various transport facilities and their respective performances have been assessed. Improvisation has been made for choosing the appropriate transportation modes and routes.

The study has created an implicit transport network that resolves optimum route problems with time and capacity constraints. First, the genetic algorithm has been used to improve the network. In the end, the study specifies an optimization model and procedure to minimise the cost from locations in the network. (Liu, 2011)

Transportation is considered to be a significant part of the product cost in many industries. The route choice and the modes of transport have a significant influence on transit time and transportation costs. The selection of transportation is crucial in international trade to cut prices

and offer on-time deliveries in a highly competitive market. The choice of efficient modes of transport reduces the cost risk and enhances customer satisfaction. (Beresford, 2011)

The criteria for selecting tariffs in a transportation system with limited options have been studied in this article. The organizations use multi-modal transportation advantages to select the mode of transportation and the route to be followed. The objective has been defined as the reduction of transport costs and improving the effectiveness of transportation. The study creates a framework for multi-modal logistics and computes the execution techniques. This article uses AHP as the best rational method for the relative measurement of various modes and routes of freight transport. (Kopytov, 2012)

The study focuses on the development of multi-modal passenger transport hubs. The diverse modes of transport are available, and there is a definite scope for improvement. The paper outlines the need for multi-modal traveller transport centres to decrease travel times and increase passenger traffic effectiveness. Eight areas of practice have been identified. The effort for creating multi-modal traveller transport centres is exhibited. The comparative techniques, philosophy, and goals for executing have been explained in the paper. The immediate actions for the improvement have also been proposed and described. (Liu L., 2013)

This article uses the AHP model to choose the appropriate mode of transportation for a company in Turkey. Railways and roadways are the options available. However, the assessment has to be made as per the specific criteria used by the consignor. There are many other transport methods like Airways and waterways, which have not been considered since they have limited freight transport functions. Water transport may be a feasible option in a particular site if it is located in a coastal area. Although waterways have not been exploited in the nation, this mode can develop and compete with other modes in the future. Although the aviation sector has grown very fast, it is considered a costly mode and is not generally used for freight logistics. MCDM (Multi-Criteria Decision Making) process has been used for resolving the decision problems in this society. The Analytical Hierarchical Process is appropriate for modelling the logistics and selecting an appropriate transportation mode out of the various alternatives available. The factors for transport mode choice are recognized as speed, price, security, reliability, convenience, flexibility, and

sustainability. Some price parameters have been integrated into the decision making process. The outcome of this article specifies that railway transport is not generally utilized in Turkey, and it is also an option as an appropriate mode of transport. (Kumru,2013)

This study provides a procedure for making decisions in the supply chain. The interdependencies of the partners have been elaborated. Then it discusses multi-criteria decision making for the use of managers. Distance, number, priority, speed of delivery, product cost, demand, transport are the criteria used in decision making. The suggested criteria were described for decision-making managers, who require creating logistics and transport processes. These decisions permit every supply chain to normalize manufactured goods. (Diaz, 2015)

The paper highlights significant issues in the transportation system where more than two modes are involved. Such a transportation method may be stated as a blend of various transport modes used for international or national logistics. These networks provide point to point services where a single transport administrator is responsible for picking up the goods from the source and delivering it to the destination. The idea of multi-modal transportation tries to enhance the effectiveness of business. This article recognizes the primary difficulties of the Multi-modal transportation System in the industry and recommends developing the system of Multi-modal transportation, whereby these fundamental difficulties are overcome. The Logistics Services ventures and the Ethiopian Shipping, Ethiopian Maritime Affairs Authority, or the government is suggested to create a feasible new regulation that needs personal capability. MTO to be found at the state level for growing and sustaining good benefits. This research has discussed around 104 investigations in different heads, namely Strategies, Issues & Challenges and Case studies of supply chain management, Transportation, Comparison of transport modes. The researcher has not found a single study that has included the factors that influence the selection of multi-modal transportation, problems, and challenges faced by logistics companies. (Butta, 2016)

The paper provides a practical case study of PSC in LPG and demonstrates the use of DESSCOM. This approach combines various object-oriented models. (Biswas & Narahari, 2004)

This paper reports PSC failures and their impact upon the performance of the organizations. The results are deduced from a study where 800 cases of these supply chain failures have been documented in publicly traded companies. Supply chain disruptions harm shares, bottom lines, and volatility in shares. (Hendricks & Singhal, 2005)

This article discusses multiple organizations, multi-echelon, products, and the number of transport modes in a PSC network with shared infrastructure, resource capacity, supply sources, and requirements. The MILP has been used for strategic plans. The optimized location of storage points, their capacity, logistics, paths have been extracted for strategic planning purposes. The maximization of PSC's bottom line has been considered an objective that consists of crude procurement, converting to finished products, distribution, and retailing. This MILP mode is suitable for design and strategizing PSC in downstream petroleum companies. The case study is based on Portuguese PSC. (Fernandes, Relvas, and AP Barbosa-Póvoa, 2013)

It finds the alternatives available for optimizing PSC in the publications. The approach is qualitative research. Interviews have been used to collect the data. The publications reveal that customer satisfaction is essential for maximizing the bottom line and creating sustainable competency in a competitive environment. However, in actual practice, organizations consider customer satisfaction as a secondary objective during optimization. Most of the optimization models impress on cost reduction or attaining maximum profits. This case study has underlined the importance of information technology and explained that the SC must be supplied with sufficient data to reflect coordination among the various functions. (Hassan, 2012)
The secondary logistics of the refinery products from storage terminals to the retailers is the last mile of PSC and is nearly affected through tank trucks. Comparing the various modes of transportation, pipelines are capital intensive but are economical in the long run. A pipeline is the most economical mode of transport of petroleum products in India for primary logistics, while secondary logistics is through road only. (Apurva Chandra, 2013)

"SCO of BPCL has invested in PIMS linear programming technology, with surrounding modules the objective of the group is to maximize 'Net Corporate Realization' (NCR)" (Datta, 2008)

The World Bank has conducted the study of India's policies to create assets in the logistics of petroleum oils and enhance safety in the operations and handling of petroleum products. The study concludes that pipelines are a safe, reliable, sustainable, and convenient transport mode for liquid petroleum oils. (World Bank, 2011)

It describes a petroleum company in Switzerland with 12 vehicles supplying thousands of customers using DyvOil software. This paper has introduced the software tool to plan the various petroleum products supply chains' routes. The model starts from pre-planning, forecast demand, plan, and uses the Ant colony system. (Rizzolia et al., 2003)

This paper proposes an optimization scheme of the transportation assignment for secondary petroleum logistics, where a cost model has been established for a large variety of petroleum products. Then the vehicles are assigned using the table manipulation method. Based on the proposed assignments, the total transportation cost is minimized. Finally, with the results of a numerical example, the effectivity of the scheme is demonstrated. The transportation assignment scheme has been optimized by the table manipulation method. (Zhang, Chen, Zhang, & Zhang, 2013)

The presentation introduces a product for PSC to be combined with

1. plan and schedule of the refinery l
2. primary logistics
3. secondary logistics
4. enterprise resource planning
5. tank farm management system
6. payment system
7. supply and distribution of OMCs and collaboration for accurate forecast optimization of supplies scheduling and execution of dispatches. (Aspen Technology. 2009)

The report a study of the PSC of a company in South Africa. It has carried out the analysis of its value chain. The tool helps identify the organization's core competencies and locate the methods

to retain them for an extended period. The value chain analysis is a valuable tool for subdividing the companies' functions into manageable activities and establishing a framework to synergize the firm's activities as per its strategy. (Nectar, 2010)

The Just in Time (JIT) option and performance of the SC process of big petroleum organizations in Kenya have been examined. The study is by a descriptive survey method that has been used for research design. The study has concluded that improvement in operations, reduction in the setup time, trouble-free production, JIT procurement, team building, and flexible workforce are the improvement seen after the implementation of JIT. (Manese, 2014)

SCM in the petroleum oil industry have unique features and are different from other sectors. These features have a substantial effect on the pricing of petroleum products and their derivatives. There are ample possibilities for improvement and cost reduction in the PSC. Logistics is one area where there is significant scope for improvement. The efficiency and costs are essential factors in PSC optimization, which help sustain the supply lines of crude oil, reduce transit times, and reduce refining cost. (Hussain, Tiravat, & Basheer, 2006)

The uncertainty of market conditions has been incorporated in the refinery planning model while optimizing the operations. These studies are classified as per the stage of the PSC. These may be upstream, midstream, or downstream. The planning levels may be strategic, tactical, and operational, and the problem type may be linear programming, non-linear programming, mixed-integer linear programming, or mixed-integer non-linear programming. The study indicates gaps in the publications and scope for research in refinery planning under uncertainty (Leiras, Rivers, & Hamacher, 2011)

There is a pressing need for an optimization framework in the downstream supply chain as the crude and product market is very volatile. In the petroleum sector, the efficiency of the downstream sector's operations is essential as PSC's main aim is to fulfil the customers' actual requirements. The importance of downstream petroleum optimization has been discussed in this paper. (Gainsborogh, 2006)

The research has been carried out to find through data and envelopment analysis where the oil exporters can improve their performance. The low performing countries can learn from the competence of Malaysia and Canada. The research shows that China, India, the Philippines, Thailand, and South Africa are valuable benchmarks for general cargo logistics performance. (Himola, 2011)

This report aims to give a wholesome view of the petroleum industry's transportation and logistics and other related industries benefiting from 3 PL logistics. Experts are confident that the optimization of PSC is key to success for the industry. The effort is to find a probable model that can mitigate the risk sets and uncertainties. (Matveeva, 2015)

The purpose of this pepper is to suggest a model for optimization of multi refinery petrochemical systems having uncertainty in demand. The proposed model has been constructed in two stages using a mixed-integer problem. The target is to optimize the total cost of the refinery and maximize value addition by the petrochemical network. The fluctuations in the crude oil price in the international market, refinery finished product price. Petrochemical prices and market demand for refined products and petrochemicals have been considered. The sample average approximation method has been used along with scenario formation and optimal gap. The model's performance has been compared with that of the petroleum industry, with multiple refineries and petrochemical complexes. (Al-Qahtani & Alpe, 2008).The details of searches are tabulated below:

Table 2.1

List of Journals and Databases Searched

Key Words Used	Journals Explored	Databases
1. Secondary Logistics	1. International Conference on Industrial Engineering and Operations Management	1. Elsevier
2. Multi Objective Optimisation	2. International Journal of Application or Innovation in Engineering & Management	2. Inderscience
3. Transportation Problem	3. The IUP Journal of Supply Chain Management	3. Research gate

Key Words Used	Journals Explored	Databases
4. Optimisation Petroleum	4. Computers & Chemical Engineering	4. Emerald insight
5. Downstream Petroleum Optimisation	5. International Journal of Production Economics	5. Ebsco
6. Indian Petroleum Downstream	6. Asia Pacific Journal of Marketing & Logistics	6. Science Direct
7. Cost Optimisation	7. European Journal of Operational Research	7. Google Scholar
8. Truck Routing Problem	8. African Journal of Business Management	
9. Linear programming	9. International Journal of Global Logistics & Supply Chain Management.	
10. Non-Linear Programming	10. Int. J. Oil, Gas and Coal Technology,	
11. Petroleum Transportation	11. International Journal of Energy Sector Management	
12. Optimisation Methods	12. Industrial and Engineering Chemistry Research	
13. Transportation Network	13. International journal of logistics management.	
14. Decision Support Systems	14. International Journal of Emerging Technologies and Applications in Engineering, Technology and Sciences.	
15. Analytical Hierarchical Process	15. International Journal of Business, Management and Social Sciences	
16. Evolutionary Genetic Algorithm	16. Journal of Business Research	
	17. Journal of Food Distribution Research- University of California at Davis	

Key Words Used	Journals Explored	Databases
	18. Journal of Economics and Sustainable Development 19. International Journal of Production Research 20. International Transactions in Operational Research 21. Benchmarking -An International Journal 22. Journal of Marketing and Communication 23. Journal of Business Chemistry 24. International Journal of Production Research 25. South Asian Journal of Management 26. International Journal of Physical Distribution and Logistics Mgmt. 27. International Journal of Engineering Sciences &Research Technology	

Source: Compiled by Author

Table 2.2

Theme Wise Inference of Literature Review

Sr	Theme	No. of Articles	Petroleum Sector	Down Stream Petroleum Sector	Secondary Logistics in Downstream Petroleum Sector
1	Cost Optimisation	28	10	14	4
2	Multi Objective Optimisation	49	38	11	0
3	Government Policy and Data Analysis	21	21	NA	NA
4	Research Methods	3	NA	NA	NA
	Total	101	69	25	4

Cost Optimisation: Cost Optimisation is a central theme in the petroleum and downstream petroleum sector. Various models like LP, NLP, MILP, MINLP, heuristic, stochastic, deterministic have been used. The central theme of optimization for production, inventory, and transportation**.** The effect of the supply chain on the shareholders' value has been studied. Models have been suggested, and cost drivers have been identified. The performance measurement and improvement systems for manufacturing have been studied, and models of optimization are proposed. Some of the papers have provided frameworks for operational, tactical, and strategic decision-making models to maximize profits. The implementation of third-party logistics for cost optimization has been interesting to study.

Success stories of the petroleum companies in implementing cost optimization models are also available, showing the industry's focus mainly in upstream and midstream sectors. A few papers dealing with the secondary logistics of petroleum products provide cost models, and the problem is treated as a transportation problem**.** Cost optimization is a significant theme in the following publications (Sriyogi, 2014), (Chan, 2003), (Fernandes, Relvas, & A.P Barbosa-Póvoa, 2013), (Hassen, 2012),(Zhang, Chen, Zhang, & Zhang, 2013),(Hussain, Tiravat, & Basheer, 2006), (Al-Qahtani & Alpe, 2008), (Seifert & Biçer, 2014), (Tavasszy, Kees, & Igor, 2012), (Keller, 2012), (Chan, Shekhar, & Tiwari, 2014), (Molina, Eguia, Racero, & Guerrero, 2014), (Carter & Rogers, 2008), (Vasant, 2000), (Pundoor, 2005), (Smyk, 2010), (Dewan, 2005), (Lauri, 2006), (Yoon, 2008), (Zeng, 2013), (Joon, 2017), (Shuai, 2009), (Wang, 2012), (Kengpol, 2012), (Kengpol A., 2012)

Multi-Objective Optimisation: MOO is the most common theme of literature on optimization in non-petroleum sectors. ANN, MILP, Ant Colony Algorithm, fuzzy AHP, Evolutionary Genetic Algorithm, Pareto Optimal methods have been used. Customer Service, Delivery Period, Inventory, Innovation, Learning, Flexibility, agility, culture, market orientation, and environmental impact have been the objectives of various studies. The companies are using the Supply Chain Optimisation methods to gain a strategic advantage over competitors. The trade-off between total cost and environmental influence has been studied. The various perspectives identified are internal-facing, customer-facing. Reliability, responsiveness, and flexibility have given stress, along with internal facing costs and assets.

Supply chain performance measurement has also been a favourite theme in literature. Comparative analysis has been made between methods of optimization. Some studies have given the relationship of Supply chains with market orientation, and others have given metrics to improve decision making using multi-objective optimization models. The concept of dynamic modelling of networks and supply network complexity has been discussed to arrive at models close to real industry problems. The role of information technology and sustainability have been popular areas of study. The use of AHP and LP for supplier selection decision has been examined. Other methods like genetic algorithm, goal programming, Ant colony approach, and ANN networks have been discussed. This theme is present prominently in the articles listed below.
(Dhingra, 2012), (Fernandes, Relvas, & A.P Barbosa-Póvoa, 2013), (Molina, Eguia, Racero, & Guerrero, 2014), (Phekar & Ramachandran, 2004), (Shaw, Shankar, Yadav, & Thakur, 2012), (Wang, 2012), (Kumru, 2013), (Diaz, 2015), (Varma, Wadhwa, & Deshmukh, 2008), (Abdel & SAD, 2016), (Phekar & Ramachandran, 2004), (Kengpol, 2012), (Ganbat, 2015), (Gursoy, 2010), (Kumru, 2013), (Lili, 2008)

2.3 RESEARCH GAP

The petroleum industry in India has paid attention to primary logistics, and various optimization models are being used for different organizations. The methodologies have been incorporated in the primary logistics sector of the SC of OMCs in India (Mohanty, Dhalla & Mohapatra, 2010). OMCs' primary logistics have pipelines, waterways, and railways as modes of transportation between the centres of production and storage terminals. In contrast, the secondary logistics is undertaken mainly through road transportation between storage terminals and retail outlets. The last mile of petroleum product logistics involves the transportation of products, e.g., MS and HSD, from the storage terminals to the retail outlets (Petrol pumps or Petrol bunks) and is called secondary logistics. This part of the supply chain has not received attention from the OMCs in India. The downstream petroleum industry has most of its infrastructure built during the administered pricing era when its cost did not determine its price. There were assured returns on the capital investments. There was no incentive to optimize logistics costs. The petroleum marketing sector was freed up in April 2002, when the Government of India dismantled the

administered pricing mechanism. Now, many organizations in the private sector are marketing MS and HSD. (MOPNG, 2006)

The secondary logistics have generally been based on feeding the nearest markets from the storage terminals. There is a considerable scope of optimization in the secondary logistics of the petroleum industry. Since the volumes of HSD and MS are highest and sold through a common and fixed distribution channel, it is pertinent to study the factors affecting logistics optimization in these products. Northern India, consisting of states of Rajasthan, Punjab, Haryana, Delhi, UP, Uttarakhand, HP, and J&K, has peculiarities of being far away from the coast, having multiple source refineries. Very high consumption of MS and HSD is the most complex set of markets, and the factors identified here shall be helpful elsewhere also.

There is a need to have well documented and systematic studies on the factors affecting secondary logistics in the Indian petroleum industry. The literature review shows that most of the publications on supply chain optimization and modelling are in non-petroleum sectors. Even the literature in the petroleum industry is mainly in the midstream sector. Some papers on optimization of midstream and primary logistics by public sector oil marketing companies have been found. The few publications, including secondary logistics of the downstream sector, are from Europe and China. The Indian works are limited to the case study of logistics of refineries in south India.

The research specific to secondary logistics in downstream petroleum products in Northern India is missing. The factors affecting the optimization of secondary logistics in petroleum products have not been explored. Hence, the factors affecting the optimization of secondary logistics of petroleum products in Northern India have not been studied. There is no framework for the decision-makers to optimize the secondary logistics operations, thereby testing the multi-objective optimization theory's applicability to inflexible supply chains.

The research gap has been identified as under:

• The use of Cost optimization is still prominent in the petroleum and downstream petroleum sector. The oil companies in India use cost optimization in primary logistics and extend the secondary logistics part.

• multi-objective optimization has been extensively studied in non-petroleum sectors. No work has been done in secondary logistics in the petroleum sector.
• No framework available for optimization in secondary logistics

2.4 THEORETICAL PREMISE

Optimization theory has evolved from single objective Maxima or minima functions. The methods like LP (Linear Programming), NLP (Non-Linear Programming), MIP (Mixed Integer Programming) techniques have been used to multi-objective and multi-criterion models. The principle particle swarm and Ant colony, ANN(Advanced Neural Networks) and evolutionary genetic algorithms (GA) have been increasingly used to solve real-life problems. The supply chains have been evolving thanks to the spectacular change in the global economy and the competitive business structure. There is an ever-increasing thrust on the service levels (Gunashekaran, 2008).

As the supply chains become global, the companies are looking to optimize their locational configuration in the supply chain. The SC design has gained prominence with the definition of number, size, and SC node location (Zhang X.H., 2008). This design is showing itself with dominance in the organizations looking for cost efficiency and competitive performance (Ballou, 2005)

The SC managers have to look for the tools that support their decisions and allow their transportation system to be conveniently and precisely designed and frequently change configuration (Melo, 2009). The transport network configuration has been taken into account by the various technological approaches, namely genetic, heuristic, and simulation. Linear programming has been extensively used (Chopras a. s., 2007)

In linear programming, there are certain constraints (Sharma, 2006). The objective function and the limitations are required to be linear, making it unsuitable in the environment where the effect of time and variability in the parameters is there, and these are not linearly related. The LP is not appropriate in a multi-objective problem environment where the objective function is not unique, and the various objectives often conflict with each other. Even with these limitations, LP's use is

most widespread for logistics applications, and most of the network problems have been solved using this technique. Since it is convenient and computation tools, i.e., solvers, are inexpensive and readily available. These tools help the managers to solve their configuration problems while taking into account their objectives and constraints (Sharma, 2006)

Decisions are made during all aspects of production, business, and public relations. In all of them, The tasks are arduous and must be accomplished in a defined period. The most trusted decision support system is optimization. It is a combination of mathematics and information technology. A school of study solves mathematical problems and business situations and allows the managers to choose from several options available. As the business issues are complicated, the optimization models are significant, have several decision points, are stochastic(where the parameters are not predictable), and uncertainty is ingrained. This uncertainty leads to further complications in the problem set. The solutions to the business problems are crucial for companies in the logistics field, carrying out supply, manufacturing, and distribution. A hydrocarbon STD (Supply, transformation, and distribution) system operates from production centres to the storage terminals and the final destination of retail outlets and consumers with the lowest possible expenditure on raw materials, distillation, logistics, and stocks. The different types of technical, economic, and statutory limitations are to be considered. The most common objective is to schedule the activities for the minimum cost, ensuring the product's availability within the constraints of production and logistics capacities.

The problems detailed above are to be mapped into the mathematical optimization models. There are thousands of limitations and variables, so an extensive linear program is required for a determinist solution.

With increased computational powers, the solution to this linear programming problem has become very easy and quick. The deterministic models are no longer suited to the modern times' variable parameters as the field data contains several parameters with uncertainties. The perfect date is never available. Still, LP is used as an optimization tool for logistic scheduling. (Laureano, 1998)

The issues of decision making are present in all the areas of logistics, finance, transportation. These can be modelled as optimization problems. Multi-objective optimization problems define the limitations which cannot be handled independently of the underlying optimizer. One way to solve the problem is a linear integer programming method. The other process is to go for multi-objective optimization and use a metaheuristic method where the most optimal results are not sought and a good enough solution within computational time constraints (Hertz, 2003). Many iterative methods are there which have the capability of solving a combination of problems. A suitable metaheuristic method will provide a near-optimal solution to complicated issues combined within available computation time. There are specific black-box optimization methods used in complex real-world problems with certain modifications (Dreo, 2006). The sizeable real-world scale problems are increasingly being investigated for using combined metaheuristic and other optimization techniques. Some combinations include hybridized heuristics with constraint programming, tree search techniques, mixed-integer programs, and others. The resulting framework can enable efficient behaviour and high flexibility in the tool than the traditional techniques (Blum, 2011)

Multi-objective decision theory deals with problems that can arise because of multiple factors involved and the diversity of situations. The Evolutionary Genetic Logarithm has imitated the crossover and mutation functions of the natural sexual reproduction process to generate offspring, which get progressively better than the parents.

Many methods of optimization are there in the publications, and they have solved many business problems. In most of these, there is an objective function that is to be improved. In an optimal case of multi-objective optimization, the right balance among the conflicting objectives is established to arrive at an acceptable result.

The facility location and allotment of resources are the two issues that have been solved by research in the optimization field. (Ravelle, 1996) studied the publications relating to facility location problem and represented the issues with various objectives, having multiple products and machinery. (Laporte, 1994) accounted for the facility location and capacity issue where the requirements of the customers were stochastic. The problem was solved as a stochastic integer

linear program with binary variables in the first stage and continuous variable in the second stage. The method applied is known as the branch and cut method. There are several publications where optimization has helped to solve business problems. The methods may not be efficient in a finite time context. Some applications use soft computing, but they are in the nascent stage. Since the problem is complicated, the precise solutions are highly time-consuming, so the researchers have used many heuristics and soft computing methods (Wang, 2009). The genetic algorithm is one of the most promising approaches.

Genetic algorithms are an optimization process based on examples of evolution and genetics (Walters, 1993). GAs have been used to solve a wide range of problems, including complex optimization problems, whereas most optimizations are non-linear, multiple models, without adequate information (Holland J., 1975). (Tomonobu, 2004) assesses the determination of optimal condition and strength of the genetic algorithm based on reliability and load reduction.

Genetic Algorithms (GAs) are a category of optimization methods that draw their inspiration from the organisms' natural evolution process. The concepts of reproduction, competition, selection, crossbreeding, and mutation have been employed in this method (Holland, 1975). The GAs are used on the population and not on individuals. Hence these do not give a local Optima. The implementation of GAs is easy, as no auxiliary information is required. These are extensively used for solving multi-objective functions. Many applications in network design and transport routing issues have seen the merits of GAs (Zhang & Armstrong, 2008)

The shortest route issue implemented on a GA based approach is a dynamic and stochastic network where the information is dynamic. (Gen & Lin, 2005) developed a genetic logarithm in a hybrid manner to improve network design with the objectives of cost minimization and flow maximization. At the same time, these methods have been used in transport path problems. These have not been used with global information systems in multi-objective path analysis for dangerous goods. (Huang, 2004) has studied the method to assess the risk of hazardous materials logistics by combining GIS and GA. It is pertinent to mention that auto fuels come under dangerous goods needing special licenses to store and transport the product. The genetic algorithm can be applied to find the relative importance of the factors involved in selecting routes. Many different objectives can be combined into a single goal, and the cost of various options be calculated with the help of

a weighted sum approach. The weighted sum approach can provide an isolated solution in each iteration, so, may not be helpful in non-linear relationships or in situations where solution space is non-convex. The genetic algorithm is universally applicable to such problems.

Multi-objective optimization A MOP problem can be formulated as follows:
Min x F(x) = [f1(x), f2(x), . . . , fm(x)] s.t.
x ∈ X (1) where fi(x), i = 1, 2, ... , m, are objective functions, and x is the vector of decision variables in the solution space X within which all points are feasible solutions. (Das, 1997)

There are various types of optimization problems with a single objective, and there is a unique solution available to them. However, in the case of multi-objective issues, there is no single isolated solution that is optimal, but there may be many good enough options balancing the various objectives. These results are known as Pareto optimal or non dominated results. The solutions may be equally good in the absence of any management preference. If there is any other preferential information available, then a better solution may be picked up out of the results available. Traditionally, in multi-objective solutions, the problems are converted into a scalar problem with a linear function and solved as a single objective problem. One such method is the 'weighted sum method,' which reduces the positive weighted sum of all the objectives and finds a Pareto optimal solution by changing various parameters. The method is simple but disregards the concave part of the Pareto front, so the answers are not well spread (Das, 1997). It has been found necessary to find better methods for complex optimization problems. GA is a viable option for traditional multi-objective optimization methods as it is an efficient technique for global optimization. The capability of genetic algorithms in finding different areas of the solution space facilitates finding a wide range of Pareto optimal and near-optimal solutions for complicated problems with non-linear objective functions and concave solution spaces. Most of the multi-objective genetic algorithms have no requirement for prioritization or assigning weights to objectives.

Decision Theory is the mathematical study of alternative strategies to arrive at optimal decision making. Various tools or techniques are available to select the best way of carrying out the job. The alternatives, states of nature, outcomes, and objective variables are four elements of decision making. The decisions may be long term, medium term, or short term.

In AHP, the managers assign weights to the comparative significance of the available objective functions. The comparison is carried out for two objectives at a time in a systematic way by using the paired comparison method. (Saati, 1977) provided a process of finding weights using the eigenvalue method. (French S.M, 2009) was a rational and behavioural analyst who narrated the evolution of decision theory and the management discourse. He explains the basic decision theory and various tools suitable for improving decision making. The tools are 'group discussions' and 'decision tables' where different views and implications are discussed. 'Decision trees' are a network of branches where one option opens up other possibilities in a sequential manner. There are inference diagrams where the interdependent nature of the problem is presented. Analytical Hierarchical Process and Multiple Criteria Decision Analysis (MCDA) are the methods depicting the relative importance of various alternatives. Analytical Network Process (ANP) is a method where one factor's effect is found.MILP determines the results of optimization by comparing the relationships among the number of variables provided.

The utilization of these methods has helped in the advancement of optimization and decision theory. With the increase in computing power, these have become very common in the operations of many firms. These provide valuable insight and additional factors to be considered. (Simon, 1960) introduced the concept of bounded rationality. (French S.M., 2009) initiated a new branch of decision theory while the earlier approach to decision making was normative, which explained how best decisions could be made. (Simon, 1960) opened a behavioural branch as to how decisions are made in practice. The direction of research changed to psychological and political science. He described that agents are presumed to behave rationally in the classical economic theory, and the alternatives arranged in hierarchical order according to their expected utility or benefits.

The operational research used economic modelling to complex management problems mathematically and scientifically of thinking by seeking the most optimum solutions. According to (French S.M., 2009), the approach changed in the 1980s and 1990s with the concept of 'soft operation research.' However, in the field, we see that 'hard operations research' is still standing. The traditional view of operation research was strictly rational bounded rationality view where people are assumed to be having limited reasoning capabilities and subject to biases in perception.

The study of these is called behavioural decision analysis. (Statman, 1987) showed how politics could overshadow the rationality in the disinvestment decisions. There had been irrational behaviours that led to the decimation of the organizations. The prospect theory deliberated upon the fact that when there are adverse circumstances, the manager aversion to risk goes down, so they take more risk while making decisions. Similarly, under the stressed conditions, the decision maker's capability of making the right decisions is affected.

This shows that emotional intelligence is as significant as the analytical capability of the person making decisions. A detailed account was provided by (Tett, 2009). (French S.M., 2009) called for prescriptive decision analysis, which is mooted to combine the rational normative approaches with the empirical behavioural branch. The managers' preferences are considered along with the logical decision-making process to limit cognitive limitations and biases. It must be seen that these techniques are decision support systems only and inform the decision-maker to make a considered decision.

Strategic decisions are taken for an extended period, and their results are also available in the long term. These decisions are of high significance and are taken rarely. These are not repetitive and are unstructured and unique. On the other hand, operational choices are clearly defined, more frequent, structured, and repetitive. Hence these can be programmed or automated. The organizations set up their long term goals and strategies at the corporate level. The tactical and operational decisions are taken at the field or plant level. The general management models are suitable for unstructured choices that are less quantitative and predictive. Michael Porter's five forces model is in the unstructured domain of corporate strategy (Porter, 1985). The indicative and unquantifiable outputs are helping decision making. The analysis of stakeholders is another area where (Michael, 1997) identifies the various groups that impact the organization's strategy.

In operations research, the complex rational normative decision tools are used to compare the various options or alternatives available to achieve the problem's objectives. The problem is required to be structured, and variables are precisely coded and analyzed. AHP, AMP, MCDA, and MILP are all solutions in the structured decision-making domain. Recently, there is an emphasis on the capability of using unstructured decisions. Expert systems, artificial intelligence,

artificial neural networks, and genetic algorithms are such techniques available. However, these are best suited for structured problems where clear, understandable, and operational attributes are available for analysis (Decker, 2012)

There are various stakeholders in sustainable supply chain management, multiple criteria, and uncertainty in the environment. The decisions are complex and unstructured, although these have strategic importance (French & Geldermann, 2005).

2.5 RESEARCH PROBLEM:

The problem can be narrated as a condition, person, or thing, which requires attention and needs to be solved (Dictionary, 2020). Scientifically, a research problem is a general issue or controversy addressed in research. The research problem has to combine the abstract concepts and knowledge available in the publications related to the problem (O'Connor, 2000). The Research Problem is said to exist if there are at least two essential elements available. First, the current state is at variance with the ideal state (Sekaran, 2003). Second, no universally accepted solution is available. The absence of an acceptable solution means either the answer is not available in the publications or is ambiguous as to how the problem has to be appropriately addressed (Cresswell, 2005)

A thorough review of the literature establishes the existence of a research problem. Visionary people can foresee the research problems long before others do. However, most of the research is based on the already available issues in the literature (Leedy & Ormrod, 2005). The goals of research have to be appropriately defined. The research methodology is based on the research questions, and its adequacy is established through literary publications. The literature is the basis of the pattern of analysis of the results.

An extensive literature review was carried out in the present study about the secondary logistics of automotive fuels. It was found that the published literature applies the optimization solutions of primary logistics to secondary logistics. The primary logistics is multimodal and hence more flexible than the secondary logistics. Moreover, the ownership of the product remains with the oil marketing company. The literature is replete with cost optimization techniques that consider a

single objective of cost minimization for the owning company. Whereas the presence of multiple stakeholders and inflexible mode clearly distinguishes secondary logistics from primary logistics. The problem statement can be written as under:

The secondary logistics has not been distinguished from primary logistics in literature, so Optimisation Theory and Decision Theory has not been tested for customer-facing inflexible logistics networks.

2.6 RESEARCH QUESTIONS

The most usual method of raising research questions is through the search of gaps in the literary publications. The area ignored by the existing publications can be used to pose research questions. Finding gaps is relative and varies with the size and complications of the problem. It can be an extension of an existing theory or find more significant gaps in the current literature. There can be an argument that such questions coming out of the literature gap may not result in substantial theories because they may not question the existing theories' underlying assumptions in significant ways. However, the literature gap can support, moderately revise, or challenge the existing established theories. The literature gap spot is recognized as the most common way of formulating research questions.

Finding an area ignored by the present literary publication is the most typical method of raising research questions. The technique is to find out a topic or a field where research has not been carried out. This unexplored area provides an opportunity for the researcher to develop knowledge in the ignored field or subject. There are three specific ways to spot in the gaps: finding an overlooked area, finding an area where only a few publications are available, and finding the need for empirical support. A neglect spot is the most typical way to search for aspects in literary journals existing where a particular area has been ignored despite many publications.

Based on a review of existing literature, it was found that primary logistics has shadowed the optimization of secondary logistics in India's automotive fuels. Hence, its multi-objective character has been overlooked in the existing literature, which is a clear gap. The research questions have been formulated as under:

1. What are the factors of optimization in secondary logistics in the downstream petroleum industry?
2. How can these factors be optimized in the secondary logistics of Motor Spirit and High-Speed Diesel in North India?
3. What optimization framework is appropriate for decision making in secondary logistics?

2.7 RESEARCH OBJECTIVES

The research is not concerned with its process only but has to commit to communicating the conclusions to improve the situation as it exists. There has to be a balance between innovation and existing knowledge. The research process will end up in findings that can be applied and become the foundation for preparing and executing innovative real-life strategies. The objectives of the research are designed in the context of their execution in the field. The research objectives and methodology preparation is concerned with researchers as well as the users.

The research objectives of this study are :

1. To Identify the factors of optimization in secondary logistics of the downstream petroleum industry.
2. To determine the relative importance of factors in optimizing secondary logistics of MS and HSD in North India.
3. To develop a framework for optimization of secondary logistics and validating it.

CHAPTER 3
RESEARCH METHODOLOGY

3.1 OVERVIEW:

This chapter explains the methodology and the thought process of the study. The chapter has been further divided into Research Design, Data Collection, Sampling, and Analysis. It depicts the plan, including methodologies, reasons for their application in this study.

Research Methodology can be classified into multiple types based on the research purpose, research process, and research approach. From a purpose viewpoint, research can be broadly classified into Descriptive, Analytical, conceptual, Experimental, and Case Study. From a process viewpoint, research can be broadly classified into four types, i.e., Qualitative, Quantitative, Experimental (Kothari, 2004)

This research has been carried out in the organization selected as a representative of India's petroleum Marketing Company. The firm is a large size public sector undertaking having sizable turnover and market share. The name of the company has not been disclosed for privacy reasons. It is a large oil & gas company involved in petroleum refining, marketing, and distribution in India.

3.1.1 RESEARCH DESIGN

The primary step in the research is to decide and formulate a research problem. A research design is a strategy of the investigation to answer the research problem as per the investigator's wishes. It is the complete draft of the research. The method of the study is required to facilitate the activities involved in the study. It entails forming the hypothesis and their operation implication to the plan for analyzing the data. (Kerlinger, 2019)

Research design is the framework of any research project. A researcher uses a structure as the primary crux of the project to provide a path to go down while answering the research problem. It is a procedural plan that a researcher makes to conduct the research activities systematically. It is the first draft about how the research shall be carried out (Babbie, 2014)

Correlational research design entails observing two or more variables to find interdependence among them. The purpose of data collection in correlational research is to find a linear relationship between the two given variables. The direction of the correlation is either positive, negative, or zero. The target is finding out the variables having a relationship and seeing how changing one variable affects the other. It is descriptive. There are three main types of correlational research; +ve, -ve, and neutral. There are unique features of each. A +ve (Positive) Correlational Research involves two or more variables where a change in one variable creates a proportional change in the other, i.e., they are directly proportional to each other. Negative correlational research includes two or more variables that oppose each other, i.e., inversely proportional to each other. A Zero correlational study entails two or more variables that are not necessarily connected; a change in one variable shall not cause any variation in others. No correlational research accounts for variables having no statistical relationships. (Blog, 2020).

3.1.2 EXPERIMENTAL RESEARCH

Experimental research may be defined as a research design where statistical analysis can either prove or falsify a hypothesis. The cause and effect relationship is proposed to be explored. The three main factors in a true experiment are :

• Control Group: It is a set where no treatment is applied. The treatment is applied to the Experimental Group.

• Variable – Capable of variation by the researcher

• Randomly distributed population

This kind of method is most suitable for physical sciences.

3.1.3 QUASI-EXPERIMENTAL

The Quasi-experimental method is marked by its similarity to experimental research where even the independent variable can manipulate. There is no control group, as in the case of experimental design. The selection and assignment are not random. This research method is applicable when the impact group cannot be created, and selection cannot be arbitrary, as in psychology and medical sciences. A quasi-experiment is just defined as not a real experiment. Since most of the component

of a real experiment is randomly assigned groups, this suggests a quasi-experiment does not have randomly assigned groups.

The Research Designs where treatment is to one of the two groups having randomly assigned members are Tru Quasi-experimental designs. These are excellent in examining the cause and effect relationship. It does not have at least one of the two other essential characteristics of the true experiment.

3.1.4 EX-POST FACTO RESEARCH

Ex Post Facto research is the only method that is retrospective in nature, i.e. It involves tracing the history to find the cause and effect of an event or behaviour. This method has significant advantages and has limitations too. The reason cannot be altered to see the impact of the changes, reducing the validity of the research outcomes. There is no control over variables as there is no random assignment of themes to the groups. Still, this method extensively uses research applications and psychological research, where the research needs to know the cause and effect relationship between the already existing variables. The research aims to analyze the 'how' and 'what' questions about an event and explore possible effects and causes. Once the research problem is selected, the purpose of research becomes clear, i.e., to work towards the outcomes that have to be achieved to get closer to solving the problem. A clear understanding of the terms used so that no conflicts are arising later regarding their interpretation (Sequeira, 2014)

After the decision is firmed up regarding the research problem, the next step is to conceptualize, develop new and original solutions, and understand what has already been studied. It is crucial to have a superior understanding of the words, i.e., building a concrete base is conceptualizing the research problem. The concept is the notion we make of the other observation.

A word can be interpreted in many ways. Any concept that is measured in a research study is believed never to have one exact definition. The researcher should consult prior theories by various other researchers; this would help understand the different perspectives that have been worked on in the past. It will also guide the researcher to decide whether they wish to challenge those conceptualizations or rely on them. It is Presumed that this would refine the research problem to become more specific and more precise (DeCarlo, 2018)

Once conceptualization is complete, the next step is to decide upon a research method. Data collection is defined as the process of aggregating and measuring information about the variables of interest through a definitive system enabling one to reply to the questions of the stated research, test hypotheses, and evaluate outcomes.

The researcher has to use the instruments of data collection instruments that are most suitable for particular research. The selection may be an existing method or an existing method modified for the purpose, or the researcher can develop its new approach. The errors can be minimized by providing precise and unambiguous instructions. The data thus collected may be put to an analysis by utilizing various theories. One such approach is grounded theory.

These approaches are called ideographic and aim at the individual without making any reference to the control group. The researcher has to interpret the information, and exclusions have to be carefully decided.

In a case study method, the researcher clarifies which data or information is an actual description and where the result has been derived from the available data. The opinion of the researcher should also be defined clearly.

The significant consequences of not collecting data properly:

- research questions are not adequately answered.
- repeatability and validity of the study becomes questionable.
- Incorrect results are leading to wasted resources.
- distorted findings resulting in wasted resources
- subsequent researchers lose direction and waste efforts
- public policy decisions get affected adversely.
- The participants may get harmed.

Quantitative data: The data in numerals, denoting length, time duration, size, amount, price, and other measurable parameters, is called quantitative data. The representation may be in numerals,

figures, or any different values. Who? When? Where? What? How many? Does quantitative research answer the questions.

Qualitative Data

In contrast to quantitative data, qualitative data does not use numerical values. This kind of data describes a phenomenon. Measurement of qualitative data is complex than quantitative data and is obtained by observing the phenomenon of using an open-ended survey or interview. Qualitative research is used to seek answers to questions of the type Why? "How?"

Questionnaire

The questionnaire is a series of questions in a structured manner. A questionnaire proves to be a very economical tool for data collection when several persons are available at the same place and time. A questionnaire's wording is crucial as these have to communicate what the researcher wants to know through the words. The following factors are of immense importance for any behavioural research utilizing a questionnaire as a tool for data collection.

· Simplicity in the language
· Ambiguity
· Vague words
· Embarrassing questions
· Double negatives
· Leading questions
· Presuming questions
· Hypothetical questions

Characteristics of a questionnaire

· It should be in a specific area that is relevant to the research
· It should be simple, concise, and understandable.
· Clear mention of the aim and the objective of the questionnaire
· It should be as short as possible.
· Questions should be presentable. Proceeding from general to specific responses.
· It should be attractive, neat, and arranged
· Questions should be worded objectively.
· Ambiguity should be avoided \

Questionnaires have two functions

(1) Description - to describe the individual or group characteristics

(2) Measurement of individual or group variables like attitude, opinion, personality traits.

Types of questions

Based on dimensions, mainly, questions asked in a questionnaire are of two kinds

(1) open-ended, which are subjective, e.g., skills

(2) closed-ended (fixed response) In these, you have a fixed number of answers to choose from.

Bases on administration, there are

(1) Mail questionnaires are new that do not require an administrator, and are done as per the subject's convenience.

(2) Face to face administered questionnaires are where selected subjects are given the questionnaires in the presence of an administrator.

3.1.5 INTERVIEW

An interview is a face to face situation between an interviewer and subject, which intends to elicit some desired information from the latter. It is when we verbally ask the questions.

Aim

(1) description of an interview is to provide insight into the interactive quality of social life.

(2) exploration another purpose of the interview is to provide insight into the unexplored dimensions of the topic; it also helps sharpen the conceptual clarity

Interviews are of two types: formal and informal.

Factors affecting the use of interviews

• Characteristics of interviewers- objective (point of view of the interviewer) and subjective (peculiar to the individual; attitude, aptitude, understanding) characteristics of the interviewer influence the interviewer's usefulness. Any research problem incorporating the interview as a data collection tool must consider both these types of qualities of the interviewers.

• Characteristics of the interviewees-

• Capacity of the interviewee to verbalize, E.g., people with psychotic disorders.
• Willingness of the interviewee.
• Interviewee's interpretation of the question.
• Description of the problem under study- it is believed that when the research topic touches people's personal lives, they impact interviewing qualities.

IMPORTANT SOURCES OF ERROR
• Attitude of the interviewer
• Incomprehensibility of the questions asked
• Lack of rapport
• Lack of motivation
• Duration of interview

Environmental factors
• Ambiguous words in questions Disadvantages
• Less reliability
• Inter-interviewer variability
• Less validity similar responses could be recorded differently
• Validity and dependability of verbal responses
• Time consumption is relatively high
• Variations inherent to interviewing context

Advantages
• Allows great flexibility; probe questions can be put.
• It facilitates the investigator in obtaining the desired information quickly
• It facilitates the investigator in being sure that the interviewee has themself solved and interpreted the question
• A desired level of control can be exercised
• Validity of an answer can be checked with non-verbal cues.

Observation as a fundamental technique of knowledge collection refers to watching and taking note of the target persons' behaviour over time without manipulating and controlling it. The findings are recorded in such a way that it is possible to analyze and discuss the data. Observation involves selecting—recording, and encoding the behaviour for empirical studies or developing a theory (Weick, 1968).

3.1.6 Characteristics of observation

1. Occurs in natural settings though it could also happen in labs
2. Captures the significant occurrences that affect the relation which is being studied.
3. Finds significant acts and occurrences in society by analyzing data.

The observation technique gives researchers the benefits of data for feelings, expressions, interactions, communication. The observation can be done to determine the share of time used on various activities by the participants. Observation of the participants allows researchers to see the terms used by the participants in interviews. The events which the informants could not provide or are unwilling to provide. There are situations when it is impolite or insensitive to observe conditions described by participants in interviews. Observation offers valuable insights to researchers during different approaches. These provide researchers with ways to monitor the expression of emotion, determine whom to interact with, understand how participants interact with each other, and view time-outs. It is used in various activities that allow researchers to see the interpretation of the terms involved. (Marshall, Rossman, Gretchen, & Rossman, 1995)

Observation

Observation may be a technique of collecting data, where a researcher gathers information and gets a grasp of the event or process. In this method, the observer makes observations as and when the phenomenon occurs. The focus can be on anyone or many aspects of the phenomenon, e.g., in psychological research, the researcher has to focus on human behaviour. Similarly, a person carrying out physical research has to aim at observing the pre-defined physical parameters.

Purpose of observation

1) To observe and study human behaviour as and when it happens in reality.
2) To describe life graphically.

3) To explore those essential but overlooked variables tends to look beyond what is already known to us.

Types of Observation :

1) Systematic observation – Systematic observation is carried out as per the pre-defined procedure and according to scientific logic and rationality. E.g., a psychologist researching aggressive behaviour with objective and pre-defined parameters.

2) Unsystematic observation: Unsystematic observation is an informal method where the inference is not pre-defined. A researcher observed the behaviour of the people at a metro rail without any pre-defined measurements of parameters. This method has the advantage that it is flexible, simple, and gives the information. This method is appropriate for some instances, e.g., observing the behaviour of infants. This method does not require the participants' willingness to participate. However, this method has certain disadvantages, such as some events and processes that are not open for observations. There is a trust and reliance issue as no concreted evidence is available. The perception of the observer plays a significant role and may bias the findings. The process is tardy, costly, and its validity is open to questioning.

In this kind of study, the observer describes happenings from his or her perception. The researcher notes the observations, prepares a write-up of the information gathered from the available sources and deciphers the knowledge. The research observation may be carried out for an extended period as the events are observed as and when they happen. There are numerous resources that a researcher may tap for a case study. The observer can see persons' daily routine, read their diaries, carry out informal, unstructured interviews.

Purpose: In-depth knowledge growth and changes over some time. To generalise a particular community problem selecting individual validity is questioned comprises all other data collection methods. Type Based on several individuals individual- help to prove hypotheses are true but it is difficult generalizing Community-Based on purpose Deviant, isolated clinical psychoanalysis Advantages: In-depth knowledge, Cause-effect, Typical patterns can be seen, Enough information Disadvantage Time consuming Not So reliable, Difficult to define, Biases of the interviewer Post hoc fallacy -factors only associated but we think of them as cause and effect.

3.2 RESEARCH DESIGN FOR FIRST RESEARCH OBJECTIVE

The research is exploratory. The present study has been undertaken to find experts' responses towards identifying factors of optimization, determining their relative weights, and then developing a framework for optimising secondary logistics. Since the purpose is to find out variables and factors of a phenomenon, the present study's design is exploratory. It identifies variables through secondary sources and validates them through expert opinion using a survey. The reason for selecting the experimental design is to bring out the vast experience of experts to identify the factors of optimization.

Identification of the optimisation factors is exploratory as it attempts to find the answer through a survey of the opinion of the experts in the field. Thus, an inquiry about the responses, which the professionals are inclined to be the primary objective of data collection. It is mainly related to the experts' perception of the variables found in the literature, which may be considered secondary data. The expert professionals are the supply chain managers who regularly interact with the stakeholder groups such as customers, suppliers, retailers, crew, and the public at large and can accurately define the importance of each of the variables.

3.3 SECONDARY DATA

Secondary data has been first gathered by undertaking extensive literature review connected with Supply Chain Management of Petroleum products using keywords like Secondary Logistics, Multi-Objective Optimisation, Transportation Problem, Optimisation Petroleum, Downstream Petroleum Optimisation, Indian Petroleum Downstream, Cost Optimisation, Truck Routing Problem, Linear programming, Non-Linear Programming, Petroleum Transportation, Optimisation Methods, Transportation Network, Decision Support Systems, Analytical Hierarchical Process and Evolutionary Genetic Algorithm. The websites so found were further explored for insight into the subject. The references obtained were searched in the library.

Primarily the journals explored were International Conference on "IEOM", "International Journal of Application or Innovation in Engineering & Management", "The IUP Journal of Supply Chain Management", "Computers & Chemical Engineering, IJPE", "Asia Pacific Journal of Marketing & Logistics", "European Journal of Operational Research", "African Journal of Business

Management", "International Journal of Global Logistics & Supply Chain Management", "Int. J. Oil, Gas and Coal Technology", "International Journal of Energy Sector Management", "Industrial and Engineering Chemistry Research", "International journal of logistics management", "IJETAE, Technology and Sciences", "International Journal of Business", "Management and Social Sciences", "JBR", "Journal of Food Distribution Research-University of California at Davis", "Journal of Economics and Sustainable Development", "ITOR", "Benchmarking -An International Journal", "Journal of Marketing and Communication", "Journal of Business Chemistry", "IJPR", "SAJM", "IJPDLM", "International Journal of Engineering Sciences &Research Technology". "Elsevier", "Inderscience", "Research gate", "Emerald insight", Ebsco, "Science Direct" and "Google Scholar" databases were used for literature survey.

Academic journals, conference proceedings, government reports, and books were studied, and many times, one source led to another leading to a chain of relevant articles. The themes of the articles were tabulated from the abstracts. The relevance with the subject under study was established before further proceeding with the articles.

The Secondary Logistics of Automotive Fuels was not found in the literature; hence the articles related to other industries were used to find optimization variables. Once the variables were discovered, the same was offered to five experts to rephrase the variables in the industry jargon. This exercise was necessary as each industry has its terminology to define the variables.

3.4 PRIMARY DATA

The questionnaires can be sent in electronic form through standard software like Google Forms, where these are easy to respond to and are automatically tabulated. The progress of the responses can be monitored regularly, and reminders may be sent. Questionnaires are formal and standard formats and have universality. The preparation needs planning and is an essential step in the research. These are used when the data is to be collected from a large sample size. The questionnaire can have the flexibility and can be moulded as per the project's requirements and administered to many participants. As per the respondents' profile, the questionnaire can be short, long, simple, complex, straight, or branched. The design ensures the measurement of the

parameters in question, e.g., the participants' knowledge can be tested, or the behaviour can be deciphered.

In the present study, the Questions have so prepared that the answers are straightforward, and all questions except one are close-ended. The responders were experts having at least 10-year experience in their field. The survey of opinions from experts in the area has been used in literature, e.g. (Ghatee, 2009).

It was decided to prepare a structured questionnaire, and the same was ready for conducting the survey. It was validated through a pilot survey from ten subject matter experts. The survey results discussed with experts to ensure that the tool measures what is intended to be measured. The suggestion to keep the questionnaire short as senior executives cannot spare time for answering lengthy questionnaires. This practical aspect was also kept in mind while devising a questionnaire. The format was kept simple, and a uniform Likert scale was used to save the respondents' time. The sample questionnaire and its statistical analysis is given in Appendix I

3.5 CONTENT VALIDATION OF THE SCALE:

Content validity looks at the degree or extent to which a particular measure reflects all facets of a specific social construct. Content validity is done to ensure a well-formulated plan and procedure for test construction before the actual test or study is conducted (Nunnally, 1994). The first step to ensure content validity was in consultation with a guide and also other academic experts. The scale was then presented to five Subject Matter Experts having more than 15 years of experience in supply chain function. Their confirmation established the content validity of the scale.

An explanatory note was written, which preceded the questions to clarify the intent of data collection. The Google Forms were selected due to their simplicity, familiarity, and universality of usage. The questionnaire was kept context-specific and concise.

The scaling has five levels as Strongly Disagree, Disagree, Neutral, Agree, and Strongly Agree. The range of scaling is taken from strongly disagree to agree strongly. The degree of agreement and intervals of the scale are adequately kept proportionate to the response zone and are kept

consistent with the context and nature of questions. The scale design gave respondents' scope to express their level of agreement with a suitable zone without facing any difficulty.

Likert scale is an instrument used by researchers to comprehend contributors' views or perceptions related to a single 'latent' variable. This latent variable is articulated by several 'manifested' articles in the questionnaire. These items address a specific dimension of the phenomenon under inquiry mutually exclusive and measure the entire process. The item-wise scores are then assembled to establish an all-inclusive score, which helps the researcher determine the single dimension of the trait under observations.

There is a discussion in the literature about the Likert scale, as some authors consider it an ordinal scale. In their view, since the choices are arranged in ranking order, the distance between the options is not constant. The magnitude of the responses and the difference between the two responses are not provided quantitatively when the Likert scale is used not to be used as an interval scale, i.e., it cannot be subjected to all mathematical calculations.

The population coverage was based on the list of professionals available. The questionnaire was sent to 1204 professionals seniority-wise who had more than five years of experience in the supply chain or sales function in North India. The context was provided to improve the reliability, validity, measurability, and sensitivity of the responses. The process was continued until a desirable number of samples were obtained. In all, 360 samples were collected.

3.6 QUANTITATIVE CODING

The experience of the professionals was more than five years. This information strengthens the reliability of dependence from association with the stakeholders and relationships developed with them during these years. The coding was done by giving numerical value 1 to the lowest choice and 5 to the highest.

3.7 DATA ANALYSIS

The term data analysis is used to describe, combine, and make inferences from the data collection. There is a difference between something meaningful and statistically significant. Parametric tests

and Non-parametric tests are used to test the hypotheses in the research. Parametric tests usually assume specific properties of the parent population from which the researcher can draw inferences from the collected data. Non-parametric tests are used when the researcher does not depend on any assumption. These two statistical tests are used to validate the hypothesis. Parametric tests are generally adopted wherein the adoption of assumptions regarding normal distribution is made. When the data is large in number and the information is discrete categorical data measured on a nominal scale, and the assumptions regarding variable following on normal distribution cannot be made, non-parametric tests will be used.

The filled questionnaires were compiled, and analysis of the data was initiated. Statistical test to be used for data analysis was finalized. Each question was treated as a variable. The responses were then checked for their consistency. Wherever needed, the data was edited. After that, the codification of data was carried out. All the variables were coded by assigning unique numerical codes to the responses. It was further tested for consistency in coding.

3.8 SAMPLE SIZE:

Taro Yamane's formula was used to determine the Sample Size as the number of Subject Matter Experts form a finite population, and population size is known.

Yamane formula for determining the sample size is:

n=N/(1+Ne2)

Where

n= corrected sample size

N = population size, and

e = Margin of error (MoE),

e = 0.05 based on the research condition.

The population size is 1200, and at 5% margin of error, the sample size would be

n= 1260/ (1+1260*(.05) ^2) = 315

Research using experience survey from Subject Matter Experts in Supply and Operations functions of downstream petroleum products. Factor Analysis was carried out to identify the objectives and underlying factors from the variables obtained from the survey.

3.9 RESEARCH METHODOLOGY FOR OBJECTIVE 2

Objective 2 aims at assigning a relative weight to each of the factors identified in factor analysis. This time the same population was used to carry out the survey, and the primary data so collected was analyzed using Analytic Hierarchical Process (AHP).

3.10 INTRODUCTION TO TOOL FOR ANALYSIS

The AHP tool has been widely utilized to assess complicated and multi-attribute options to be decided in decision making. Any multi alternative problem can be arranged in a hierarchical order, and AHP is applied directly to determine the weights of the options on a relative basis. The direct application of AHP is possible when there are fewer levels and sublevels. As the size of the hierarchy increases, the count of pairwise comparisons enhances exponentially. (Saaty, 2008) states the weights shall be less sensitive to judgment errors if the questionnaire has redundancy.

AHP is a convenient technique for decision making and analysis in any sphere of life. The method was formulated to resolve a particular problem that involves hierarchical order of feasible and proposed options. The assessment of several criteria establishes the prioritization by using pairwise comparisons. AHP has been applied to numerous diverse situations.

Delhi is a process that is one of the best techniques for systematic collections of data and combining the judgment of teams of experts. The RAND Corporation developed this technique in the 1960s for forecasting. The method allows the problem formulation in a group and analyzes the results using geometric means to decide on weights or hierarchical order instead of eigenvalues. This method helps in aggregating the judgments of the group (Byun, 2001).

3.11 CONSISTENCY OF AHP

The idea of AHP was developed by (Saati, 1977) to assess the qualitative and quantitative factors in decision making. The method promises to facilitate decision making based on the opinions, feelings, memories, and other parameters influencing decisions at a multi-level hierarchical

structure. This method can combine the differences and inconsistencies in the data, and easy commercial software can do all the mathematical calculations as per the requirements. In this method, the decision criteria are firmed up first. Subsequently, the levels of criteria and subcriteria and pointers towards each of these are determined. These are assessed in a hierarchical structure. (Mani, Agrawal, & Sharma, 2014)

The numerals obtained from the pairwise comparisons are very specific to the condition representing the importance of one factor in respect to the other. It cannot be universalised. Weber's law defines that the increment in sensation is perceived when a fraction of the stimulus itself increments the stimulus. The law is applicable where the delta S is small as compared to S.

The survey participants can compare even different things with at least one common attribute or property. The researcher has adequate knowledge as the comparison can be distinguished from common measurements. Even the intangible properties may be compared even when there are no scales of measurement available.

In group decision-making, each participant's opinions have to be combined so that the resulting opinion of the team as a whole is formed. There is bound to be a difference in the views of the participants. Fewer team members may have strong feelings about a matter and can overshadow the opinion of a large number of persons who do not have strong feelings for that particular matter. The combination of the group's views is combined so that the reciprocal of the combined judgements is equal to the reciprocals of individual opinions. The geometric mean is used to combine the pairwise comparison results.

AHP has been applied where complex decisions are to be taken involving costs, benefits, opportunities, and risks are to be relied upon for an extended period. There are various examples, both real and hypothetical, and it has produced pragmatic and valuable results in decision-making. Many instances have been used to validate AHP. It is said that the outcomes of AHP are not as objective as the data on judgments is used in paired comparisons. However, it is valid for any other decision model.

The construction of the pairwise comparison matrix is the central requirement of AHP. This comparison matrix is for items the participants tell about the relative importance of one factor to another. The direct comparison of item i is made to item j. the comparison is made on the scales of 1,2,3,…….n. The item n-1 and n are included to create redundancy in the system, which gives valuable information while carrying out value comparison. The expressions providing the comparative significance get translated into numerals. The importance of choice is explained well to the participants of pairwise comparison.

3.12 APPLICATIONS OF AHP

There are various decision-making business situations where the AHP technique has been widely used for making group decisions. It has been applied in governments, business houses, industrial houses, medical institutions, shipyards, and academics. AHP does not emphasize a perfect result but aids the decision-maker to search for the most appropriate decision for their targets and their interpretation of the issue. It provides a combined and logical framework for making structured decision making. The process consists of identifying and representing the elements selected to the overall objectives and assessing the options available.

AHP involves the division of the decision making problem into subcategories arranged in a hierarchy. These easily comprehensible sub-problems are up for independent evaluation. These elements are the hierarchical structure and can be related to the problem's tangible or intangible faces. Hierarchy is created in the decision-making process and the various components using pairwise comparison. Two of the features are taken for comparison at a time. The decision-maker can use the actual field information about the features or may use the participants' opinions. The essence of AHP is human judgment and not the underlying data. It can be used for weighing and assessing the alternatives in the decision-making process.

AHP transforms the opinion in words into numbers that can be analysed. The relative weight is found numerically for each of the elements in the hierarchy. This method allows very different kind of elements to be compared in a logical approach hey. This unique ability of AHP sets it apart from other models of decision making. Finally, the numeral or weights are computed for each of the decision options. These weights represent the relative ability of the particular element to influence the decisions.

Isolated individuals may utilize the method for making direct decisions. AHP is used in the groups of people facing complicated problems having serious issues, and human perceptions are involved, or the decisions have a long term impact. AHP has the advantage of quantifying and comparing the essential elements whose comparison is not easy. This method is also proper when the group's interaction is not possible due to their very different expertise, technologies, or opinions.

The AHP has been utilized across the world for crucial decisions. IBM used it for the improvement of quality in its computer business. This process was implemented to find a city in Turkey, annihilated in an earthquake in 1998. British Airways selected an entertainment system vendor using this method in 1987. An oil company in the North Atlantic used this method to find the appropriate platform to drill crude oil. This platform cost $ 3 billion, and the cost of dismantling was a critical element in the decision making. This process was used to resolve the USA China conflict regarding intellectual property rights in 1995. The Chinese were pirating music, videos, and software tapes and CDs. Hierarchies for cost, benefits, and risks were made, and it showed that the United States should not impose sanctions on China, and the USA instead gave the most favoured nation status to China. Xerox Corporation allotted more than a billion dollars in research using AHP. Ford Motors used AHP to work out the priorities for criteria that improved customer satisfaction in 1999. In 1986, The Institute of Strategic Studies in Pretoria used AHP to decide a dispute in South Africa. It provided decisions such as the release of Nelson Mandela and the removal of apartheid. As a result, the black majority was granted citizenship rights. The recommendations made by AHP were quickly implemented.

AHP has been used in academics, the military, and even in hiring decisions. In 1995, a football team going into Super Bowl used this and won with the correct outcome. In Santiago, a baseball team used it to decide on the players to be retained. It has been used in China many times to determine the locations of dams and other engineering products. (Saaty, 2008)

3.13 RESEARCH METHODOLOGY FOR OBJECTIVE 3

The study's final objective is to develop a framework for optimising secondary logistics of auto fuel. Having identified the factors and after assigning the weights to each of these. There was a need to have top-level experts to put the results logically into a framework. The Delphi was selected as it is best to arrive at a consensus among the subject matter experts.

3.14 INTRODUCTION TO DELHI METHOD

This method finds its origins in the studies by RAND Corporation in the 1950s. The Corporation wanted to invent a trustworthy technique for consensus building in a group of experts (Dalki & Helmer, 1963). The method was characterised as structuring team communication to make it useful in dealing with individuals with a complicated problem at hand. The pre-requisites of such structured communication are:

1. A process of receiving the required feedback of individual contribution of information and data
2. Assessments of the group's judgments or views
3. Opportunities for individuals to revise views
4. Degrees of anonymity for the individuals responsible.

The Delphi method is used where it is necessary to have the opinion of participants and is usually carried out with a questionnaire with channels of feedback (Rowe, Wright, & Bolger, 1991). An essential advantage of this method is that it prevents explicit conflicts between professionals. (Dalkey & Helmer, 1963) found that a controlled discussion enables the experts to form well thought out opinions by giving feedback gradually. Direct interaction often induces the participant to take hard stands based on preconceived notions, and the group members close their minds to innovations. There is a clear tendency for the members to stick to their perspective, and sometimes the style of persuasion of other members makes others alter their opinions.

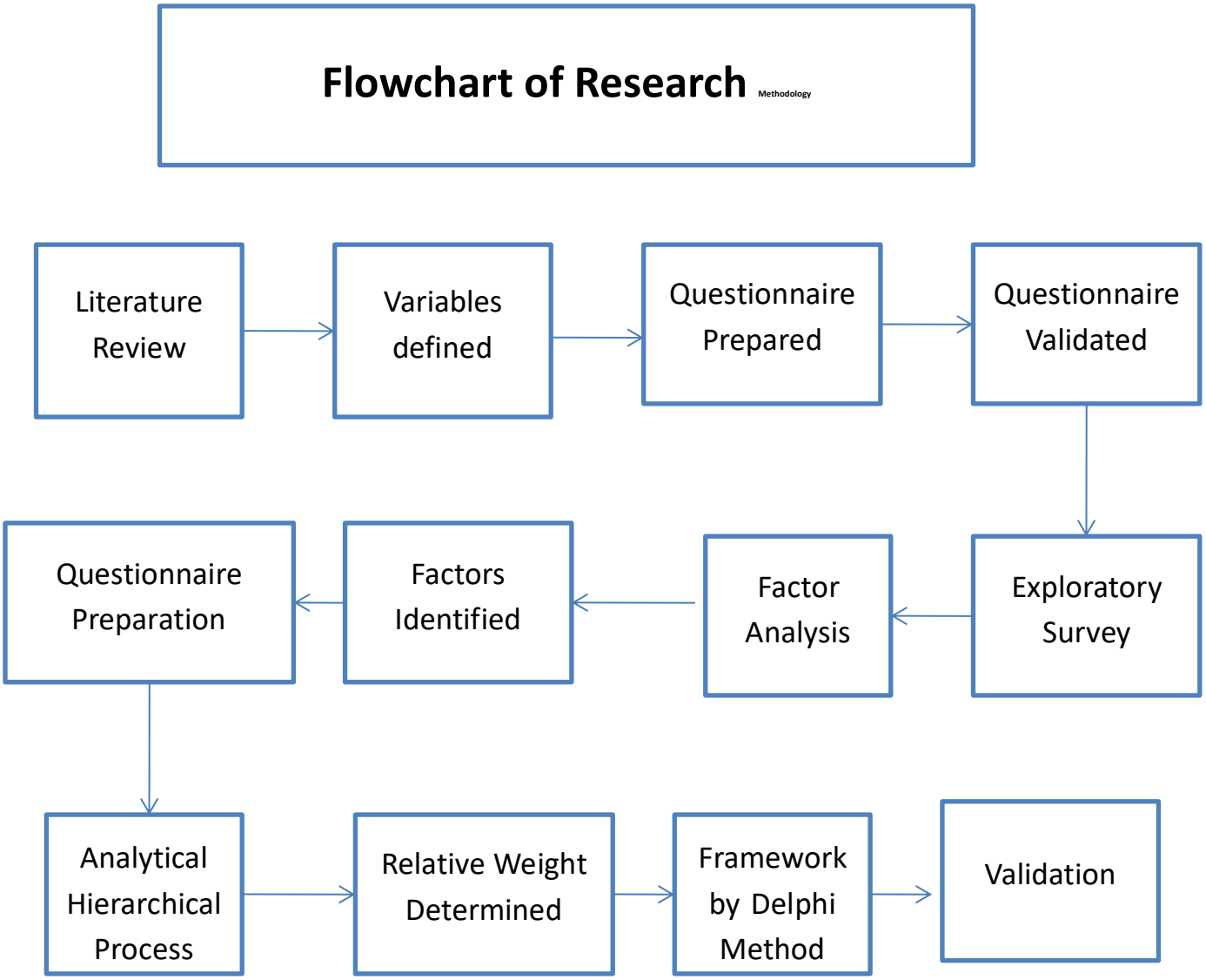
3.15 APPLICATIONS OF DELPHI METHOD

Researchers have used the Delphi method in various business situations to be a method where professionals' opinions are required in problem-solving. Different ways have been developed to solve multiple problem types and output goals. Ranking type Delphi is one of the most widely used variants where a group opinion is made regarding the relative significance of elements presented. In the first decade, most of the Delphi efforts went towards forecasting for short and long-range. Subsequent publications (Ono & D.J. Wedemeyer, 1994) showed precision in the long-range forecasting of the Delphi method. (Kendall, Kendall, Smithson, & IO Angell, 1992) have demonstrated that difference of opinion helps in developing alternative forecasting scenarios. Another variant of the Delphi method is framework development. This method is a 2 step process

where the set of abstract concepts are identified or elaborated, followed by classification and taxonomy development(Okoli & Pawlowski, 2004)

The Delphi method was used for the present study, with ten experts from various disciplines having at least 30 years of experience in their respective fields. The survey results and factor analysis carried out to identify the factors of optimization were shared with the experts along with the relative weights obtained by the Analytical Hierarchical Process. The experts were requested to sequence the factors and suggested a framework for optimization. A flow chart of the methodology adopted in the present research has been summarized in Figure 3.1

FLOWCHART OF RESEARCH METHODOLOGY



Source: Compiled by Author **Fig 3.1**

CHAPTER 4
FACTOR IDENTIFICATION FOR SECONDARY LOGISTICS

4.1 INTRODUCTION:

This chapter deals with the process, results, and analysis of research objective one, i.e., identifying optimisation factors. The method involved an extensive literature review in finding the variables. The literature does not have a direct reference to the optimization of the secondary logistics of auto fuels. It is mainly considered as a part of the downstream supply chain. The works in the other industries were used to find variables. These variables were paraphrased to the respondents' understanding during the questionnaire's validation, with five experts having at least 10-year experience in the supplies field. The SPSS was used for factor analysis.

4.2 IDENTIFICATION OF VARIABLES

Secondary logistics is the last mile of the petroleum supply chain and faces the channel partner and customer; hence, the parent company, transporter, retail outlet dealer, community, crew, and employees have to be considered. The objective is to provide a reasonable return on investment to each stakeholder to maintain a sustainable and competitive supply chain. Since not much has been studied in the secondary logistics of petroleum products, similar studies have to be used in other sectors.

In the PSC study, the cost considered is inventory cost, distillation cost, the cost of delays in order processing, the opportunity cost of loss of sales, and transportation cost to the markets. The cost during custody transfers within the supply chain has not been taken into account. Since the cost of sales per unit of the products is the cost of buying in the next part of the supply chain (Bairanbhand, Mahdi and Vishwamay, 2018).

The following variables have been identified while reviewing the relevant literature in the petroleum and other industries :

Customer Approach: Quality, Service Level, Customer Satisfaction, Response to customer demand, Market Reach

Financial Aspects: Budget compliance, Transportation Expenses, Cost of operations, Inventory Expenses, Savings

Internal business perspectives: punctuality, waste reduction, accuracy, resource utilization, dispatch process visibility, and innovation

Learning Approach: Automation, Learning, and Growth, Implementing Tips (Mohapatra, 2010)

It has been argued that the organizations are having state of the art logistics, and SCM can enhance and maintain their advantages over the competitors. Core competencies of the organizations are available in their costs or value propositions. In the most optimal cases, both exist in a balanced way simultaneously to the degree required by the customer segment in which the organization is operating. SCM's target is to meet customer requirements and achieve customer satisfaction most efficiently, thereby reducing cost while maintaining the collaboration of suppliers and buyers (Christopher, 2005). PSC consists of oil, gas, and petrochemical divisions. There is a focus on PSC due to the great importance of the oil. The twin aims to improve SC efficiency in cost and make the customer-focused organization (Szucs & Hassen, 2012). There is a mention that SCM has to be concentrated on managing and examining the network within the SC and to optimize cost and provide improved customer services (Assey, 2012)

PSC is considered to be complicated in comparison to other businesses (Jenkins P. G., 1998). Various causes make it a complex set of activities. The entire petroleum SC is categorized under upstream and downstream sectors. The upstream part consists of the sequence of tasks performed before the refinery, and the downstream involves activities carried out after the refinery has produced the finished products. The raw material, i.e., crude oil, in PSC, has to be transported to inter-continental destinations and cause long transit durations from extraction to consumption while compared to other supply chains. Not only this, the raw material, i.e., crude oil, is subjected to a complicated chemical process in the refineries, which are set up at a very high cost (Gainsborough 2006). The modes of transport during the transit of the raw material and finished products are Ocean tankers. Tank Trucks, Crude and product pipelines, and Railways. The long transit time and distances make the transport cost high (Hussain, 2006). PSC flexibility is a source of cutting edge competitive advantage in the volatile and complicated industry (Hussain, 2006). The PSC has various properties, such as long lead time and inflexible payment terms for procurement. The procurement process has to start three quarters before the actual use of the raw

material. There are limitations on the primary logistics capacity. The number of different modes of movement is there in various parts of the SC. The choice of these modes is a constraint on account of geographical location. The organization's resource mobilization capabilities lead to an increase in flexibility. The high level of competition, complexity, and inflexibility has prompted the major petroleum firms to go for integration in a vertical direction to get a competitive edge due to greater authority on the SC (Gainsborough, 2006).

In PSC, the marketing is push type as there is little flexibility in the production process. The pull in the demand side is evident only while scheduling the final supply of petroleum products to the end consumers. The storage terminals act as the cushions points for the shocks caused by variable demand in the environment where production is constant to avoid the bullwhip effect. Customer satisfaction largely depends on reliable transportation and providing stocks of products closer to the market, leading to lower lead times and faster response to customer orders (Hall, 2002).

TOC (Theory of Constraints) was the idea mooted by Goldratt in the 1980s with the basic assumption that the constraints determine the systems' performance. Organizations should concentrate on the limitations and not on the product cost. The theory of constraints has been utilized to optimize lead times improvement of quality of product end marked improvement in profitability (Ruhl, 1996)

PSC has numerous challenges, apart from logistics issues. Integration of process management information system and information sharing, restructuring, and cultural reorientation is the firms' other issues. The efficiency of PSC helps in meeting the challenges posed. However, there are opportunities across the SC to enhance the efficiency and profitability and get a cutting edge competitive advantage by creating higher value for the customers (Hussain, 2006).

The transportation cost of petroleum products is affected by various factors, e.g., the distance travelled, the risk associated with the selected path, and the contract period. The organizations can enter into contracts at individual capacity with service providers for reasonable rates of transportation. The relationship among the SC partners is crucial in the process. The OMCs

perform routes selection, and the transporters have to follow these routes. The security and safety in transportation have to be considered to lower the accident risk by the OMCs. To optimize transportation costs, OMCs have to resort to exchange products. The product exchanges take place mainly at the refinery level when one of the refineries supplies particular products to another organization in exchange for a similar volume of product at another site. These transactions help reduce the volumes and distances in the transportation of products, thereby reducing transportation costs and ensuring sustainability (Rusinga, 2010)

The petroleum products are highly flammable, thereby requiring stringent safety measures during storage and handling. The safety systems have to be ensured during the transit, also under the supervision of specialists. Since petroleum products are essential commodities, product availability is a significant concern. The OMCs position the storage points to make the product available as near to the markets as possible. The market volumes determine the size of the storage points and their tankages and the area proposed to be fed from that terminal (Rusinga, 2010).

One of the challenges of outsourcing in a petroleum company is the massive increment in demand. The infrastructure is capital intensive and requires updating with the use of advanced technologies. The challenge is to integrate real-time data from different sources on a common platform. The facilities are old and ageing. The operators have to incur high maintenance cost caused by the scaling and corrosion of field well equipment (Hies, 2016)

PSC's goal is to use the experience and skillsets of the SC professionals who are part of a highly competitive network (Mentzer D.K., 2001). Petroleum products are a prime source of energy in the world. Hence these products must flow uninterruptedly from the source to the consumers continuously without interruptions. Random failures, natural calamities, accidents, terrorist attacks, and intentional disruptions disrupt supplies.

A review of literary publications on the network's geographical properties has been carried out (Zavitsas, 2012). It is also proven that reliability, vulnerability, robustness, and criticality of the

network structure are vital for PSC. The various causes of supply failures have been studied to identify the failure scenarios.

The dependence on crude oil can partially be reduced by using biofuels. Various governments are taking steps towards this. The Indian government has announced and modified its biofuel policy to encourage biofuels to mix in automotive-grade petroleum products. However, the biofuel manufacturers will have to improve their sourcing and supply chains to compete with petroleum-based fuels. This emerging industry will be able to attract investments only after becoming economically viable, so the design of their supply chains is crucial (Heungjo, 2011)

A performance management system should be in place to understand value drivers. It needs to be so configured that it encompasses the information available on various business processes and not only on financial results (Bryaant, 2004). An accounting-based reward system is required to overcome short term orientation. The organizations are now designing their compensation plans, so that performance assessment is included and the financial parameters. These additional performance parameters are not reflected in the short term financial results (Ittner, 2003).

All the variables identified in the literature and their components derived through in storming with SMS are listed below

Table 4.1

List of Variables Identified

Product Cost- Crude Price, Processing cost, Inventory, Handling cost, Dealer Commission.	(Hussain, 2006) (Ruhl, 1996)
Transport Cost- Fuel Cost, Wages, Market distance, Fleet availability, Fleet operating efficiency, Average Vehicle Capacity, Market volumes, Operating hours.	(Rusinga, 2010) (Hussain, 2006)
Experience – Maturity of Market, Domain knowledge	(Mentzer D. K., 2001)
Service Level - Order cycle time, Quality Assurance, Supply point distance, Information sharing, operating schedule, Working Hours, Response to queries	(Assey, 2012) (Mohapatra, 2010)
Lead time of Product delivery- Queue control, Inventory level, Demand variation, Operating efficiency	(Gainsborough, 2006) (Ruhl, 1996) (Hall, 2002)
Responsiveness- Information System, Fleet flexibility, Level of Automation, Workforce.	(Mohapatra, 2010) (Hussain, 2006)
Reliability- Plant maintenance, Standard Operating Procedures, Customer training, Quality Monitoring Systems	(Hall, 2002) (Hussain, 2006) (Zavitsas, 2012)
Flexibility- Flexible operating schedules, Operation timings, Variability of fleet	(Hussain, 2006)
Market Reach - Inter-location distance, spatial variations in demand, proximity to state boundaries, taxation of product.	(Mohapatra, 2010)
Mileage- Fleet size, Market Demand	(Rusinga, 2010)
Development- Automation Level, Customer training, Local Competition	(Mohapatra, 2010)
Viability - Sales Growth, Road Condition.	(Heungjo, 2011)
Compensation- Crew remuneration, Performance incentive	(Ittner, 2003) (Bryant, 2004)
Profitability - Contracting flexibility, Margins	(Ruhl, 1996)
Value-added to Society- Community programs, Labour policy, Material sourcing policy.	(Christopher, 2005) (Hussain, 2006)

Source: Compiled by Author

Discussion on Variables :

Product Cost: The product cost is the sum of all costs incurred by the Oil Marketing company from the crude procurement to the customer. The price of crude is the primary determinant of the cost, and the OMCs have little control over it. The processing cost at refineries has to be added to it. Raw material for all petroleum products is the same; the costs assigned to the product depends on its worth in the market. The refinery is a continuous process unit, whereas the market demand is variable, so the OMCs have to maintain a certain inventory. Keeping the stock and handling cost is added. The dealer commission is added to obtain the final product cost.

Transport Cost- The secondary logistics in North India is exclusively through road using tank trucks where fuel is a significant cost element. The transportation contracts of OMCs provide for escalation and de-escalation as per the changes in diesel prices in the market. The wages of the crew and administrative staff have to be added. The distance between the supply location and the market increases the cost of transportation proportionately for the OMCs as the rates are decided based on distance travelled and volume of product carried by the tank truck. However, a minimum rate is fixed for small distances. The carrier's actual cost incurred per Km decreases with the increase in total distance travelled by the fleet and impacts fleet operating efficiency. Te fleet availability is linked to maintenance cost incurred. The higher capacity vehicles are more efficient, and their cost per kilolitre of product carried per Km of distance is lower. Higher volumes in the market lead to higher utilization of the fleet, thereby reducing transportation cost.

The operating hours of the supply location and the customer also affect fleet utilization, thereby affecting the cost. Experience – The maturity of the market leads to predictability in the business. The reduction in uncertainty results in a reduction of risk premium, thereby reducing cost. Maturity does not always mean stable demand. It means that the customers, suppliers, and suppliers can predict demand variability and, with experience, improve fleet utilisation efficiency. Information Technology has played a significant role by making the data available universally and providing the tools to analyse it. The trends of previous periods allow the OMCs to predict the demand and mobilise resources accordingly. The domain knowledge of market players leads to stability in the market.

Service Level - (Mohapatra, 2010) classifies service level from the customer's perspective. The organisations have to be competitive to survive in the market. Since supply chains are competing, their performance needs to be measured to meet the customer needs and provide better value than competitors. The supply chains have to show how well they are serving their customers. The various metrics are developed for assessments and continuous improvements. (speed, assets, inventory and financial metrics). Order cycle time defines the speed of delivery from placement of order up to the delivery of the product. Quality Assurance gives customers confidence that the product delivered is as per their requirements and meets the standard national or international specifications.

The customer's distance from the supply point affects the service levels as the uncertainty in the order fulfilment will increase, and the customer may have to keep higher inventory or be complacent with lesser reliability. Information sharing can lead to a reduction in uncertainty and allows the customer to plan better. Similarly, the convenient operating schedule of the supply location, longer and flexible working hours and better response to queries leads to higher customer satisfaction regarding service levels.

Lead time: The raw material for the petroleum industry are located away from the demand centres. The distance from the oil exploration to the consumers is enormous. This distance leads to a higher lead time as compared to other industries. The process of refining is complex and capital intensive (Gainsborough, 2006). The complexity underlines the importance of lead time of conversion from raw materials to the finished products and then placing them in the market for consumption. The average lead time will depend on the queue control exercised by supply location. Each customer gets the product in a reasonable time, and there are no dry outs due to stock-outs at the retailer or consumers end. Maintenance of adequate inventory near the customer reduces the time to market and cater to the demand variation. Lead time is also a measure of the operating efficiency of the entire supply chain.

Responsiveness- The agility of the supply chain depends on the kind of Information System it has. The response of the supply chain member to the demands made and the speed of information

sharing is an essential factor while servicing the customer requirements. In secondary logistics of auto fuels, there is wide variation in daily, weekly, monthly and seasonal demands. The fleet being dedicated, the source of flexibility lies in the inter-location movements through contractual provisions. The automation level of the OMCs like having automated entry systems, automated loading, Global Positioning System (GPS), Automation of Retail Network and trained workforce imparts flexibility to the secondary logistics.

Reliability- Reliability of the supply chain is related to the information flow among the supply chain partners. (Hussain, 2006) cites the case as to how data flow diagrams could improve reliability as the synchronization of receipt and dispatch improved. The use of this data resulted in higher supply chain efficiency and fewer deviations. Although the study was on slope oil, it can be transferred to auto fuels as it has a similar logistics profile. Regular maintenance of plants, following Standard Operating Procedures(SOPs), imparting training to customers and robust, Quality Monitoring Systems impart reliability to the supply chain.

Flexibility- The petroleum supply chains are notorious for their inflexibility, which can be defined as the constraints encountered like long lead time, production capacity and limited fleet availability, hard to change at short notice. (Hussain, 2006). Even in otherwise inflexible supply chains where the loading capacity of supply points is fixed, and the fleet is dedicated, the flexibility may be impaired by having flexible operating schedules, Operation timings and Variability of fleet

Market Reach - The market reach in terms of logistics of auto fuels is included from the customers perspective (Mohapatra, 2010) , which is a function of the distance among the supply locations. The lesser the distance, the more markets the location can serve. The cost of transportation gets added to the product price, so the distance of the market from location will affect the competitive position of an OMC. Since the taxes vary across states, the retail sales in another state may involve double taxation. The locations do not supply to other states even if the distance from the market is less.

Mileage- This is important from the carrier's perspective. The remuneration to the transporter will depend on transportation rates, distance travelled by the fleet, and the volume carried in each

trip. Since the vehicles are manufactured for a fixed capacity and rates are fixed during contracting, the only variable during operation is the distance travelled. The Fleet size and Market Demand will determine the mileage for the carrier.

Development - The development of logistics is related to the learning and innovation aspect during the operations. A higher automation level of the supply location enables it to capture more data for analysis. This data is available for study and helps in the development of a more competitive supply chain. Regular training of customers improves logistics efficiency and response. Intense competition in the market compels the supply chain partners to offer innovative offerings to their customers.

Viability – Auto fuels are not the only fuels available for mobility or industry. For example, biomass-based fuels have other advantages of contributing lesser greenhouse gas emissions than petroleum-based auto fuels as the sources are renewable. Economic viability becomes a critical issue where the viability is calculated not only in terms of price to the customer but also in environmental degradation. Reporting carbon emissions in the organisations' annual performance leads to overall viability checks for each part of the supply chain, and secondary logistics is no exception. (Heungjo, 2011). Continuous sales growth in the supply area and condition of roads will significantly impact the viability of supply locations.

Compensation- (Ittner, 2003) has concluded that the subjectivity in the compensation system has a statistical association with the performance of organisations. It states that the compensation decisions align with the performance achieved. Hence, this variable cannot be ignored while optimizing secondary logistics of auto fuels, which is the customer-facing supply chain and involves multiple stakeholders and TT crews being essential elements. Crew remuneration and performance incentives add to the cost of the logistics but improve the performance. Any optimization model has to consider this variable.

Profitability – The theory of constraints states that the constraints determine the system's performance, and any system will have limitations. (Ruhl, 1996) has shown that improvement in profitability is the aim and can be achieved by using the theory of constraints. In the secondary

logistics of auto fuels, flexibility must be built while contracting for higher profitability to stakeholders. Their margins impact the overall optimization of this part of the supply chain.

Value – The success of a business is determined by the customer value it delivers in the market segment. It is defined as the perceived benefit minus the cost incurred. (Christopher, 2005). It is hard to maintain a competitive edge with the product only. The value added to society gets associated with the brand. The Community programs, Labour policy and Material sourcing policy are all ingredients to the value-added. The firms are increasingly using these in their annual performance reports along with the financial information.

4.2 Tools for Analysis

AHP has been used as it is useful even in the absence of criteria and choices. In the present study, no literature is available on the secondary logistics of petroleum products, so the method used allowed the Experts to compare two variables at a time, making decision making easier. These variables were placed in the form of questionnaires to the subject matter experts (SMEs). A questionnaire was prepared to determine how Experts rate the importance of each of the variables identified. The questionnaire was discussed with five Experts before administering, and they expressed the need to bifurcate cost into overall cost and transport cost for better understanding.
The questionnaire was sent to 532 Experts with experience in a leading public sector oil marketing company's operations and supplies function. The sample selection from the directory of officials and the online link was sent to officials' seniority wise till the required number of responses were received. It is clear that the tool used has good convergent validity, such as no factor loading is less than 0.5, and all loadings are significant statistically. CR (Composite Reliability) for all latent factors is above 0.7, and no factor has AVE (Average variance Extracted) below 0.5 (Kamble & Gunnasekaran, 2018). The correlation between latent variables is also below 0.85, which indicates good discriminant validity. Cronbach's Alpha is more than 0.7, which is acceptable.

4.4 Analysis of Results

The total number of respondents was 360, and the respondents' profile was such that 98.6% of the respondents were from the operations group of public sector oil marketing companies. 16.7% were

having experience of more than 30 years, 36.1% having 20-30 yrs. Experience, 29.2% were having experience in the range of 10 to 20, and the rest, 18.1% were having less than ten years of experience. The survey data was fed into the SPSS version 25 software, and a reliability test was carried out. None of the variables was deleted to arrive at the acceptable reliability level. The test results showed the Cronbach Alpha as 0.706, which implies that the data is reliable. Results of the reliability test are tabulated as under:

Table 4.2

"Case Processing Summary".			
		N	%
Cases.	Valid.	360	100.0
	Excluded.	0	.0
	Total.	360	100.0
a. Listwise deletion based on all variables in the procedure.			

Source: Compiled by Author

Case Processing Summary: Table 4.2 is an output of SPSS showing the sample size of 360, and none of the observations was excluded from the analyse.

Table 4.3

"Reliability Statistics"		
Cronbach's Alpha	"Cronbach's Alpha Based on Standardized Items"	N of Items
.706	.679	15

Source: Compiled by Author

Cronbach alpha indicates internal consistency in a test or a scale. It can vary from 0 to 1 and explain whether all the measured items are interrelated and measure the same concept or construct. The value of alpha is more if the items in a test are interrelated. The number of test items, item inter-relatedness and dimensionality, affects the value of alpha. The range o 0.7 to 0.95 is an acceptable measure of reliability. A low alpha points towards either a low number of questions or less relationship between items. The low value may be an indicator of non-homogeneous constructs. A high alpha suggests that the items are repetitive and are testing the same thing in different words. Reliability of data determines the quality of the test, so it is usually used to find reliability. It is an essential measure for evaluating the questionnaires. In the present study, the alpha value is 0.706, which is acceptable, and the test qualifies in reliability.

Table 4.4

Item Statistics			
	Mean	Std.	N
Prod Cost	1.37	.512	360
Lead Time	1.23	.600	360
Profitability	1.22	.601	360
Responsiveness	2.99	.993	360
Reliability	3.01	.987	360
Viability	2.89	.837	360
TPTCOST	3.51	.543	360
Flexibility	3.50	.522	360
Mileage	3.43	.507	360
Compensation	3.45	.509	360
Development	1.00	.756	360
Value	.98	.763	360
Experience	.87	.746	360
Service	.94	.738	360
Market Reach	1.14	.741	360

Source: Compiled by Author

Table 4.4 gives the mean and standard deviation obtained against each of the 15 variables out of the sample size of 360. The scale being Likert with values ranging from 1 to 5, the neutral is at a value of 3. The mean score above 3 indicates that the average respondents agree that these variables are essential to optimising secondary logistics of auto fuels. Flexibility, Compensation, Mileage and reliability have average towards agreement. This table means that an average respondent agrees that these are essential variables for the optimization. The standard deviation is a measure of the test variability. A higher value is seen in reliability, responsiveness and viability, suggesting that the respondents have varying views on these variables.

Table 4.5

Item-Total Statistics					
	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Squared Multiple Correlation	Cronbach's Alpha if Item Deleted
Prod Cost	30.16	21.276	.118	.278	.709
Lead Time	30.30	20.880	.156	.341	.707
Profitability	30.31	21.073	.120	.376	.710
Responsiveness	28.54	17.113	.486	.647	.665
Reliability	28.52	17.326	.462	.604	.669
Viability	28.64	17.818	.506	.617	.664
TPTCOST	28.02	21.487	.062	.472	.714
Flexibility	28.03	21.097	.151	.508	.706
Mileage	28.10	20.929	.195	.570	.703
Compensation	28.08	21.469	.077	.569	.712
Development	30.53	18.450	.473	.481	.671
Value	30.55	19.424	.311	.291	.692
Experience	30.66	18.920	.404	.391	.680
Service	30.59	18.672	.451	.476	.674
Market Reach	30.39	18.818	.424	.466	.677

Source: Compiled by Author

Table 4.5 shows the value that Cronbach's alpha will become if one of the items is not considered in the scale. Transportation cost, product cost, lead time and profitability are the variables whose removal will cause a slight improvement in Cronbach's alpha. However, it meets the requirements, so none of these was considered for removal.

Table 4.6

Scale Statistics			
Mean	Variance	Std. Deviation	N of Item
31.53	22.094	4.700	15

Table 4.6 is an output of SPSS, which provides the mean, variance and standard deviation of all the responses. It can be interpreted that an average respondent has given responses corresponding to 2 on the Likert scale, i.e. slightly disagree. The high value of standard deviation indicates that the spread of answers is high.

Table 4.7

Sampling Error

Report															
	Prod Cost	Lead Time	Profitability	Responsiveness	Reliability	Viability	TPTC OST	Flexibility	Mileage	Compensation	Development	Value	Experience	Service	Market Reach
Mean	1.37	1.23	1.22	2.99	3.01	2.89	3.51	3.50	3.43	3.45	1.00	.98	.87	.94	1.14
N	360	360	360	360	360	360	360	360	360	360	360	360	360	360	360
Std. Deviation	.512	.600	.601	.993	.987	.837	.543	.522	.507	.509	.756	.763	.746	.738	.741
Std. Error of Mean	.027	.032	.032	.052	.052	.044	.029	.028	.027	.027	.040	.040	.039	.039	.039

Source: Compiled by Author

The sampling error in the 15 variables is a maximum of 5.2%, which is well within the acceptable range of 4 to 8 %.

4.3 INTERPRETATION OF FACTOR ANALYSIS

The output of SPSS was analyzed concerning each of the parameters to arrive at the reduction of factors. The communality's values of the variables were found to be above 0.4 for all 15 variables. The highest value has been observed in ‘Responsiveness’ which accounts for 82.5% of the variability. ‘Reliability’ accounts for 81.1% of the variance by the extracted factor.

Table 4.8

Communalities		
	Initial	Extraction
Prod Cost	1.000	.592
Lead Time	1.000	.650
Profitability	1.000	.695
Responsiveness	1.000	.825
Reliability	1.000	.811
Viability	1.000	.809
TPTCOST	1.000	.643
Flexibility	1.000	.683
Mileage	1.000	.723
Compensation	1.000	.707
Development	1.000	.639
Value	1.000	.431
Experience	1.000	.575
Service	1.000	.639
Market Reach	1.000	.649
Extraction Method: Principal Component Analysis.		

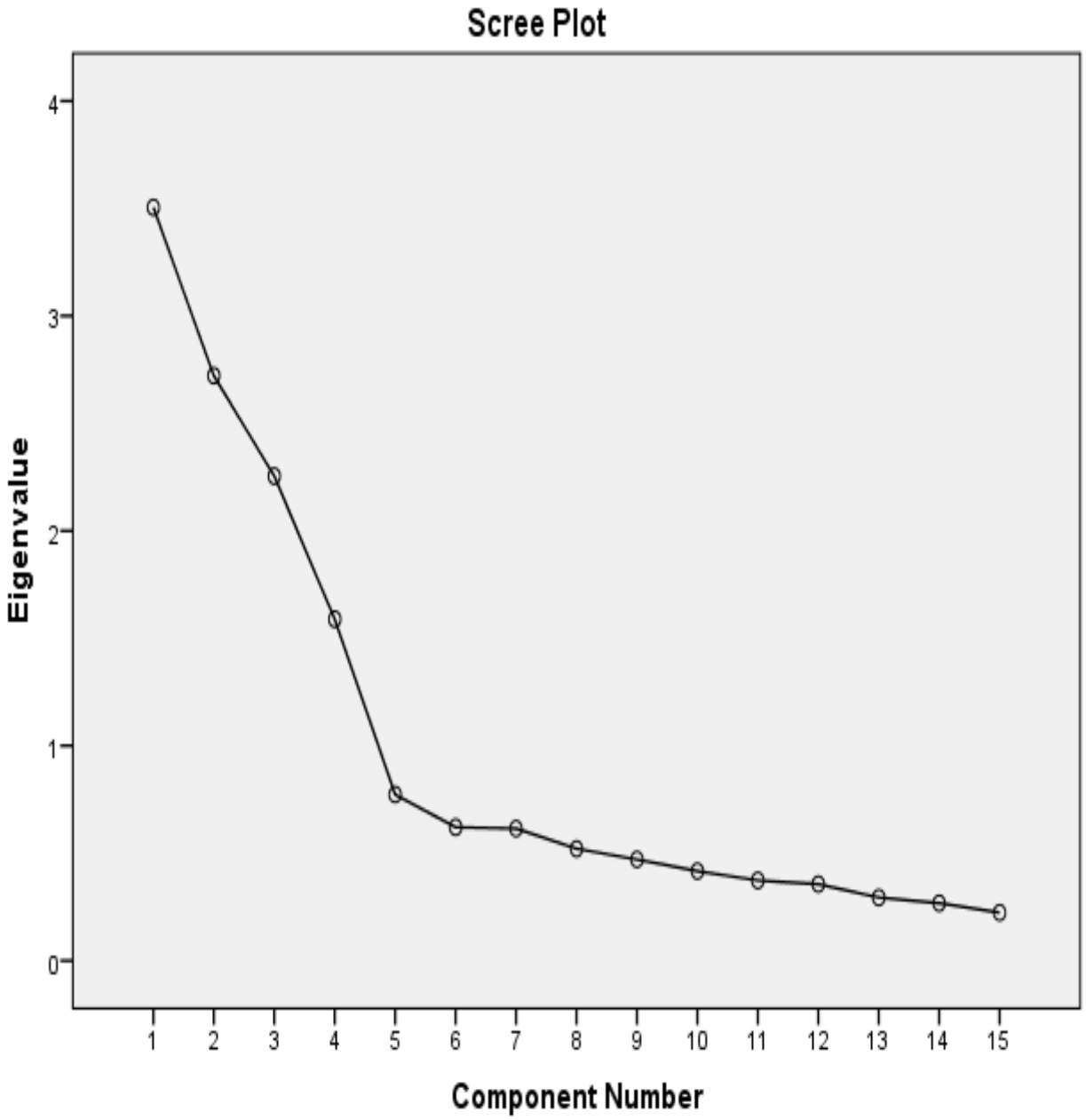
Source: Compiled by Author

Table 4.9

Total Variance Explained									
	Initial Eigenvalue			Extraction Sums of Squared Loadings			Rotation Sums of Squared Loadings		
Component	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	3.505	23.366	23.366	3.505	23.366	23.366	2.908	19.388	19.388
2	2.722	18.145	41.510	2.722	18.145	41.510	2.736	18.237	37.625
3	2.255	15.031	56.541	2.255	15.031	56.541	2.438	16.255	53.881
4	1.589	10.593	67.134	1.589	10.593	67.134	1.988	13.253	67.134
5	.773	5.154	72.287						
6	.621	4.138	76.426						
7	.614	4.096	80.522						
8	.521	3.471	83.993						
9	.471	3.137	87.130						
10	.417	2.777	89.907						
11	.373	2.487	92.395						
12	.356	2.375	94.769						
13	.294	1.958	96.727						
14	.267	1.783	98.510						
15	.224	1.490	100.000						
Extraction Method: Principal Component Analysis.									

Source: Compiled by Author

Extract Sum of Square Loading for the four significant factors shows that the first factor account for 23.37% of the variance, the second 18.15%, the third 15.03% and the fourth 10.59%. The values of the first factor reduce, but the subsequent three increase with rotation.



Source: Compiled by Author Fig 3.2

The scree plot is a graph of the eigenvalues of all the factors. The chart helps decide which factors are to be retained. The point of interest is where the curve begins to flatten. It can be seen that the curve has changed its slope at point 5. The eigenvalues beyond factor 5 are less than one, so only four factors are retained.

Table 4.10

Component Matrix				
	Component			
	1	2	3	4
Prod Cost			.578	.481
Lead Time			.644	.450
Profitability			.644	.489
Responsiveness	.689		.365	-.465
Reliability	.584		.517	-.447
Viability	.658		.456	-.403
TPTCOST	-.331	.707		
Flexibility		.772		
Mileage		.724	.369	
Compensation	-.339	.711		
Development	.677	.347		
Value	.541			
Experience	.578	.300		.357
Service	.675			
Market Reach	.610	.405		
Extraction Method: Principal Component Analysis.				
a. 4 components extracted.				

Source: Compiled by Author

Suppressing the values less than 0.5, the table is modified as under ;

Table 4.11

Rotated Component Matrix				
	Component			
	1	2	3	4
Prod Cost				.769
Lead Time				.800
Profitability				.830
Responsiveness			.884	
Reliability			.891	
Viability			.877	
TPTCOST		.791		
Flexibility		.819		
Mileage		.844		
Compensation		.835		
Development	.772			
Value	.647			
Experience	.754			
Service	.787			
Market Reach	.790			
Extraction Method: Principal Component Analysis. Rotation Method: Varimax with Kaiser Normalization.				
a. Rotation converged in 5 iterations.				

Source: Compiled by Author

The average variance extract and composite reliability have been calculated for the four factors as under A denote factor 4, B denotes factor 3, C denotes factor 2, and D denotes factor 1:

Table 4.12

	A	A2	E=1-A2
	0.769	0.591361	0.408639
	0.8	0.64	0.36
	0.83	0.6889	0.3111
Sum	2.399	1.920261	1.079739

N	3
Av Variance Extracted	0.640087
Composite Reliability	0.842027

	B	B2	F=1-B2
	0.884	0.781456	0.218544
	0.891	0.793881	0.206119
	0.877	0.769129	0.230871
Sum	2.652	2.344466	0.655534

N	3
Av Variance Extracted	0.781489
Composite Reliability	0.91474

	C	C2	G=1-C2
	0.791	0.625681	0.374319
	0.819	0.670761	0.329239
	0.844	0.712336	0.287664
	0.835	0.697225	0.302775
Sum	3.289	2.706003	1.293997

N	4
Av Variance Extracted	0.676501
Composite Reliability	0.89316

	D	D2	H=1-D2
	0.772	0.595984	0.404016
	0.647	0.418609	0.581391
	0.754	0.568516	0.431484
	0.787	0.619369	0.380631
	0.79	0.6241	0.3759
Sum	3.75	2.826578	2.173422

N	5
Av Variance Extracted	0.565316
Composite Reliability	0.866135

Source: Compiled by Author

The composite reliability is above 0.7, so the construct reliability is established.

We can see that Product Cost, Lead Time, and Profitability are substantially loaded on Factor (Component) 4 while Responsiveness, Reliability, and Viability are considerably loaded on Factor 3. Similarly, Transport Cost, Flexibility, Mileage, and Compensation are heavily loaded on Factor 2, whereas Development, Value, Experience, Service, and Value are loaded on factor 1.

4.6 DISCOVERY OF FACTORS

The identification of underlying factors was carried out with five Experts having a 20-year minimum experience. The first factor has components of Product Cost, Lead Time, and Profitability. These variables are essential for the business perspective of the oil marketing company and can be termed logistics' performance. The second factor has Responsiveness, Reliability, and Viability as components that essentially relate to the Retail Outlet Dealer, the receiver of the services, so this may be called Service Factor.

Transport Cost, Flexibility, Mileage, and Compensation essentially are the concern of the transporter who would require flexibility for optimum fleet utilization and transport cost. Both are related to the cost incurred by the logistics provider. The fourth factor is defined by Development, Value, Experience, Service, and value is the concerns of the local community and can be termed as Perceived Value to the local community and customers.

Performance, Service, Cost, and Value are the four factors identified for optimising secondary logistics of Petroleum products in India. The customer, transporter, retail outlet dealer, crew, community are stakeholders; the least cost methods may affect the company's competitive position. The paper has identified various factors to be considered to optimize secondary logistics in the petroleum industry.

CHAPTER 5
DETERMINATION OF RELATIVE WEIGHT OF FACTORS OF OPTIMISATION

5.1 INTRODUCTION:

This chapter pertains to the assignment of relative weights to the factors identified in objective 1. Performance, Service, Cost, and Value are the four factors identified for optimising secondary logistics of Petroleum products in India. The customer, transporter, retail outlet dealer, crew, and customer are stakeholders; the least cost methods may affect the company's competitive position. The description of factors identified has been given as under:

1. Cost: Providing flexible logistics at least transportation cost.
2. Service: Providing best Product Quality with high Responsiveness while ensuring Reliability
3. Performance: The ability to deliver the product at least the Lead time of delivery and minimum overall cost to the company.
4. Value: The ability to provide value to customers and locality.

5.2 ANALYTICAL HIERARCHY PROCESS (AHP)

AHP has been designed for rational decision-making situations. This process helps managers make multi-objective, multi-criteria, and multi-factor decision-making where there is uncertainty about the options' count. Professor Thomas Saati immensely improved this method. He utilized it for decision-making areas of economic, social, and management science as an efficient tool in handling complicated decision-making problems. It supports decision-makers to list the options available according to their weights in a hierarchy to make the appropriate decision out of the alternatives available. AHP deals with subjective as well as objective criteria of a decision. This method has been used in various investment proposals for the projects envisaged in the 1980s. The process has now evolved and used in a variety of applications. The selection of facilities, investment in technology under uncertainty, and buying a car is the decisions where the use of AHP was demonstrated. In the method, the decision matrix is constructed, and priority scores are established using this method.

Analytical Hierarchical Process (AHP) was used to assign weights to each factor in the decision-making process. The method provides objectivity to the complex process, which can be influenced by the personal biases and subjective judgments of individuals or groups in making a decision. AHP can build hierarchies and feedback networks based on the pair-wise comparisons of elements. A ratio scale is derived, synthesized throughout the structure to select the best out of the available alternatives.

Measurement of a phenomenon for specific characteristics involves utilizing standards against which the features can be measured. In AHP, it is vital to build a relative scale using the information from the standard and carry out arithmetic calculations on these scales. The opinions provided by the participants are in the form of paired comparisons. Hierarchy allows the researcher to focus on judgments individually on each of the various properties essentially required for taking a considered and sound decision. To compile assessments most effectively, one takes one pair of comparisons and compares them to an isolated property without showing concern for the other properties of the decision process. The hierarchical structure is combined with the paired comparisons for arriving at a suitable measurement. It can be noted that the comparisons can be made based on standards established in the memory of the participants through their experiences and earlier training (Saaty TL, 1990)

The objectivity of the accurate decision making may be affected by using opinions as to the basis. However, if we compare it to the numerals derived from a standard scale that is considered objective, it is observed that deductions are not objective. We have to check the tangible values arrived at from the opinions are validated, especially when intangibles are involved. To compare these numerals, we need a scale to know how much more critical one element is than another about a particular property being observed. The respondent always has to enter a whole number at a specific position in the response sheet, which automatically puts a reciprocal entry in a transpose position (Saaty, 2008)

(Saaty & Kearns, 1985) recommended a 9 point scale for making pair-wise comparisons in this process. The decision-makers make a pair-wise comparison of elements at a given level and

speculate their significance relative to the component immediately at the preceding level. The scale for this activity is a 9 point scale (Saaty, 1994). The opinions are given in words, e.g., "equally important," "moderately more important," "strongly more important," "very strongly more important," and "extremely more important."

AHP has been widely analyzed in publications, especially in the area of multi-criteria decision making. Its simplicity leads to its broader applicability and higher flexibility (Ho, 2008). The method computes the inconsistency index and the ratio of the decision-makers inconsistency and randomly generated index, which is vital for decision making.

AHP can be integrated with other techniques like TOPSIS, LP, MILP, DEA, Genetic algorithm, and Goal programming and can consider qualitative and quantitative factors (Ho, 2008).

The questionnaire has been designed to get the judgments of the SMEs (Subject Matter Experts) in the PSC. 356 Experts responded to the questionnaire. Reference has been taken from the conference paper on the world conference on transport research WCTR-2019 in Mumbai, having a theme towards developing tariff safety strategies in developing countries- analysis of road users. A large sample size has been used in a sample survey conducted in December 2016, in which is a sample of 300 public citizens and 15 transport experts have been taken (Minh & Truong, 2019).

There are different sample sizes used by various publications (Diyaz, 2013) used the sample size of one and judged himself, and there are papers where 1283 participants (Mühlbacher, 2015). (Katerina, 2015) reported the in 50 articles, the average respondents were 109 depending on the objectives of the study. The respondent belong to the categories of hospital employees, patients, public, doctors, specialists, medical students, teachers, engineers, and technical persons (Katerina, 2015)

The Experts selected for the survey are from a leading oil company in India. Even in the company, the experts having adequate knowledge of PSC were eligible to respond. It was ensured that respondents have at least five years of operations or supplies experience in the industry. AHP develops hierarchies of options and criteria used in their judgment. The choice of criteria depends

on the understanding of the decision-maker. There are various measuring scales for the criteria, e.g., weight and lengths, even in intangibles with no scales. Indeed, measurements on varied parameters cannot be aggregated or compared. First of all, the judgmental hierarchies for specific criteria are arranged based on their relative significance for the ultimate objective. After that, the priorities are arrived at to measure the performance of alternative options on each of the criteria. The pair of wise judgments are precursors to finding the priorities. If the scale of measurement exists, it can be used in the form of ratios. This process of the hierarchy of options resolves the variability of scales by assigning importance to the user's values. The possibilities are weighed and added to find overall priorities regarding how much they contribute to the objective. Without AHP, one would have to consider and add parallels mathematically, comparing the alternative parameters under various criteria with a uniform scale to an overall result. AHP translates a multidimensional problem into a unidimensional (Vargas, 2012). The characteristics of AHP, as observed above, are ideal for determining the relative weight of factors of optimization in secondary logistics of Auto Fuels. The problem has multiple objectives and needs the judgment of subject matter experts to ensure it balances supply chain partners' interest.

5.3 METHOD OF AHP

AHP is a method of selecting alternatives systematically and justifying the issues using hierarchical structure analysis. (Ozer, 2007) has devised a five-step procedure to find the relative weights utilizing average and then arrange policies in ranking order for group decision-making in the marine ecosystem. (Abdullaha, Jaafarb, & Taib, 2013) has proposed seven steps while using geometric average to compute the weight. The use of geometric mean dampens the effect of extraneous data. These extraneous data values can impart bias in the arithmetic average. The seven stepwise algorithms have been utilized to ascertain the relative weights of factors using pairwise comparison.

Step 1: Develop a hierarchical structure and get a normalized matrix. First of all, these criteria are compared with the objective. A n x n Matrix is created utilizing the paired comparisons with elements ij denoting the value of ith criterion against jth criterion as depicted below:

$$A = \begin{vmatrix} a11 & a12 & a13 & . & . & . & a1n \\ a21 & a22 & a23 & . & . & . & a2n \\ a31 & a32 & a33 & . & . & . & a3n \\ . & . & . & . & . & . & . \\ . & . & . & . & . & . & . \\ . & . & . & . & . & . & . \\ an1 & an2 & an3 & . & . & . & ann \end{vmatrix}$$ nxn

The value aij are obtained by the aii = 1, aij = 1/aji, where aij > 0, for all i. In each of the entries element, i is compared to the element j, whereas j has a reciprocal value compared to j. All the elements are normalized to get Normalize matrix A (Anorm) as follows.

$$Anorm = \begin{vmatrix} a11/a1 & a12/a2 & a13/a3 & . & . & a1n/a'n \\ a21/a'1 & a22/a'2 & a23/a'3 & . & . & a2n/a'n \\ . & . & . & . & . & . \\ . & . & . & . & . & . \\ . & . & . & . & . & . \\ an1/a'1 & an2/a'2 & an3/a'3 & . & . & ann/a'n \end{vmatrix}$$

Aij compares the ith row relative to the ith column, and a'n is the sum of elements in the ith column.

Step 5: Find the criteria weight.

The Eigenvector method has been used to derive matrix A.:

$A.p = \lambda max\,.p$

Where A is the comparison matrix

p is the priorities vector

λmax is the maximal eigen value

The maximal eigenvalue is also used to calculate the consistency index

CI = $(\lambda max - n) \,/\, (n - 1)$

Where n = dimension of the matrix

λmax = maximal eigenvalue

Suppose CR, the ratio of CI and RI (an average CI of 500 randomly filled matrices of the same dimension), is less than 10%. In that case, the evaluations of the decision-maker can be considered a having an acceptable consistency.

CR= CI/ RI

Where CR is the consistency ratio

RI is the random index

(Saaty, 1977) random indices as given in the following table:

Table 5.1

Random Indices in AHPn	3	4	5	6	7	8	9	10
RI	0.58	0.9	1.12	1.24	1.32	1.41	1.45	1.49

Step 5: Comparing alternative pair-wise- there are 'n' criteria in the decision making problem. Hence there will be 'n' matrices for the options available. Each matrix element contains weights of options, and the same is found in the same way as described above for discovering the importance of the criteria.

Step 6: Choose the option having the highest preference among the options. There are 'n' criteria and 'm' alternative options then a matrix of 'n X m' is formed. The matrix contains the score or the weights of a_{ij} for alternatives concerning the observed criteria. As per AHP, the best option is given by the following relationship

$$A_{AHP-Score} = max \sum_{j=1}^{n} \binom{n}{k} aij\ wj, for\ i\ = 1,2,3\ldots., m$$

Where $A_{AHP-Score}$= Overall relative rating

Aij=Average normalisation rating for j with respect to factor i

Wi = Average normalisation weight for I

Step 7 Ranking the alternatives

Obviously, ranking is generated according to decreasing value of $A_{AHP-Score}$

In summary, the steps in AHP offer a hierarchy using ordinal scales through pair-wise comparison.(Abdullaha, Jaafarb, & Taib, 2013)

A survey was conducted from Subject Matter Experts (SMEs), asking them to make pairwise comparisons among the various factors on a scale of 1 to 9. Option 1 denoted that the first factor is five times more important than the second, and 9 denoted that the second factor is 5 times more important than the first. The respondent was asked to select any value in between. The questionnaire was sent to 1204 Experts, and 356 responded. The Experts were asked to determine the relative weight of optimisation factors for MS and HSD supplies in North India. They were asked to provide appropriate response against nine choices for pairwise comparison amongst the factors as under:

1 - Very Strongly agree means the first factor is 5 times more important than the second

2- Strongly Agree means the first factor is 4 times more important than the second

3- Agree means the first factor is 3 times more important than the second

4- Slightly Agree means the first factor is 2 times more important than the second

5- Neutral indicates first and second factor is equally important

6- Slightly Disagree means the second factor is 2 times more important than the first

7- Disagree means the second factor is 3 times more important than the first

8-Strongly Disagree means the second factor is 4 times more important than the first

9- Very Strongly Disagree means the second factor is 5 times more important than the first.

The Experts were from a leading public sector downstream oil companies in India with a minimum of five years' experience in logistics in North India. 44.3 % of respondents had 10 to 20 years, 35.4 % had 20 to 30 years, and 19% had more than 30 years of experience. The geometric mean of the responses was taken for each pairwise comparisons and fed into Super decisions software for AHP analysis. The resulting weights are as under:

The Result of Calculations done by Super decisions is given below:

Table 5.2

Calculation Results of AHP

Inconsistency	0.07925	
Name	Normalized	Idealized
1 Cost	0.27471472	0.585238241
2 Service	0.46940666	1
3 Performance	0.20354837	0.433629078
4 Value	0.05233023	0.111481661

The inconsistency value of 0.07925 was thrown, which is much less than 0.1 and hence acceptable. The comparison matrix states that Cost is equal in importance to performance and Service but is four-time more valuable than Value. Service is four-time more valuable than performance and eight times more important than value.

Table 5.3

Comparison Matrix:

	1 Cost	2 Service	3 Performance	4 Value
1 Cost	1	1	1	4
2 Service	1	1	4	8
3 Performance	1	0.25	1	5
4 Value	0.25	0.125	0.2	1

Source: Compiled by Author

5.4 ANALYSIS OF RESULTS

The results indicate that service is the most critical factor for secondary logistics optimization, followed by Cost and Performance. The Experts have judged value as an unimportant factor and is given minor importance. This is a significant revelation as cost optimization has been the sole criteria in downstream petroleum logistics in India. The respondents consider service as the topmost priority indicates that the framework for optimizing auto fuels in North India must start with service definitions for the customer. The elements of service, i.e., Product Quality, Responsiveness, and Reliability, must be fixed depending on the company strategy and market positioning. The following step ensures that these service parameters are maintained while

applying the least-cost method to maintain optimum performance for the organization. The stakeholder's perspective can be understood from the results as the customer being the most important as the service has to meet the requirement of the market segment targeted by the company. The transportation cost and performance are transporter and company perspectives and must be considered while aligning with customer service. It is pertinent to point out that service to the customer is the most critical factor, even in public sector organizations.

CHAPTER 6
OPTIMIZATION FRAMEWORK FOR SECONDARY LOGISTICS

6.1 INTRODUCTION:

This chapter provides methodology, results, and analysis of objective 3 of the research, i.e., developing a framework for optimization. In the later part, the practical demonstration of the framework will be given.

6.2 DELPHI METHOD

Delphi is a technique for building consensus. RAND Corporation first used this method in 1950; it emerged as a consensus tool in the 1970s. The basic premise of the process is that the group's judgment is superior to that of individuals. This method has been applied in medical, logistics, education (Kittell-Limerick, 2005).

The method has typically been used for solving problems or formulating policies where the information about an issue or the process is not complete. The target or objective is to form a reliable opinion of the group (Kittell-Limerick, 2005). Delphi method has been used where there is incomplete information with the assumption that n +1 opinions are better than n (Rowe & Wright, 2001)

The Delphi method is carried out through a focused discussion, and the results are recorded. It is conducted without the disadvantages of interpersonal conflict. The technique is for consensus, but there is no available tool for analyzing the results statistically, and the analysis varies with the kind of study undertaken. The critics say that there are no checks on the precision and reliability of this method.

The Delphi technique involves designing a questionnaire, selecting an expert panel, and measuring consensus. The method is advantageous in areas where the information or data is significantly less, and there is no agreement among the experts. This technique is desirable as the experts are free to

express their opinions as the survey is conducted anonymously, thereby removing any chances of personal conflict, which is evident in the meetings (Skulmoski, Hartman, & Krahn, 2007).
The procedure involves:

1. Iteration- This allows participant an opportunity for reconsidered and refined opinion
2. Controlled feedback- The data about the group perspective is provided to the participants to clarify or change their view
3. Statistical response- This represents the group's view quantitatively.

(Landeta, 2006)

Essential prerequisites for the Delphi study are the questionnaire designs and the selection of an expert panel. Questionnaire design means the choice of a Likert scale. The expert panel selection involves the choice of panel size, their characteristics, and the response rate. Various rounds may be required to be conducted to build consensus. The conduction of various rounds is a demanding task and depends very much on the participants' group and expertise. It is hard to find time with experts in the industry as they are busy people and may not spare time for academic discussions.

Delphi is a repetitive process of getting responses until an agreement is found. However, in most cases, where the sample size is small, even one round may be sufficient, but a minimum of two rounds is required so that the experts can give feedback and revise their responses (Mullen, 2003). It is the choice of the researcher to select the number of rounds. It is more important to have participation among the experts' group and the process's continuity than the number of rounds. The selection of the panel involves consideration of expertise and knowledgeability. These characteristics will decide the validity of (Kittell-Limerick, 2005).

Hence, the expert should have four characteristics :

1. knowledge and experiences
2. willingness to participate,
3. sufficient time (to participates)
4. effective communication skill

(Skulmoski, Hartman, & Krahn, 2007)

Knowledgeable persons with expertise in the field are discovered through literary sources or references from reputed academic or business institutions and enrolled as subject matter experts. This process can be carried out using purposive and snowball sampling (Bryman, 2011). The expert panel's size and response rate are essential in the Delphi technique, although these are not fixed. The purpose of the research will determine the size of the group (Mulen, 2003). The response rate may differ for different disciplines as per the experts' research interest (Mason, 2007). The increase in sample size leads to an increase in the quality of the decisions and reduced group errors (Skulmoski, Hartman, & Krahn, 2007).

The primary purpose of Delphi is to arrive at a consensus among the expert panel participants. However, it is rare to have a consensus in actual practice. Various publications have tried to measure the degree of agreement by using statistical parameters like frequency distribution, standard deviation, and the interquartile range. The fraction of the people responding to any given category can be used. (McKenna, 1989) has found the value to be 51%. In contrast, there have been cases where the distance from the average value is taken into account, e.g. (Christie & Barela, 2005) proposes that 75% is the number and the response of participates should fall above and below the mean 10 point scale.

The standard deviation should be less than 1.5 (Christie & Barela, 2005). The interquartile range is used to assess should be less than 2.5 (Kittell-Limerick, 2005). Each time the analysis has to have the computation regarding average and median. These critical parameters define the central value of the typical responses (Kittell-Limerick, 2005). Coefficient of variation can be used to measure the homogeneous nature of the observations made, and the most frequent value is the other statistical analysis possible (Saunders & Lewis, 2009)

6.3 FRAMEWORK DEVELOPMENT

The framework was developed and validated using Delphi Method from Ten Experts with more than 25 years of experience in Operations (5), Retail Sales (3), and Institutional Sales (2). An open-ended questionnaire was distributed to the experts after briefing on the factors identified and

weights assigned. The responses were collected for validation of the earlier results and the development of a framework for optimization.

The responses were collected, summarised, and offered to the experts again to revise their opinions. The consensus was obtained after four iterations.

There is no consensus on the ideal number of experts on the Delphi panel. There is no recommendation or detailed description of small or large. Experts disagree on the sample size, and no standard criteria are available in the literature. There have been instances of studies of almost any panel size. In one of the studies, there are only five experts in serious drug interaction. In ambulatory pharmacy, a panel of 6 international experts was used to explore competence training in primary care (Akins RB, 2005).

The method involved the selection of experts having requisite domain knowledge from heterogeneous backgrounds. Ten experts who are heads of different departments were selected. Five experts were from the operations function, three from retail sales, and two from Institutional business, having more than 25 years of experience in their respective fields. The author played the role of moderator and briefed the experts regarding the study. The process of factor identification and assigning weights was explained initially. The Delphi method was also presented.

In the first round, an open-ended questionnaire was circulated. Each of the experts was asked to jot down their opinion on developing a framework for optimising secondary logistics of automotive fuel in North India. They were asked to give their opinion on the achievement of multi-objective optimization.

Three of the five experts suggested that services should be defined first, two each recommended Performance and Value. One voted for Cost as a starting point. The results of the four rounds are tabulated below:

Table 6.1

Results of Delphi Method

Factor	Denoted by
Service	1
Cost	2
Performance	3
Value	4

Experts	First Round	Second	Third Round	Fourth Round
I	3,2,4,1	1,3,2,4	1,2,3,4	1,2,3,4
II	1,2,3,4	1,2,3,4	1,2,3,4	1,2,3,4
III	1,3,2,4	1,3,2,4	1,3,2,4	1,2,3,4
IV	1,2,3,4	1,2,4,3	1,2,4,3	1,2,3,4
V	4,1,2,3	4,1,2,3	1, 3,2,4	1,2,3,4
VI	3,2,4,1	1,3,2,4	1,2,3,4	1,2,3,4
VII	1,2,4,3	1,3,2,4	1,2,4,3	1,2,3,4
VIII	1,2,3,4	1,3,2,4	1,3,2,4	1,2,3,4
IX	2,3,1,4	1,2,4,3	1,2,4,3	1,2,3,4
X	4,1,2,3	4,1,2,3	1,2,3,4	1,2,3,4

Source: Compiled by Author

The methods for optimization in each of the factors were described in each round. There was a unanimous view that the linear programming method is not sufficient for use in secondary logistics. Services parameter having the maximum weight was opined to be the centre of the optimization process. The emerged view was that service delivery should be clearly defined based on company strategy and market segment targeted. After that, the least cost method to achieve those services should be designed. The performance can be enforced through contracting and contract administration with the channel partners, and value is determined by fulfilling the other three objectives.

The following framework has been achieved through consensus.

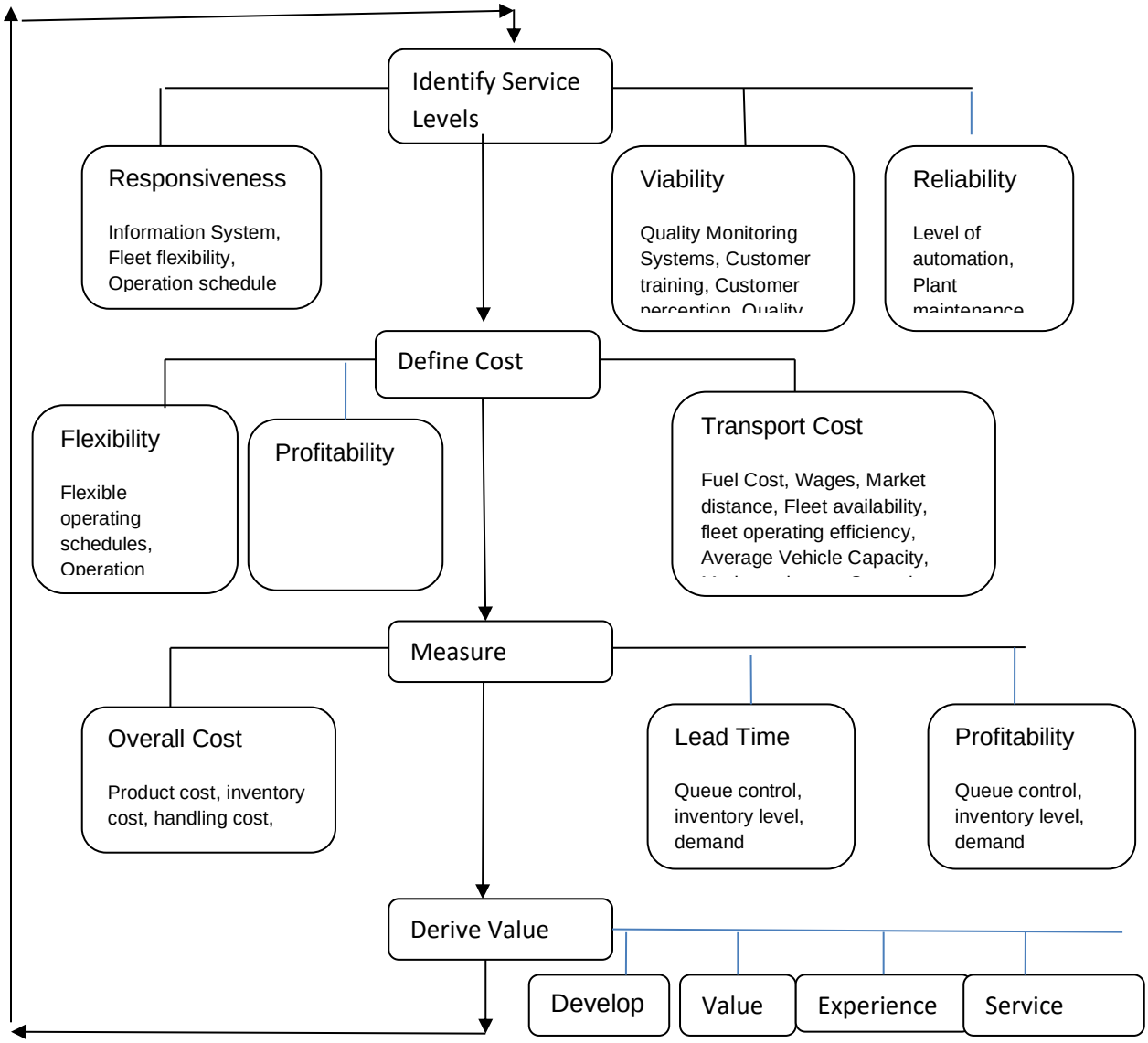


Fig 6.1

6.4 OPTIMISATION:

Optimization is an area of operations research based on the determination of Maxima or minima in an objective function where constraints have been mapped. Optimization is a powerful tool and is developing continuously within the operations research (Figueira & Ehrgott, 2016). In other words, optimization can be called a process of improving things for the better. In this process, several inputs are arranged to obtain the output as per the criteria given. It can also be called a

process of discovering the best possible values from the inputs to get the desired outcome. The best possible value would vary from problem to problem, but mathematically it means Maxima or minima of the objective function by changing the input variables. Traditionally, the optimization tries to discover an isolated solution, a weighted sum of all the objectives. If all the goals get better or worse together, the traditional approach is helpful to find out the most optimal solution. However, in reality, the objectives are conflicting with each other, e.g., increasing performance and reducing costs typically move in opposite directions. There cannot be a single optimal solution in such cases, which necessitates the study of multi-objective optimization methods, which can provide many solutions for balancing the objectives. The results are called Pareto optimal (Chase et al., 2014).

SCM is defined as a compilation of methods to manage the relationships upstream and downstream with suppliers and clients and to deliver value to the customers at the lowest possible price (Christopher, 2005). The purpose is to produce and sell a lot of the goods and services in the correct quantity, at the right geography, at the right time to effect a reduction in cost while increasing customer satisfaction (Jeong, 2002). An SCM problem is essentially multi-objective, as retaining customer satisfaction is inherently linked to cost minimization.

With the increase in competition, the latest design methods, and extensive planning exercises, the widespread crude oil supply chains, including upstream, midstream, and downstream networks, have attracted many researchers. Hence many kinds of research have been recently undertaken in this area. The goal is to achieve the maximum bottom line of SC as a whole. It is essential to devise an optimal structure for the crude oil network, considering the variability in the price and demand and factoring uncertainty. The deterministic mathematical programming is not suitable under uncertainty (Beiranvand, 2018)

Single objective optimization needs significantly fewer computation efforts as compared to multi-objective optimization problems. Many times, solutions to many single objective functions must find a single acceptable solution (Arora & Marler, 2014). These solutions have no articulation of the preferences and are arbitrary when compared to the Pareto optimal set. In single-objective functions, the objectives are added according to their weights, and solutions are calculated. These

methods require less effort in computations and are easy to use and benchmark multi-objective optimization (Arora & Marler, 2014). The weighted sum method is helpful as it is easy, but in severe cases, it is depicted to complete a Pareto optimal set. The problems are complicated, and alternate methods should be used (Arora, Marler, & Jasbir, 2009).

SCM is a unique way to manage importers and their customers to deliver high-quality customer values as a whole (Christopher, 2005). A PSC problem is essentially multi-objective, as retaining customer satisfaction is inherently linked to cost minimization.

Research shows that genetic algorithms find a near-optimal solution in most cases and demands significantly less computational efforts and time (Alexandre, 2018)

In the past 15 years, EMO (Evolutionary Multi-objective Optimization) is widely used in publications and business applications. The method has been used in instances where more than one solutions are available, and each iteration gives a new resulting set.

These have become popular as EOs are:

1. Applicable without any derivative pieces of information
2. Relatively easy to implements, and
3. Flexible and widely applicable.

EOs are perfect options for solving multi-objective optimization problems. In single optimal solutions for solving a single-objective optimization problem, a population of solutions may not be necessary (Deb, 2001).

Genetic algorithms are motivated by nature. It draws its terms from biology, especially reproduction.

The genetic algorithms were developed by John Holland, his students, and colleagues, including David E. Goldberg. These are mathematical models which simulate the process of genetic selection, natural elimination in biological evolution (Holland, 1975)

The use of a genetic algorithm provides a vast set of probable solutions to any problem. This set of solutions undergoes crossover and mutation to produce new solutions. This is a repetitive process for many generations. Each prospective solution is assigned a fitness score. The solution, which is better than the other as per the given criteria, is given a higher opportunity to mate and produce further offsprings. Genetic algorithm (Holland J., 1975) is a category of research methods that have been designed as per the natural evolution of biological species by reproduction, rivalry, natural selection, and mutation. Genetic algorithms have a population of solutions rather than a single solution and therefore are not having a single or local Optima. Genetic algorithms are easy to execute, as these do not require additional information. These have become a top-rated tool for network design and solving routing problems (Leung, 1998)

The solutions keep on getting better and better over the generations until a stop criterion is reached. In the genetic algorithms, calculations are done randomly but give results better than local search as they are using historical information. These methods are based on Darwin's theory of survival of the fittest. GA has become a very popular search technique for solving optimization problems as it does not require derivative information. A direct search algorithm is used to get the most probable or near-optimal solutions to the optimization and search problems (Hall, 1992)

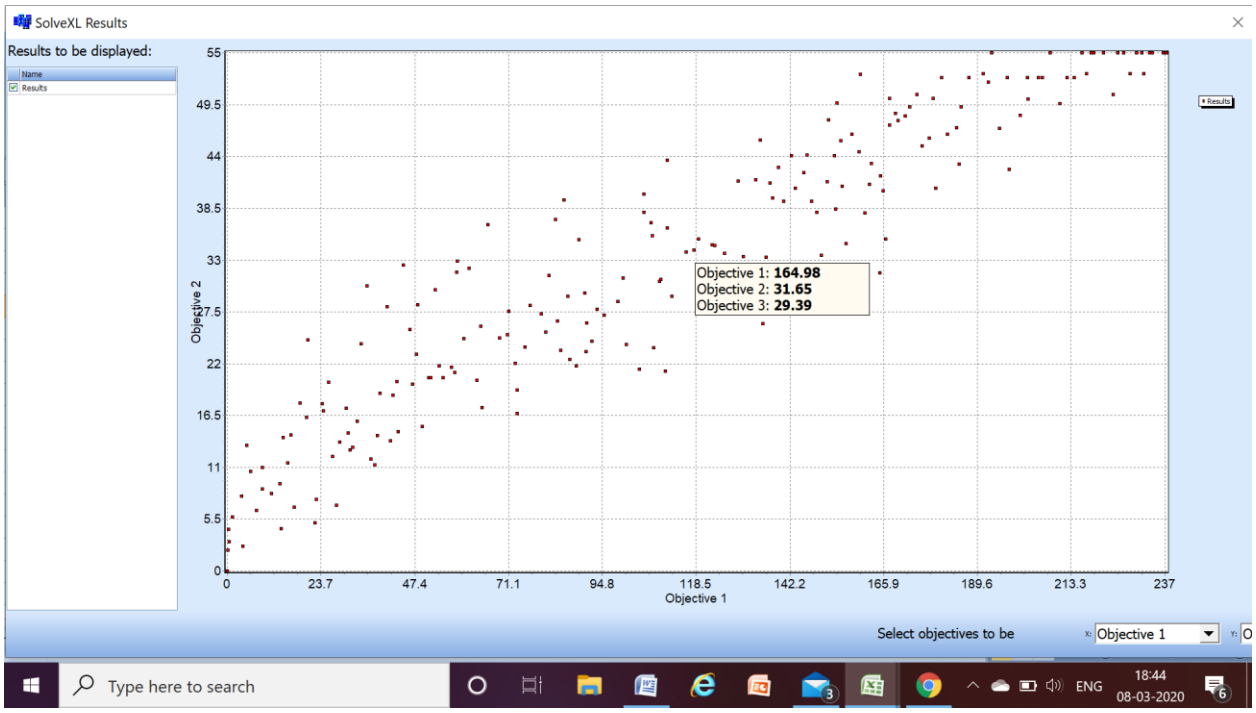
Genetic Algorithms do not require any derivative information and more efficient when compared to traditional methods. These can optimize both continuous and discrete functions. Hence these are best suited to the complex secondary logistics problem where the objectives functions are varied and subjective. It provides the decision-maker with the flexibility of choosing the results based on the preferences of the decision-maker. The SolveXL uses a Crowded Tournament type selector, which involves running several "tournaments" among a few individuals (or "chromosomes") chosen at random from the population. The one with the best fitness is considered the winner of each tournament and is selected for crossover. The size of the tournament determines the likelihood of participation of the chromosome in the tournament. In a large size tournament, the weak chromosomes have a feeble chance of being selected. A weak individual is selected; the opportunity of selection of a strong individual is higher. The chosen solutions are used for progression into the next generation for input to the crossover and mutation procedures. (Microsoft, 2020)

The framework proposed in the present study was used in a test case of a northern Indian state with three locations and five no. of customers. The (MOO) was carried out using the Evolutionary Genetic Algorithm.

In this method, the product's volume supplied from a location to a customer is defined as a gene, forming these 15 possible combinations constituting a chromosome. The first objective is the maximization of service, and to simplify only one component, i.e., a delivery time has been used, the calculations have been carried out in Table 6.2. The minimization of cost has been defined in terms of each gene (product volume from locations) multiplied by the round-trip distance and transportation rate with local levies added. The third objective is the maximization of value, defined as the volume multiplied by the distance travelled. SolveXL has been used with the Simple One Point crossover type, and the crossover rate of 0.9 was used.

The probability of mutation has to be less than reciprocal of chromosome length, i.e., 15 in the present study; otherwise, no mutation is performed. If the reciprocal of chromosome length is less than or equal to the Mutation Rate, which is less than twice the reciprocal of chromosome length, then one mutation can be expected per chromosome. The choice of mutation rate implies the number of bits that will be undergoing mutation. Mutation probability is multiplied by the chromosome length, and it has been taken as 0.95. Thus, the integer value is compared with the random value, and if the integer is smaller, the mutation is performed. The optimization was run for 100 iterations, and the results have been shown in the following graph:

RESULTS OF GENETIC ALGORITHM USING SOLVEXL



Source: Compiled by Author Fig 6.2

TABLE 6.2

OPTIMISATION RESULTS OF GENETIC ALGORITHM

Retain Outlet name	Location1	Location2	Location3	Sale in KL	Demand in KL	Unmet Demand In KL
RO 1	0	1656	0	1656	1656	0
RO 2	0	0	624	624	624	0
RO 3	3644	0	0	3644	3644	0
RO 4	0	1696	0	1696	1696	0
RO 5	0	0	2084	2084	2084	0
Total	3644	3352	2708	9704	9704	

Source: Compiled by Author

The cells in the table are genes constituting a chromosome

Table 6.3

ROUND TRIP DISTANCE (RTD) IN KM FROM ALTERNATE LOCATIONS

Retail Outlet Name	Location1	Location2	Location3
RO 1	257	319	92
RO 2	88	178	90
RO 3	99	193	90
RO 4	90	180	90
RO 5	125	205	104

Source: Compiled by Author

Table 6.4

LOCAL LEVIES COMPONENT OF LOGISTICS COST

Local Levies in Rs

Retail Outlet Name	Location1	Location2	Location3
RO 1	630	0	0
RO 2	180	0	0
RO 3	0	0	420
RO 4	180	0	0
RO 5	730	0	0

Source: Compiled by Author

Table 6.5

TRANSPORTATION COST COMPONENT OF LOGISTICS COST

Transportation Cost in Rs/KL/KM

Retail Outlet Name	Location1	Location2	Location3	Total
RO 1	0	2782434	0	2782434
RO 2	0	0	329370	329370
RO 3	2054728	0	0	2054728
RO 4	0	1606311	0	1606311
RO 5	0	0	1271513	1271513
		Total Rs lac		**80.44**

Source: Compiled by Author

Table 6.6

SERVICE TIME PARAMETER FOR OPTIMISATION

Service Time in Hrs.

Retail Outlet Name	Location1	Location2	Location3	Hours
RO 1	0	8	0	8
RO 2	0	0	2	2
RO 3	2	0	0	2
RO 4	0	4	0	4
RO 5	0	0	3	3
Source: Compiled by Author			Total Hrs.	**19.82**

TABLE 6.7

PERFORMANCE MEASURE FOR OPTIMISATION

Performance (Number of Locations operated)

Head	Location1	Location2	Location3	No. Of Loc
Location Operation	1	1	1	3

Source: Compiled by Author Total No. **3.00**

Table 6.8

VALUE PROPOSITION FOR OPTIMISATION

Value is Lac Rs

Retail Outlet Name	Location1	Location2	Location3	
RO 1	0	528741	0	528741
RO 2	0	0	56257	56257
RO 3	361244	0	0	361244
RO 4	0	305244	0	305244
RO 5	0	0	217178	217178

Source: Compiled by Author **Total Rs 14.69 Lac**

The results obtained through the evolutionary genetic algorithm give various solutions satisfying each of the objectives to a varying degree as per the relative weights of factors. The same can be used to arrive at the optimal solution in each case**.** The weights assigned to the factors Service, Performance, Cost, and value have been used to arrive at the most optimal solutions in the test case. In the set of solutions, the comparison between two chromosomes, the incremental benefit obtained in each solution are compared and assigned a relative weight to decide on the suitability.

CHAPTER 7
CONCLUSIONS

7.1 CONCLUSION

The secondary logistics of auto fuels is the customer-facing supply chain where Oil Marketing Company, Carrier, Crew, Retailer, Consumer, and local community are the primary stakeholders. The relationships among these stakeholders determine the supply chain's performance as a whole as it appears to the customer. This logistics is the portion where the interface with the customer takes place. These stakeholders have contractual relationships with the Oil Marketing Company (OMC), responsible for making sustainable parameters to meet their objectives. The supply chain's primary logistics part is in the complete control of OMC as the product remains in its custody at the dispatcher and receiver end. In this case, cost optimization is a universally accepted solution using the Linear Programming technique since the relationship between cost and other variables like inventory, transportation, lead time to delivery, product quality assurance, taxation. have linear relationships. However, in secondary logistics, the various stakeholders have their objectives, and such unilateral cost optimization efforts will affect them.

The gap in the literature is evident as the secondary logistics of auto fuels has not been studied, and the factors of optimization have not been identified. In India, the sector is dominated by large public sector companies that have exclusive experience in this sector for six decades. The practising managers have tried to balance various stakeholders' objectives without any theoretical framework, and no reporting can be seen in the literature.

In the downstream petroleum industry, secondary logistics is the last mile connectivity between the Oil Marketing Companies and the retailers/ consumers. It is essentially accomplished through the road in North India. The Logistics costs are controllable and significantly contribute to the oil industry's expenses running on low margins. The Oil Marketing Companies (OMCs) are using various models for optimizing primary logistics. In the past secondary logistics, optimization has

been limited to supplies from the nearest available source. Secondary logistics can be a crucial distinguisher in OMCs' service delivery as it is the customer-facing part of the supply chain.

The channel partners' objectives have to be considered and balanced while constructing optimization models for secondary logistics and aligned with the company's strategy. The study has been limited to the highest-selling petroleum products MS and HSD sold through retail channels of OMCs, affecting the day-to-day life of the Indian consumers. North India is farthest from the sea, so it is more dependent on surface transport and has high volume sales and high complexity. Hence, the model developed here may be applied to other areas with suitable modifications. The business problem has been defined as "Oil Marketing Companies in India are incurring high secondary logistics cost without a corresponding increase in sales thereby denting their margins significantly."

The SC executives need a DSS to conveniently handle transportation and logistics precisely and flexibly change as per market conditions. The configuration of a logistics network has been considered, and many methodologies have been suggested. Some of these are genetic, heuristic, and stimulation based. Linear programming is most widely used, although it has some severe limitations. The objective function and constraints have to be linear, making it an unsuitable method for observing the effect of time and uncertainty. This method is not applicable when the parameters are not constant. LP is not an appropriate option for multi-objective problems where the diverse objectives may conflict with each other. Despite the limitations of LP, it is still prevalent in solving logistics network configuration problems as it is convenient and many optimization tools and solvers are available for the help of the managers.

The multi-objective decision theory deals with problems that can arise because of multiple factors and diverse situations. Many methodologies are available in literary publications. Some of these are already successful in solving business problems in practice. However, their use in secondary logistics of petroleum products has been limited as the stakeholders have different and often conflicting interests. The impact of each objective function is that improvement in one objective harms another, and for getting a nearly optimal solution, multi-objective optimization is appropriate.

The exact solutions to these complicated problems are very time-consuming. Some of the researchers have suggested several heuristics and soft computing methods. The Genetic algorithm has also been widely recommended for location-allocation problems. It is an optimization method based on evolutionary adaptation in nature. It can be applied to many issues, including complex optimization problems where the functions are nonlinear, multi-model, and have no gradient information available. It is a category of global search methods designed on Darwin's theory of natural selection.

To create a framework for optimizing the secondary logistics of auto fuels in North India, the variables needed to be identified. Since no literature is available in this area, the variables were identified through a literature review of other industries and synthesized and reworded as per industry parlance through subject matter experts. The literature review from other industries provided the following variables: Product Cost, Transport Cost, Experience, Service Level, Lead Time, Responsiveness, Reliability, Flexibility, Market Reach, Mileage, Development, Viability, Compensation, and Profitability. Identifying underlying factors was carried out with five experts having more than 20 years in the field. After identifying the variables, a survey was conducted from experts in logistics, sales, and operations, and factor analysis threw up four underlying factors. The first factor has components of Product Cost, Lead Time, and Profitability. These variables are essential for the business perspective of the oil marketing company and can be termed logistics' performance. The second factor has Responsiveness, Reliability, and Viability as components that essentially relate to the Retail Outlet Dealer, the receiver of the services, so this may be called Service Factor.

Transport Cost, Flexibility, Mileage, and Compensation essentially are the concern of the transporter who would require flexibility for optimum fleet utilization and transport cost. Both are related to the cost incurred by the logistics provider. The fourth factor is defined by Development, Value, Experience, Service, and value are the concerns of the local community and can be termed as Perceived Value to the local community and customers.

Performance, Service, Cost, and Value are the four factors identified for optimising secondary logistics of Petroleum products in India. The customer, transporter, retail outlet dealer, crew, community are stakeholders; the least cost methods may affect the company's competitive position. The paper has identified various factors to be considered to optimize secondary logistics in the petroleum industry.

Performance, Service, Cost, and Value are the four factors identified for optimising secondary logistics of Petroleum products in India. The customer, transporter, retail outlet dealer, crew, and customer are stakeholders; the least cost methods may affect the company's competitive position. The development of the framework required the assignment of relative weights to each of the factors. The assignment of weights was achieved through a survey using pair-wise comparison and then applying the Analytical Hierarchy Process. The results indicate that service is the most critical factor for secondary logistics optimization, followed by Cost and Performance. The SMEs have judged value as an unimportant factor and is given the least important. This result is a significant revelation as cost optimization has been the sole criteria in downstream petroleum logistics in India. The framework was developed and validated using Delphi Method from Ten Experts with more than 25 years of experience in Operations, Retail Sales, and Institutional Sales. The framework was used to demonstrate the optimization of secondary logistics in small markets using a genetic algorithm.

The framework developed was demonstrated by using it to a small market segment with five markets and two supply locations. The solution provided is found to be balancing the conflicting interests of various stakeholders. The cost optimization methods earlier applied for logistics decision making had an inherent drawback of considering only one stakeholder in the supply chain. The Business problem has been solved as the companies shall realize the benefits of optimization in the secondary logistics of automotive petroleum products while retaining their competitive edge by balancing the interests of their stakeholders. Genetic Algorithms are appropriate for the secondary logistics of petroleum products as the method does not require any derivative information and is more efficient than traditional methods. These can optimize both continuous and discrete functions. Hence these are best suited to the complex secondary logistics problem

where the objectives functions are varied and subjective. It provides the decision-maker with the flexibility of choosing the results based on the preferences of the decision-maker.

The first research question was to identify the optimisation factors in secondary logistics in the downstream petroleum industry. The variables from the literature survey were presented before the experts in the field, and the results threw four factors, namely Performance, Cost, Service and Value. The next question was to study how can secondary logistics be optimized. The relative weights of these factors were established using another survey using where experts assigned weightage to each of these. The results show that the service level has the highest weightage, followed by cost, performance and value, in that order. The third and last question was to develop a framework having practical utility for the organisations. The framework was determined using the Delphi method, and the results were that the service level is required to be identified first, followed by cost optimization. The system's performance has to be measured to derive maximum value to the customer for whom the service levels were defined. The feedback loop can continue to improve performance continuously. An example has been provided for the industry using the genetic algorithm to know how the framework designed can be practically implemented in decision making.

7.2 LIMITATIONS

Petroleum products have various modes of custody transfer to the customer. In automotive fuels, the OMCs have the responsibility of delivery of products to the customer. The study is limited to these delivered supplies of automotive fuels and does not cover the customer transported fuels.

The geographical limits of North India, consisting of UP, Rajasthan, Haryana, Punjab, HP, and J&K, have been used. Since this area is far from the sea, the logistics cost has a more pronounced impact on the organization's overall profitability and limits the applicability to onshore locations only.

The subject matter experts are from a leading public sector petroleum country in India that have worked in north India. The study cannot be extrapolated to other geographical areas without contextualizing.

7.3 SCOPE FOR FURTHER RESEARCH

A model based on the suggested framework can be developed and applied to a market, and the results can be measured to validate the model. The framework created for north India may be studied for other geographical areas. Sensitivity analysis can be carried out to find the effect of the variables. The resultant model may be integrated with primary logistics and refinery models to obtain an integrated logistics model for the petroleum industry.

7.4 CONTRIBUTION

The literature is available for optimization techniques in the petroleum supply chains from the exploration and storage points. Cost optimization has been the dominant theme in all this literature. The last mile part of the supply chain has not been reported in the literature. There was a knowledge gap as the literature has not distinguished secondary logistics, which essentially is the customer-facing part of the supply chain. Hence, the industry has been hesitant in carrying out the optimization. The experience of the supply chain managers deters them from using cost optimization methods in secondary logistics. However, in the absence of any conceptual framework, the optimization is left to the field offices' judgment.

Contribution to Theory: The present study has reported the current practices of the Indian downstream petroleum industry. The multi-objective nature of the problem has been established as distinguished from cost optimization, which is the central theme in literature. The factors optimising secondary logistics of auto fuels have been identified. Their relative weights determined to develop a framework for the decision-making in this part of the supply chain.

Contribution to Practice: Multi-objective optimization theory and multi-criteria decision theory have been studied, and their applicability to the secondary logistics of automotive petroleum fuels has been discussed. A Framework has been proposed for the optimization of secondary logistics of automotive petroleum products. Even a demonstration has been provided for easy understanding.

This study has defined secondary logistics and clearly distinguished it from the primary logistics requiring an entirely different optimization approach.
Methodological contribution by using AHP in decision making in secondary logistics of petroleum products and Evolutionary Genetic Algorithm to solve the multi-objective optimization problem.

This research draws attention to the most critical part of the supply chain, where it interfaces with the customer, which defines the supply chain's competitive edge. It is well known that the competition now is among the supply chains and not among companies. Hence it becomes imperative to focus on each part of the supply chain. The optimization theories are obsessed with cost optimization throughout the supply chain and do not change their overall purpose of optimization, be it manufacturing or logistics operations. The simplicity of linear programming has led to its extensive use in literature and industry. This research has discussed the limitations of this approach and the importance of using multi-objective optimization methods.
The present study has merged the concepts of optimization and decision theories as supply chain management aims to make the supply chain efficient and provide value to the customer in a cost-effective and timely manner.

Contribution to Policy: The study moots the idea that the starting point for any supply chain design has to be the secondary logistics where the service to the customer is the most critical factor in optimization and is central to the design of the supply chain. The impetus has to be given to balancing the factors affecting the various participants so that viability of the supply chain is maintained.

7.5 Ethical Considerations :

Privacy, anonymity, and confidentiality are vital ethical considerations, particularly in online survey research. Anonymity means that the participant's identity is unknown and cannot be connected to the response provided. Confidentiality means that the reactions of the other participants are not shared. (Clark, 2006) states there are three broad reasons for making the data anonymous. To protect the identity, disguise the location and comply with privacy requirements.

The identity of the participants in the online and offline survey has been kept confidential. Participation in the study was purely voluntary, and the participants were able to make informed choices. The two online surveys were carried out on google forms. The participants had to essentially fill the consent form, which informed them about risk, privacy policy, and data security. The purpose of the survey was clearly explained at the beginning.

7.6 PUBLICATIONS

Term Paper I on "Identification of Factors of Optimization in Secondary Logistics of Indian Downstream Petroleum Industry" has been published in UGC approved journal

Term Paper II has been published in UGC approved journal titling "Decision Making in Secondary Logistics of Petroleum Industry Using Analytic Hierarchy Process."

Term Paper III has been published in SCOPUS approved journal on the topic "Framework for Optimizing Secondary Logistics of Automotive Fuels in Downstream Petroleum Industry in North India."

REFERENCES :

(2005, September). Retrieved December 19, 2015, from www.honeywell.com: https://www.honeywellprocess.com/library/marketing/case-studies/SuccessStory_IndianOil_SupplyChainMgmt.pdf

Abdel, M., & SAD, S. (2016). *Fuzzy Analytical Hierarchy Process for the selection of Maintenance Policy within Petroleum Industry.*

Abdullaha, L., Jaafarb, S., & Taib, I. (2013). Ranking of Human Capital Indicators using Analytic Hierarchy. *Evaluation of Learning for Performance Improvement International Conference*, 23-25.

Abdurahman, N., Rosli, Y., Azhari, N., & Hayder, B. (2012). Pipeline transportation of viscous crudes as concentrated oil-in-water emulsions. J. 2012, 90, 139−144. 139-144.

Adeleke, E. (2012). *Journal of Business Management and Economics, 3(6)*, 238.

Akins RB, T. H. (2005). Stability of response characteristics of a Delphi panel: application of bootstrap data expansion. *BMC Med Res Methodol.*

Alderton. (1995). The thought of multimodal transportation .

Alessandro Creazza*, F. D. (2012). Applying an integrated logistics network design and optimisation model: the Pirelli Tyre case. *International Journal of Production Research*, 3021-3038.

Alexandre, T. M.-J. (2018). Optimising integrated inventory policy for perishable items in a multi-stage supply chain. *International Journal of Production Research*, Vol. 56, Nos. 1–2, 902–925.

Al-Othman, W., Lababidi, M., Alatiqi, I., & Al-Shayji, K. (2008). Supply chain optimization of petroleum organization under uncertainty in market demands and prices. *Eur. J. Oper Res*, 822–840 .

Al-Qahtani, K., & Alpe, A. E. (2008). Multi refinery and Petrochemical Networks Design and Integration. *Industrial and Engineering Chemistry Research* .

Altekar, R. V. (2008). *Supply Chain Management, .* Prentice Hall .

Altiparmak, F., Gen, M., Lin, L., & Paksoy, T. (2006). A Genetic Alogorithm Approach for Multi Objective Optimisation of SC Networks. *Computers & Industrial Engineering*.

Analytic Hierarchy Process. (n.d.). Retrieved 8 7, 2020, from Wikipedia: The Free Encyclopedia: http://en.wikipedia.org/wiki/Analytic_hierarchy_process

Ankalikar, A., & S, S. (2014). SUPPLY CHAIN MANAGEMENT OF DOWNSTREAM RETAIL OIL AND GAS PRODUCTS – IMPERATIVES FOR NEXT GENERATION E-GAS STATION. *INTERNATIONAL JOURNAL OF EMERGING TECHNOLOGIES AND APPLICATIONS IN ENGINEERING, TECHNOLOGY AND SCIENCES ISSN: 0974-3588, Vol: 7, Issue 1*.

Apurva Chandra . (2013). *Report of the Working Group on Integrated Strategy for Bulk Transport of Energy and Related Commodities in India* .

Arora, R. M. (2004). *Springer-Verlag 2004* .

Arora, R., & Marler, a. J. (2014). Survey of multi-objective optimization methods for engineering. *https://www.researchgate.net/publication/225153273*.

Arora, R., Marler, T., & Jasbir, S. (2009). The weighted sum method for multi-objective optimization: new insights. *Struct Multidisc Optim*.

Aspen Technology. (2009). Integrating the Petroleum Supply Chain Drives Value.

Assey, J. J. (2012). A New Introduction to Supply Chains and Supply Chain Management: Definitions and Theories Perspective. *Journal of Business and Economics.* , 5(1), 194-207.

Audy, J.-F., Lehoux, N., SophieD'Amours, & Ronnqvist, M. (2010). A Framework for an Efficient Implementation of Logistics Collaboration. *International Transactions in Operational Research*.

Babbie, E. (2014). *The Basics of Research* . Belmont: Wadsworth.

Balasubramanian, K. (2002). *Supply Chain Management in Oil Downstream Distribution Business: A Perspective on IT Alternatives and Issues.*

Ballou, R. 2. (2005). *Business logistics management. .* Upper Saddle River, NJ: : Prentice-Hall.

Barbosa, P. A. (2014). Process supply chains management – where are we? Where to go next? *Process Energy Syst. Eng*, 2,23.

Bask. (2001). Relationships among TPL providers and members of supply chains: A strategic perspective. *The Journal of Business and Industrial Marketin* , 16, 470-86.

Battini, D. (2008). *Dynamic Modeling of Networks and Logistic Complex Systems.*

Bayraktar, E., M Demirbag, M., Lenny, K., E Tatoglu, E., & Zam, H. (2009). Bayraktar, E., Demirbag, M., Lenny Koh, S.C., TatoglA causal analysis of the impact of information systems and supply chain management practices on operational performance: Evidence from manufacturing Experts in Turkey. . *Int. J. pro*, 133-149.

Beiranvand, H. ,. (2018). A robust crude oil supply chain design under uncertain demand and market price: A case study. *Oil. Gas Science and Technology*, 99.

Beiranvand, H., Mahdi, G. H., & Pishvaee, M. S. (2018). A robust crude oil supply chain design under uncertain demand and market price: A case study. Oil. *Gas Science and Technology* -, 66.

Benferhat, S. K. (2001). A possibilistic logic handling of strong preferences. , . *In: Proceedings 9th IFSA World Congress and 20th NAFIPS International Conference* (pp. vol. 2, pp. 962–967). IEEE Press, Piscataway .

Beresford. (2011). Multimodal supply chains from: iron ore from Australia to China. Supply chain Management: An International journal . 32-42.

Bezerra. (2017). Comparative Analysis about the Application of Methods of the DEA. *International Journal of Engineering Sciences &Research Technology*.

Bhatt, Y., & Roychoudhary, J. (2021). *https://www.researchgate.net/publication*. Retrieved from https://www.researchgate.net: https://www.researchgate.net/publication/337049369_India's_Automotive_Fuel_Policies_Evolution_and_Challenges

Biswas, S., & Narahari, Y. (2004). Object oriented modeling and decision support for supply chains. *European Journal of Operational Research* , 153(3): 704-726. 2004 .

Blog, F. (2020, January 23). *Correlational Research Designs: Types, Examples & Methods. Formplus. .* Retrieved from https://www.formpl.us: https://www.formpl.us/blog/correlational-research

Blum, C. P. (2011). *Appl. Soft Comput.*, 11, 4135–4151.

Bondada, P. R. (2013). *SCM in Fertilizer.*

Bone, T., & Ganesha, R. (2005). *New Direction in Supply Chain Management Technology Strategy & Implementation.* Jaico Publishing House.

Bontekoning.Y. (2004). Is a new applied transportation research field emerging? A review of intermodal rail truck freight transport literature. Transportation Research Part A: Policy and Practice . 1-34.

BPCL. (2016). *BPCL Annual Report 2015-16.* BPCL.

BPCL Annual Report. (2013-14).

BPCL Annual Report. (2014-15).

BPCL Annual Report. (2014-15).

BPCL Annual Report. (2018-19).

Brooks, F. D., & Davenport, T. H. (2004). Enterprise systems and the supply chain. *Journal of Enterprise Information Management*, 8-19.

Bryant, L. J. (2004). Managing value creation with the firm :: an examination of multiple performance measures. *Journal of Management Accounting*.

Bryman, A. &. (2011). *Business research methods.* New York: Oxford University Press, Inc.

Butta, T. L. (2016). Challenges in the operation of multimodal transport system: The case of Ethiopian shipping and logistics services enterprise.

Byun, D.-H. (2001). The AHP approach for selecting an automobile purchase model. *Information & Management*, 289–297.

Carneiro, M., G P Ribas, G., & Hamacher, S. (2010). Risk management in the oil supply chain: a CVaR approach. *Ind. Eng. Chem. Res.* , 3286–3294.

Carter, C. R., & Rogers, D. S. (2008). A Framework of Sustainable SCM : Moving towards New Theory . *International Journal of Phusical Distribution and Logistics Mgmt Vol.38 No. 5* .

Chakraborty. (2008). Impact of lean manufacturing on Global Supply Chain going lean with SAP LPO (Lean planning and Operations) .

Chan, e. a. (2003). Conceptual Model of Performance Measurement for supply chains .

Chan, F. T., Shekhar, P., & Tiwari, M. K. (2014). Dynamic Scheduling of Oil Tankers with Splitting of Cargo at pickup and delivery locations -A Multi Objective Ant Colony based approach . *International Journal of Production Research*.

Chandra, A. (2013). *Report of the Working Group on Integrated Strategy for Bulk Transport of Energy and Related Commodities in India.* Report- Policy Committee (NTDPC).

Chapra, S., & Meindl, P. (2013). *Transportation in a Supply Chain: Strategy, Planning and Operation.* (Fifth, Ed.) Pearson.

Chase, M., Rademacher, E., & Lansing, G. E. (2014). cedar technology. *A Benchmark Study of Multi-Objective Optimization Methods*.

Chen. (2011). Modelling Vehicle Routing Problem with Pick-Up Time Constraint for Multimodal Transportation . 464-469.

Chen. (2015). Research on Multimodal Transport Optimization Problem Based on Carbon Constraint Policies. 339-344.

Chiu, Y. J., Chen, H. C., & Tzeng, G. H. (2006). Marketing strategy based on customer behavior for the LCD-TV. *International Journal of Management and Decision Making*, 143-165.

Chopra, S. a. (2007). *Supply chain management: strategy, planning and operations. .* Upper Saddle River, NJ: PrenticeHall.

Chopra, S., & Meindel, P. (2002). *Supply Chain Management: Strategy, Planning, and Operation.* Prentice Hall of India.

Christie, C. A., & Barela, E. (2005). The Delphi technique as a method for increasing inclusion in the evaluation process. . *The Canadian Journal of Program Evaluation*, 20(1), 105-122.

Christopher, M. (2005). Creating value-adding networks. . *Logistics and supply chain management:*.

Christopher, M., & Peck, H. (2013). Building the resilient supply chain. *International journal of logistics management. Vol.15*, 1 - 13.

Cigolinia, R. a. (2010). Managing operational risks along the oil supply chain. *Production Planning and Control*, 1-16.

Clark, A. (2006). Real Life Methods - Anonymising Research Data [Internet]. ESRC National Centre for. *ESRC National Centre for Research Methods, 7*, 06. Retrieved from http://eprints.ncrm.ac.uk/480/1/0706 anonymising research data.pdf

Clarke, K. (2010). India's Downstream Petroleum Sector-Refineed Product Pricing and Refinery Investment . *International Energy Agency*.

Cohen, B. (2016). *BP statistical review of world energy 2016.* BP.

Cook, D. R. (1990). Challenges and Opportunities in the US Fresh Produce Industry. *Journal of Food Distribution Research-University of California at Davis*.

Cooper, M. L. (1997). Meshing Multiple Alliances. *Journal of Business Logistics, 18 No. 1*, pp. 67-89.

Costello, A. B., & Osborne, J. W. (2005). Best Practices in Exploratory Factor Analysis. *Practical Assessment Research and Evaluation Vol10 No. 7* .

Creswell, J. W. (2005). *Educational research Planning, conducting, and evaluating quantitative and qualitative research.* NJ: Pearson.

CSO. (2019). *Energy Statistics .* New Delhi: GOI.

CSO, M. O. (2018). *Energy Statistics.* NEW DELHI: GOVERNMENT OF INDIA.

Cuthbertson, R., & Piotrowics, W. (2008). *Supply Chain Best Practices-Identification and Categorisation of Measures and Benefits.*

Dalkey, N., & Helmer, O. (1963). An experimental application of the Delphi method to the use of experts, . *Management Science* , 458–467 .

Dantzig, G. (1955.). Linear programming under uncertainty. . *Management Science*, 1, 197±206.

Das, I. a. (1997). A closer look at drawbacks of minimizing weighted sums of objectivesfor Pareto set generation in multicriteria optimization problems. . *Structural and Multidisciplinar Optimization,* , 14, 63–69.

Dasgupta, M. (2015). Exploring the Relevance of Case Study Research . *Sage Publications*.

Datta. (2008). BPCL Supply Chain Optimisation.

Datta, B. K. (2008). Retrieved from www.iimb.ernet.in: http://www.iimb.ernet.in/~review/imrc2008/Resources/Datta.pdf

Davar, R. (2015). Industry Sales Review . *PPAC, MOPNG*.

Davies, C. a. (2003). Genetic algorithms for rerouting shortest paths in dynamic andstochastic networks. . *European Journal of Operational Research,*, 144 (1), 27–38.

Deb, K. &. (2007). Interactive evolutionary multi-objective optimisation and decision-making using reference direction method.

Deb, K. (2001). Multi-objective optimisation using evolutionary algorithms. *Chichester, UK*.

Deb, K. S. (2006). Reference point based multi-objective optimisation using evolutionary algorithms. . *International Journal of Computational Intelligence Research* , 2(6):273–286 .

DeCarlo, M.). (2018, August 7). *Scientific Inquiry in Social Work. Pressbooks.* Retrieved from https://scientificinquiryinsocialwork.pressbooks.com: https://scientificinquiryinsocialwork.pressbooks.com

Dekker, R. B. (2012). Operationsresearch for green logistics – an overview of aspects, issues,contributions and challenge. *European Journal of Operational Research*, Vol. 219 No. 3, pp. 671-679.

Demirel, N. a. (2008). A mixed integer programming model for remanufacturing in reverse logistics environment. *The International Journal of Advanced Manufacturing Technology*, 1197-1206.

Deshpande. (2009). Development of supply chain performance measurement system for the leading soft drink distributor in Nagpur. International Conference on Global Meltdown, Opportunities and Challenges. Himalaya Publication House.

Dewan. (2005). Towards Supply Chain Integration Through Multimodal Transport in Developing Economies: The Case of Bangladesh . Maritime Economics & Logistics , 7 (4). 382 399.

Dhanalakshmi, S. (2014). *Minimisation of the Total Operating Cost susing Supply Chain Optimisation Model .* Chennai: Anna University.

Dhingra, R. (2012). *Integrated Multi Objective Optimisation of Supply Chain Under Customer Oriented Dynamic Environment.* Faculty of Science, Dayalbagh Educational Institute.

Dhingra, R. (2012). *Integrated Multi-Objective Optimization of Supply Chain Under Customer Oriented Dynamic Environment.* Agra: Dayalbagh Educational Institute.

Diaz, J. T. (2015). Criteria for decision-making in Transportation Logistics Function Multicriteria Decision Network for transport logistics costing .

Diaz, L. C. (2013). Surgical approaches for cam femoroacetabular impingement: the use of multicriteria decision analysis. *Clin Orthop Relat Res.*, 471(8):2509-16.

Dictionary, C. O. (2020). *Dictionary*. Retrieved from Cambridge Online Dictionary: https://dictionary.cambridge.org/dictionary/english/

Dijkstra, T. K. (2013). On the extraction of weights from pairwise comparison matrices. *Central European Journal of Operations Research, 21*(1), 103-123. Retrieved 8 7, 2020, from https://link.springer.com/article/10.1007/s10100-011-0212-9

Dreo, J. S. (2006.). *Metaheuristics for Hard Optimization.* Heidelberg: Springer-Verlag.

Dua. (2015). The Multimodal Transportation : Research Trend and Literature Review.

Dua, A. (2015). The Multimodal Transportation : Research Trend and Literature Review.

Economic Survey of India. (2014-15).

Economic Survey of India. (2014-15).

(2015). *Energy Statistic.*

(2019). *Energy Statistic.*

Ettl, e. a. (2000). Supply Network model with Base-Stock control and Service Requirements . *Operations Research*.

Fawcett, S., Osterhaus, P., Magnan, G. M., Brau, J. C., & McCarter., M. (2008). Information sharing and supply chain performance: the role of connectivity and willingness, . *Supply Chain Management: An International Journal* , 358-368.

Feng. (2013). Multimodal Transport System Coevolution Model Based on Synergetic Theory.

Fernandes, L. J., Relvas, S., & Póvoa, B. (2016). Collaborative design and tactical planning of downstream petroleum supply chains. *Ind. Eng. Chem. Res*, 17155–17181.

Fernandes, L. J., Susana Relvas, A. P., & Barbosa-Póvoab. (2013). Strategic network design of downstream petroleum supply chains: Single versus multi-entity participation. *Chemical Engineering Research and Design*, 1557-1587.

Fernandes, L., Relvas, S., & A.P Barbosa-Póvoa. (2013). Strategic network design of downstream petroleum supply chains: single versus multi-entity participation. . *Chem. Eng. Res.*, 1557–1587.

Fernandesa, L. J., Relvas, S., & Barbosa, A. P.-P. (2013). Strategic Network Design of Downstream Petroleum Supply Chains: Single versus Multi-entity Participation. *Chemical Engineering Research and Design*.

Figueira, J., & Ehrgott, S. M. (2016). *International Series in Operations Research & Management Science.* Springer.

Filani. (1978). Multimodal Transport Operations in international cargo movement: International cargo movement: Implications for transport policies and development in tropical Africa,Vol 2, Issue 5. *Geo Journal*, 413 - 418.

Fisher, M. (1997). What is the right supply chain for your product. *Harvard Business Review, Reprint 97205*, 106-116.

Fitzgerald. (2007). Strategies for sustainable Supply Chain Management.

Fox, M. e. (2000). Agent-Oriented Supply-Chain Management. . *International Journal of Flexible Manufacturing Systems*, 12. 165-188.

Francis, M., Fisher, R., Thomas, A., & Rowlands, H. (2014). The meaning of Value in Purchasing, Logistics and Operations Management . *International Journal of Production Research*.

French, S. M. (2009). *DecisionBehaviour, Analysis and Support,.* Cambridge: Cambridge University Press.

French, S., & Geldermann, J. (2005). The varied contextsof environmental decision problems and their implicationsfor decision support. *Environmental Science and Policy*, Vol. 8 No. 4, pp. 378-391.

Gabriela Ribas, A. L. (2011). TACTICAL PLANNING OF THE OIL SUPPLY CHAIN: OPTIMIZATION. *XLIII Simposio Brasileiro de Pesquisa Operational.*

Gainsborough, M. (2006). Building World Class Supply Chain Capability in Downstream Oil Business. *Business Briefing: Oil and Gas Processing*, 29-32.

Gainsborough, M. (2006). BUILDING WORLD CLASS SUPPLY CHAIN CAPABILITY IN THE DOWNSTREAM OIL BUSINESS . *Business Briefing: Oil and Gas Processing Review*, 29-32.

Ganbat. (2015). Empirical Study of Multimodal Transport Route Choice Model in Freight Transport between Mongolia and Korea. .

GangWang. (2007). A Primary Study on Making the Decision of the Selection of Multimodal Transport.

Gen, M., & Lin, L. (2005.). Multi-objective hybrid genetic algorithm for bicriteria network designproblem. *Complexity International*, 11, 73–83.

Ghatee, M. S. (2009). Optimal network design and storage management in petroleum distribution network under uncertainty. *Eng. Appl. Artif. Intell.* , 796–807.

GoI. (2011). *India Hydrocarbon Vision 2025.* Retrieved from petroleum.nic.in: http://petroleum.nic.in/sites/default/files/vision.pdf

GoI. (2019). *Energy Statistic.* MINISTRY OF STATISTICS AND PROGRAMME IMPLEMENTATION. New Delhi: Government of India. Retrieved 2019, from mospi.gov.in

GOI. (2021, 03 10). *https://niti.gov.in*. Retrieved from https://niti.gov.in: https://niti.gov.in/sites/default/files/2020-01/IEA-India%202020-In-depth-EnergyPolicy_0.pdf

GOI. (2021, 03 10). *https://pib.gov.in*. Retrieved from https://pib.gov.in: https://pib.gov.in/Pressreleaseshare.aspx?PRID=1532265

GOI. (2021, 03 10). *https://pib.gov.in/Pressreleaseshare.aspx*. Retrieved from https://pib.gov.in: https://pib.gov.in/Pressreleaseshare.aspx?PRID=1532265

GOI. (2021, 03 10). *https://pib.gov.in/Pressreleaseshare.aspx?PRID=1532265*. Retrieved from https://pib.gov.in: https://pib.gov.in/Pressreleaseshare.aspx?PRID=1532265

GoI. (2021). *https://www.indiabudget.gov.in*. Retrieved from https://www.indiabudget.gov.in: https://www.indiabudget.gov.in/budget_archive/ub2000-01/mem/mem3.pdf

GOI. (2021, 03 10). *https://www.investindia.gov.in/sector/oil-gas*. Retrieved from www.investindia.gov.in: https://www.investindia.gov.in/sector/oil-gas

Gray. (2001). Logistics and International Shipping.. Gursoy. (2010). A Decision Supportive Method for Multimodal Freight Transport Mode Choice: an Example from Turkey.

Guibin. (1999). Multimodal transport and trade facilitation: implications in the Chinese context.

Gunasekaran, A. L. (2008). Responsive supply chain: a competitive strategy in a networked economy. *Omega*, 36 (4), 549–564.

Gunasekaran, A., & Ngai, E. W. (2004). Information systems in supply chain integration and management. *European Journal of Operational Research*, 269-295.

Gursoy, M. (2010). A method for transportation mode choice.

Guyonnet, P., Grant, F., & MJ, B. (,2009). Integrated model for refinery planning: oil procuring, and product distribution. *Ind. Eng. Chem. Re*, 463–482.

Hall, B. (2002). A Structure for Supply Chain Information Flows and Its Application to the Alaskan Crude Oil Supply Chain. *Logistics Innovation Management, 15(1)*, 8-23.

Hao, C. (2016). Optimization on Combination of Transport Routes and Modes on Dynamic Programming for a Container Multimodal Transport System.

Haripriya, S. e. (2017, 03 10). GOODS AND SERVICE TAX GSTIN INDIA. *Shanlax International Journal of Commerce*, 23-26. Retrieved from https://www.researchgate.net/publication/337311510_GOODS_AND_SERVICE_TAX_GSTIN_INDIA: https://www.researchgate.net/publication/337311510_GOODS_AND_SERVICE_TAX_GSTIN_INDIA

Hassen. (2012). *Supply Chain Optimization in the Oil Industry : A Case Study of MOL Hungarian Oil and Gas PLC* .

Heckmann, I., Comes, T., & Nickel, S. (2015). A critical review on supply chain risk −Definition, measure and modeling. *Omega*, 119–132.

Hendricks, K., & Singhal, V. (2005). Kevin Hendricks ViThe Effect of Supply Chain Disruptions on Long-term Shareholder Value, Profitability, and Share Price Volatility . *Supply Chain and Logistics Group*.

Hertz, A. W. (2003.). *Eur. J. Oper. Res.*, 151, 247–252.

Heungjo, A. N. (2011). A mathematical model to design a lignocellulosic biofuel supply chain system. *Bioresource Technology*, 1.

Hilmola. (2011). Logistics sector development potential of world's oil exporters. *International Journal of Energy Sector Management Vol. 5 Iss: 2*, 256 - 270 .

Ho, W. (2008.). Integrated analytic hierarchy process and its applications – A literature review. *uropean Journal of Operational Research* , 186(1): 211-228. .

Holland. (1992). Genetic algorithms. *Sci. Am*, 267(1): 66–72.

Holland, J. (1975). Adaptation in natural and artificial systems. *Ann Arbor, MI: University of Michigan Press*.

Honeywell. (2005). *www.honeywellprocess.com/library/marketing/case-studies/SuccessStory_IndianOil_SupplyChain.* Retrieved from www.honeywellprocess.com: Honeywell International Inc. (2005)Title: Indian Oil Improves Supply Chain withHoneywelhttps://www.honeywellprocess.com/library/marketing/case-studies/SuccessStory_IndianOil_SupplyChain

HPCL. (2016). *HPCL Annual Report 2015-16.*

HPCL Annual Report. (2018-19).

http://www.qualitative-research.net/index.php/fqs/article/view/466/996. (n.d.). *http://www.qualitative-research.net/index.php/fqs/article/view/466/996.* Retrieved from http://www.qualitative-research.net/index.php/fqs/article/view/466/996: http://www.qualitative-research.net/index.php/fqs/article/view/466/996

http://www.theanalytic.co.in/downloadfile/CostofPetrolinIndiaBriefOverview.pdf. (2015). Retrieved from http://www.theanalytic.co.in: http://www.theanalytic.co.in/downloadfile/CostofPetrolinIndiaBriefOverview.pdf

http://www.yourarticlelibrary.com/social-research/data-collection/advantages-and-limitations-observation-method. (2020, July 27). *http://www.yourarticlelibrary.com/social-research/data-collection/advantages-and-limitations-observation-method.* Retrieved from http://www.yourarticlelibrary.com: http://www.yourarticlelibrary.com/social-research/data-collection/advantages-and-limitations-observation-method

https://www.leadquizzes.com/blog/data-collection-methods/data-collection/64507. (2020, July 27). *https://www.leadquizzes.com/blog/data-collection-methods/data-collection/64507.* Retrieved from https://www.leadquizzes.com/blog/data-collection-methods/data-collection/64507: https://www.leadquizzes.com/blog/data-collection-methods/data-collection/64507

https://www.ppac.gov.in/content/146_1_ProductionPetroleum.aspx . (2021, 03 10). Retrieved from www.ppac.gov.in: https://www.ppac.gov.in/content/146_1_ProductionPetroleum.aspx

Huang, B. C. (2004). GIS and genetic algorithms for HAZMAT route planning with security considerations. . *International Journal of Geographical Information Science,*, 18 (8), 769–787.

Hugos, M. (2018). *Essentials of Supply Chain Management.* New Jersey: John Wiley & Sons. doi:10.1002/9781119464495

Hussain, R. (2006). Supply Chain Management in the Petroleum Industry:. *International Journal of Global Logistics & Supply Chain Management. Vol.1*.

Hussain, R. (2006). Supply Chain Management in the Petroleum Industry:. *International Journal of Global Logistics & Supply Chain Management. Vol.1*, 1.

Hussain, R. (2006, November). Supply Chain Management in the Petroleum Industry:. *International Journal of Global Logistics & Supply Chain Management. Vol.1, 1 No. 2*, 90-97.

Hussain, R., Tiravat, A., & Basheer, K. (2006). Supply Chain Management in the Petroleum Industry:Challenges and Opportunities. *International Journal of Global Logistics & Supply Chain Management.Vol. 1*.

Hyung. (2006). An Optimal Transport Algorithm for Multimodal Transport. Proceedings of the Second International Intelligent Logistics Systems Conference.

IEA. (2020). *India 2020 : Energy Policy Review.* International Energy Agency.

(n.d.). *International Journal of Energy Sector Management.*

IOCL. (2016). *IOCL Annual Report 2015-16.* IOCL.

IOCL Annual Report. (2018-19).

Ittner, C. L. (2003). Subjectivity and the weighting of performancemeasures: evidence from a balanced scorecard. *Accounting Review*, 425-58.

Jarasuniene. (2016). Application and Management of Information Technologies in Multimodal Transportation.

Jeffs, V. P. (1990). Determinants of modal choice in freight transport.

Jenkins, G. P., & Wright, D. S. (1998). Managing Inflexible Supply Chains. *The International Journal of Logistics Management, 9*(2), 83-90.

Jenkins, P. G. (1998). Managing Inflexible Supply Chains. *The International Journal of Logistics Management*, 9(2), 83-90.

Jeong B, J. H. (2002). A computerized causal forecasting system using genetic algorithms in supply chain management. *J. Syst. Softw*, 60: 223–237.

Jha, H. M. (2009). *http://www.slideshare.net/laxmikantd/logistical-cost-optimization-through-application-of-ptp-model.* Retrieved from http://www.slideshare.net/laxmikantd/logistical-cost-optimization-through-application-of-ptp-model

Joon. (2017). Multimodal Transportation: The Case of Laptop from Chongqing in China to Rotterdam in Europe.

Jun, J. (2008). Research on Optimum Combination of Transportation Modes in the Container Multimodal Transportation System.

Kamble, S., & A Gunnasekaran, H. A. (2018). Understanding the blockchain technology adoption in supply chains-Indian context. *International Journal of Production Research*.

Kaplan. (2009). Conceptual Foundations of Balanced Score Card. *Handbook of Management Accounting Research Volume 3* .

Karami, M., & Malekifar, S. (2015). A Conceptual Model of the Relationship between Market Orientation and SC performance . *Global Business and Organisational Excellence*.

Katerina, S. I. (2015). Applying the Analytic Hierarchy Process in healthcare research: A systematic literature review and evaluation of reporting. *BMC Informatics and Decision Making*. Retrieved from https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4690361/

Katiyar, R., & Barua, M. K. (2015). Modelling the Measures of S C Performance in the Indian Automobile Industry . *Benchmarking -An International Journal* .

Kebede, B. R., & Hussen, S. O. (2015). Export Trade Logistics Determinant Factors- The Case of Ethiopian Major Export Products. *Journal of Economics and Sustainable Development* .

Keller, M. (2012). Delivering More with Less . *NPN Magzine* .

Kendall, J., Kendall, K., Smithson, S., & I.O. Angell. (1992). SEER: a divergent methodology applied to forecasting the future roles of the systems analyst, . *Human Systems Management*, 123–135.

Kengpol. (2012). Design of a Decision Support System on Selection of Multimodal Transportation with Environmental Consideration between Thailand and Vietnam.

Kengpol, A. (2012). Multimodal transportation routing with in Greater Mekong sub.

Kerlinger, F. (2019). *Foundations of behavioural research .* surjeet publication.

Ketchen Jr., G., & Hult, T. (2006,). Bridging organization theory and supply chain management: The case of best value supply chains. . *Journal of Operations Management*, 573-580 .

Khan, A. (2019). *Redesigning of High Speed Diesel Supply Chain Network: A Case Study.* Researchgate accessed on 9th Feb'2020.

Kim, Y., C Yun, C., S.B Park, ,. S., & Fan, L. T. (2008). An integrated model of supply network and production planning for multiple fuel products of multi-site refineries.), . *Comput. Chem. Eng.*, 2529–2535.

Kimani, C. (2013). *Supply chain management challenges in Kenya petroleum industry: Case of national oil company.*

Kingman, D., Phillips, N., Steiger, D., Wirth, R., Padman, R., & Krishnan, R. (1987). An Optimiastion based Integrate Short Term Refined Petroleum Product Planning System. *Management Science*.

Kittell-Limerick, P. (2005). *Perceived barriers to completion of the academic doctorate: A Delphi study.* Texas: Texas A&M University.

Koh, S. (2004). MRP-controlled batch-manufacturing environment under uncertainty. *Journal of the Operational Research Society*, 219-232.

Kopytov, E. (2012). MULTIPLE-CRITERIA ANALYSIS AND CHOICE OF TRANSPORTATION ALTERNATIVES IN MULTIMODAL FREIGHT TRANSPORT SYSTEM. Volume 13, Transport and Telecommunication. 148 158.

Kotachi. (2013). Simulation Modelling and Analysis of Complex Port Operations with Multimodal Transportation.

Kothari, C. (2004). *Research Methodology- Methods and Technology.* Jaipur: New Age International Publishers.

Kumar. (2002). Performance analysis of intelligent supply chain.

Kumru, M. (2013). Analytic hierarchy process application in selecting the mode of transport for a logistics company.

Kuo, T., & Chang, C. (2008). Application of a mathematic programming model for integrated planning and scheduling of petroleum supply networks. *Ind. Eng. Chem. Res.*, 1935–1954.

Kurien, G. P., & Qureshi, M. N. (2011). Study of Performance Measurement Practices in Supply Chain Managerment . *International Journal of Business, Management and Social Sciences*.

La Londe, B. J. (1997). Supply Chain Management: Myth or Reality. *Supply Chain Management Review,, 1*, 6-7.

Lambert, D. M. (2008). *Supply Chain Management-Processes, Partnerships and Performance.* Ohio: Ohio State University.

Landeta, J. (2006). Current validity of the Delphi method in social sciences. . *Technological Forecasting & Social Change,* , 73(5), 467-482.

Laporte, G. L. (1994). Exact solution to a locationproblem with stochastic demands. Transportation Science, . *Transportation Science,*, 28(2), 95–103.

Larson, P., & Halldorsson, A. (2004). Logistics versus supply chain management: an international survey. *International Journal of Logistics: Research & Application* , Vol. 7, Issue 1 page 17-31.

Larson, P., & Halldorsson, A. (2004). Logistics versus supply chain management: an international survey. *International Journal of Logistics: Research & Application*, Vol. 7, page 17-31.

Laureano, F. E. (1998). CORO, a modeling and an algorithmic framework for oil supply,. *European Journal of Operational Research*, 114 (1999) 638±656.

Lauri. (2006). Eastern/Western European shipping companies and multimodal transport operations. *Maritime Policy & Management journal*, 331-344.

Lee. (1992). Managing supply chain inventory: pitfalls and opportunities .

Leedy, P. D., & Ormrod, J. E. (2005). *Practical research: Planning and design .* NJ: Prantice Hall.

Leiras, A. (2006). Literature review of oil refineries planning under uncertainty. *Business Briefing: Oil and Gas Processing* , 29-32.

Leiras, A., Ribas, G., & Hamacher, S. (2011). Literature review of oil refineries planning under uncertainty . *Int. J. Oil, Gas and Coal Technology, Vol. 4*, 2.

Leiras, A., Ribas, G., & Hamacher, S. (2013). Tactical and operational planning of multirefinery networks under uncertainty: an iterative integration approach. *Ind. Eng. Chem. Res. .*, 8507–8517.

Leiras, A., Ribas, G., & Hamacher, S. (2013). Tactical and operational planning of multirefinery networks under uncertainty: an iterative integration approach. , . *Ind. Eng. Chem. Res. 52 (25)*, 8507–8517.

Lespier. (2013). Examining the efficiency of multimodal transportation systems: a systems dynamics approach.

Leung, Y. L. (1998). A genetic algorithm for multiple destination routing problems. *IEEE Transactions on Evolutionary Computation*, 2 (4), 150–161.

Li, L., & Lai, K. (2000). A fuzzy approach to the multiobjective transportation problem. *Computers & Operations Research*, 57.

Liberatore. (1972). A Model of Freight Transport Selection. Transportation Journal . 92-100.

Lili. (2008). Advances in Neural Networks . Lecture Notes in Computer Science.

Lima, C., Susana, R., & Barbosa-Póvoa, P. A. (2016). Downstream oil supply chain management: A critical review and. *Computers and Chemical Engineering*, 78-92.

Liou, J. J., & Tzeng, G. H. (2007). A non-additive model for evaluating airline service quality. *Journal of Air Transport Management*, 131-138.

Liou, J. J.-a.-1. (2007). Liou, J. J. H., & Tzeng, G. H. (2007). A non-additive model for evaluating airline service quality. Journal of Air Transport Management, 13, 131-138. *Liou, J. J. H., & Tzeng, G. H. (2007). A non-additive model for evaluating airline service quality. Journal of Air Transport Management, 13, 131-138*, 131-138.

Liu. (2011). Optimization Model of Multimodal Transportation Mode and Its Algorithm. 1068-1075.

Liu, D. (2015). Joint slot allocation and dynamic pricing of container sea-rail multimodal transportation.

Liu, L. (2013). System Framework and Key Activities of Developing Multimodal Passenger Transport Hubs. 851-857.

Lynch, & Cross. (1989). The SMART way to define and sustain success. *National Productivity Review*.

Malcolm. (2002). Multimodal transport in the new millennium. WMU Journal of Maritime Affairs , 1 (1). 71 - 84.

Manappa, D. O. (2014). Role of IT in SCM . *Journal of Marketing and Communication*.

Manese, S. N. (2014). *JUST IN TIME ADOPTION AND PERFORMANCE OF MAJOR OIL COMPANIES IN KENYA.*

Mani, V., Agrawal, R., & Sharma, V. (2014). Supplier selection using social sustainability: AHP based approach in India. *International Strategic Management Review, 2*(2), 98-112. Retrieved 8 7, 2020, from https://sciencedirect.com/science/article/pii/s2306774814000209

Manzano, F. S. (2005). *SC Practices in the Petroleum Downstream.*

Maravelias. (2009). Integration of Production planning and scheduling : Overview , Challenges and Opportunities. *Computers & Chemical Engineering*.

Marit. (2003). A Spatial-Economic Multimodal Transportation Simulation Model For US Coastal Container Ports . Maritime Economics & Logistics , 5 (2). 158-178.

Marler, R. T., & Arora, J. S. (2009). The Weighted Sum Method for Mulit Objective Optimisation-New Insights. *Springer-Verlag* .

Marshall, C., Rossman, G. B., Gretchen, D., & Rossman, B. (1995). *Designing Qulaitative Research.* Michigan: Sage Publications.

Marx. (1978). The circuit of money capital. In Capital. A Critique of Political Economy, 2. Matear. Factors influencing freight service choice for shippers and freight suppliers. *International Journal of Physical Distribution & Logistics Management*, 25-35.

Mason, K. J. (2007). EU network carriers, low cost carriers and consumer behavior: A Delphi study of future trends. . *Journal of Air Transport Management,*, 13(5), 299-310.

Matveeva, K. (2015). *EXPLORING CURRENT ISSUES IN THE SUPPLY CHAIN MANAGEMENT IN THE OIL AND GAS INDUSTRY .*

McKenna, H. P. (1989). The selection by ward managers of an appropriate nursing model for long-stay psychiatric patient care. *Journal of Advanced Nursing*, 14(9), 762-775.

McKinnon. (1989). Physical Distribution Systems.

McNabb, D. E. (2010). *Research Methods for Political Science.* New York: M.E Sharp Inc.

Melo, M. N.-d.-G. (2009). Facility location and supply chain management—A review. European. *Journal of Operational Research*, 196 (2), 401–412.

Mentzer, D. K. (2001). DEFINING SUPPLY CHAIN MANAGEMENT. *JOURNAL OF BUSINESS LOGISTICS, 22*(2), 2.

Mentzer, J. T., & al, e. (2001). DEFINING SUPPLY CHAIN MANAGEMENT. *JOURNAL OF BUSINESS LOGISTICS,*, Vol.22, No. 2.

Mentzeret. (2001). *Supply chain management .*

Microsoft. (2020, 04 26). *SolveXL Manual.* Retrieved from www.solverxl.com: https://www.solvexl.com/download/manual.pdf

Min. (1997). Analytical Hierarchical Process .

Minh, N., & Truong, T. M. (2019). Towards the Development of Traffic Safety Strategies in Developing Countries: Analysis of Road Users' Perspective. *World Conference on Transport Research - WCTR 2019 Mumbai 26-31 May 2019.* Mumbai: Elsevier.

Mitchell, R. A. (1997). Towarda theory of stakeholder identification and salience: definingthe principle of who or what really counts. *Academy ofManagement Review*, Vol. 22 No. 4, pp. 853-886.

Mohanty, R. P., Dhalla, R. S., & Mohapatra, R. K. (2010). Reengineering of Logistics Value Chain of a Petroleum. *International Conference on Industrial Engineering and Operations Management.*

Mohapatra, R. K. (2010). Reengineering of Logistics Value Chain of a Petroleum Products Marketing Company – Formulation of a Performance Measurement System. *International Conference on Industrial Engineering and Operations Management.* Dhaka.

Molina, J. C., Eguia, I., Racero, J., & Guerrero, F. (2014). Multi Objective Vehicle Routing Problem with Cost and Emission Functions . *Science Direct* .

Monczka. (2005). Purchasing and Supply Chain Management. Thomson SouthWestern.

MOPNG. (2006). *Report of the Working Group on Petroleum & Natural Gas Sector for the XI Plan.* Govt of India.

MoPNG. (2021). *http://petroleum.nic.in*. Retrieved from http://petroleum.nic.in/sites/default/files/rtigp052.pdf : http://petroleum.nic.in/sites/default/files/rtigp052.pdf

MoPNG. (2021). *http://petroleum.nic.in*. Retrieved from http://petroleum.nic.in: http://petroleum.nic.in/sites/default/files/expertcomm_0.pdf

Moradinasab, N., Jafarzadeh, H., R., M., Amin-Naseri, H.Cody, & Fleming. (2019). A Dynamic Sustainable Competitive Petroleum Supply Chain Model for Various Stakeholders with Shared Facilities. *arXiv:1907.11789v1 [math.OC] 26 Jul 2019*, 1.

Mühlbacher, A. B. (2015). *Objective Criteria in the Medicinal Therapy for Type II Diabetes: An Analysis of the Patients' Perspective with Analytic Hierarchy Process and Best-Worst Scaling.* Retrieved from https://www.thieme-connect.com/DOI/DOI?10.1055/s-0034-1390474

Mullen, P. M. (2003). Delphi: Myths and reality. . *Journal of Health Organization and Management*, 17(1), 7.

N.Viswanadham. (2001). An example of a supply chain involving Multi modal containerised transport.

National Statistical Office. (2020). *Energy Statistics 2020.* New Delhi: Government of India.

Nectar, R. (2010). *Value Chain Analysis along the Petroleum Supply Chain.*

Negi. (2015). Issues and Challenges in the Supply Chain of Fruits & Vegetables Sector in India.

Neiro, S., & Pinto, J. (2004). Multiperiod optimization for production planning of petroleum refineries. *Chem. Eng. Commun*, 62–88.

Nunnally, J. I. (1994). *Psychometric Theory.* New York: McGraw Hill.

O'Connor, B. N. (2000). The research problem. *Information Technology, Learning and Performance Journal*, 1,2.

Okoli, C., & Pawlowski, S. D. (2004). The Delphi method as a research tool: an example, design considerations and applications. *Information & Management, 42*(1), 15-29. Retrieved 8 7, 2020, from https://sciencedirect.com/science/article/pii/s0378720603001794

Ono, R., & D.J. Wedemeyer. (1994). Assessing the validity of the Delphi technique. *Futures 26*, 289–305.

Ozer, I. (2007). *Multi-Criteria Group Decision Making Methods Using AHP and Integrated Web-Based Decision.* Ottawa: University of Ottawa.

P.T. Harker, L. V. (1987). The theory of ratio scale estimation: Saaty's analytical hierarchy process. *Management Science*, 1383–1403.

Pangotra, P. P., & Shukla, P. P. (2012). Promoting Low Carbon Transport in India. *IIM, Ahmedabad* .

Papageorgiou, L. (2009). Supply chain optimisation for the process industries: advances and opportunities. *Comput. Chem. Eng.*, 1931–1938.

Paul, K. P. (2012). *SCM in Indian Petroleum Refineries.*

Petroleum Planning & Analysis Cell. (2015). *Ready Reckoner Snapshot of India's Oil & Gas data.* Ministry of Petroleum & Natural Gas.

Petrovic, e. a. (1999). Supply chain modeling using fuzzy sets . *International Journal of Production Economics*.

Phekar, S. D., & Ramachandran, M. (2004). Application of Multi Criteria Decision Making to Sustainable Energy Planning A Review . *Renewable and Sustainable Energy Reviews*.

Pisharodi, R. M. (1991). The Transport-choice Decision Process: The Potential, Methodology and Applications of Scripttheoretic Modelling. International Journal of Physical Distribution & Logistics Management . 13-22.

PNGRB. (2012). *Report of the Working Group on Petroleum & Natural Gas Sector for the XI Plan.* GOI.

PNGRB. (2015). *PNGRB Annual Report.* Delhi: PNGRB.

PNGRB. (2018). *PNGRB Annual Report.* Delhi: PNGRB.

Pohekar, S. D. (2004). Application of multi-criteria decision making to sustainable energy planning—A review. *Renewable and Sustainable Energy Reviews* , 8(4): 365-381.

Porter, M. (1985). *Competitive Advantage: Creating and Sustaining Superior Performance.* New York: Free press.

PPAC. (2020). *Snapshot of India's Oil and Gas Data.* New Delhi: Govt of India.

PPAC. (2021). *https://www.ppac.gov.in*. Retrieved from https://www.ppac.gov.in: https://www.ppac.gov.in/content/156_1_GovtNotifications.aspx

PPAC. (2021, 03 10). *https://www.ppac.gov.in/content/146_1_ProductionPetroleum.aspx*. Retrieved from www.ppac.gov.in: https://www.ppac.gov.in/content/146_1_ProductionPetroleum.aspx

Prado. (2014). A parameterized model of multimodal freight transportation for maritime services optimization.

Punakivi. (2006). Selection Criteria of Transportation Mode: A Case Study in Four Finnish Industry Sectors. Transportation Reviews . 207-219.

Pundoor. (2005). Integrated production-distribution scheduling.

Qahtani, K. A., & Elkamel, A. (2009). *Multirefinery and Petrochemical Networks Design and Integration.* Retrieved from ResearchGate.

Qahtani, Y. K., & Elkamel, A.-A. (2011). *Planning and Integration of Refinery and Petrochemical Operations.* John Wiley & Sons.

Qin. (2008). Supply Chain Event Management in Multimodal Transportation.

Qu, W. G., & Yang, Z. (2014). The effect of Uncertainty Avoidance and Social Trust on SC Collaboration. *Journal of Business Research* .

R. P. Mohanty, a. R. (2010). Reengineering of Logistics Value Chain of a Petroleum. *International Conference on Industrial Engineering and Operations Management.*

Rani, M. (2009). *Some Supply Chain Models and Their Analytical Evaluation P.* PHD Thesis Chaudhary Charan Singh University.

Rao, M. (2011). *Integration of SCM elements and Supply Chain Performance Measurement* . Anantpur : Jawaharlal Nehru Technological University, .

Ravi. (2001). A Disaggregate Study of Mode Choice for Inland Movement of Export Cargo Containerised on Marine Segment.

Reis, V. (2009). Modal Choice of Freight Transport Services.

Revelle, C. S. (1996). The plant location problem: New models andresearch prospects. . *Operations Research,*, 44(6), 864–874.

Ribas, G., Hamacher, S., & Street, A. (2010). Optimization under uncertainty of the integrated oil supply chain using stochastic and robust programming. . *Int. Trans. Oper. Res.*, 777–796.

Ribas, G., Leiras, A., & Hamacher, S. (2011). TACTICAL PLANNING OF THE OIL SUPPLY CHAIN: OPTIMIZATION. *XLIII Simposio Brasileiro de Pesquisa Operational.*

Ribas, G., Leiras, A., & Hamacher, S. (2011). TACTICAL PLANNING OF THE OIL SUPPLY CHAIN: OPTIMIZATION UNDER UNCERTAINTY. *XLIII Simposio Brasileiro de Pesquisa Operational* .

Rizzolia, A. E., Casagrandea, N., Donatia, A. V., Gambardellaa, L. M., Leporib, D., Montemannia, R., . . . Zaffalona, M. (2003). Planning and optimisation of vehicle routes for fuel oil distribution . *MSSANZ*.

Rokhlin. (2013). Strategic directions of multimodal transportation development.

Rondinelli. (2000). Multimodal transportation, logistics, and the environment: Managing interactions in a global economy . *European Management Journal , 18 (4)*, 398-410.

Ross, D. F. (1998). *Competing Through Supply Chain Management,.* New York: Chapman and Hall.

Rossi, C. a. (2010). *https://www.investindia.gov.in/sector/oil-gas.* Retrieved from www.investindia.gov.in: https://www.investindia.gov.in/sector/oil-gas

Rowe, G., & Wright, G. (2001). Experts opinions in forecasting: The role of the Delphi technique. . *Principles of forecasting*, 125-144.

Rowe, G., Wright, F., & Bolger, F. (1991). Delphi: a re-evaluation of research and theory, . *Technological Forecasting and Social Change*, 235–251.

Rudan. (2002). The effect of logistical decision-making upon the multimodal transportation. 139-152.

Ruhl, J. M. (1996). An Introduction to the Theory of Constraints. *Journal of Cost Management*, 43-48.

Rusinga, N. (2010). *Value Chain Analysis along the Petroleum Supply Chain.* University of Cape Town .

Saaty. (1977). A scaling method for priorities in hierarchical structures. *Journal of Mathematical Psychology*, 15, 59–62.

Saaty. (1980). *The Analytic Hierarchy Process.* New York: McGraw-Hill.

Saaty. (1994). How to make a Decision: The Analytic Hierarchy Process. *University of Pittsberg*, 19-43.

Saaty. (2008). Decision making with the analytic hierarchy process. *Int. J. Services Sciences, Vol. 1, No. 1, 2008 83*, 83.

Saaty, T. (2008). Decision Making with the AHP. *Int. J. Services Sciences. Vol 1, No. 1*, 83-98.

Saaty, T. L. (1990). How to make a decision: The Analytic Hierarchy Process . *European Journal of Operational Research*.

Saaty, T. L. (2008). Relative Measurement and Its Generalization in Decision Making Why Pairwise Comparisons are Central in Mathematics for the Measurement of Intangible Factors The Analytic Hierarchy/Network Process. *Statistical and Operations Research*, 251-318.

Saaty, T., & Kearns, K. (1985). *Analytical Planning; The Organization of Systems.* Pittsburgh: RWS Publications.

Saaty, T., & Vargas, L. (2012). The Seven Pillars of AHP. *International series in Operations Research & Management Science*.

Sahebi, H., & Nickel, S. (2014). Sahebi, H.; Nickel, S. *Offshore oil network design with transportation alternatives. European Journal of Industrial Engineering, 8 (6)*, 739−761.

Saini, R., & Saini, S. (2014). Improvement in the "Energy Supply Chain Risk Management of Oil and Petroleum Industries" Using the concept of ANN embedded in SCM. *International Journal of Application or Innovation*.

Sanders, N., & Premus, R. (2002). IT applications in supply chain organizations: a link between competitive priorities and organizational benefits. *Journal of Business Logistics*, 65-83. Retrieved from Sanders, N.R and Premus, R., (2002). IT applications in supply chain organizations: a link between competitive priorities and organizational benefits. Journal of Business Logistics, 23, 65-83. .

Sarode, A. (2010). *Effect of Logistical Operational Relationship on the Performance of SCM.* Amravati: Government College of Engineering.

Saunders, M., & Lewis, P. &. (2009). *Research methods for business students.* Essex: Pearson Education Limited.

Schijndel. (2000). Congestion and multimodal transport: a survey of cargo transport operators in the Netherlands. .

Schwenner, M., & Kubler, A. (2016). The Logistics Profile of the German Chemical Industry . *Journal of Business Chemistry*.

Sear, T. N. (1993).). Logistics Planning in the Downstream Oil Industry. *Journal of the Operation Research Society , 44 No. 1*, 9-17.

Seifert, R. W., & Biçer, I. (2014). SETTING UP SUPPLY CHAIN STRATEGIES FOR INNOVATIVE PRODUCTS. *IMD*.

Sekaran, U. (2003). *Research methods for business (4th ed.). .* Hoboken, NJ:: John Wiley & Sons.

Sen, A. (2013). *A Study to Understand the Processes of Co-created Vision and Achievement orientation in HPCL.*

Sequeira, A. (2014). Conceptualization in Research. *SSRN Electronic Journal*.

Sevkli, M., Koh, S., Zaim, S., & al, e. (2007). Sevkli, M., Koh, S.C.L., Zaim, S., Demirbag, M., and Tatoglu, E., (2007). An application of data envelopment analytical hierarchy process for supplier selection: a case study of BEKO in Turkey. *International Journal of Production Research*, 1973-2003.

Shaban, H., & Khan, A. (1995). Pressure-related operational problems and their remedies in hydrotreating reactors in petroleum refineries. *J. Pet. Sci. Eng., 14 (1)*, 79−88.

Shah, J. (2009). *Supply chain management-Text and cases.* Banglore: Pearson Education.

Shah, J. (2009). *Supply chain management-Text and cases.* Pearson Education.

Shao. (2007). Carrier Selection Optimization Model and Algorithms for Various Sections of Multimodal Transportation. International Conference on Transportation Engineering .

Sharma, J. (2006). *Linear programming: theory and applications. .* New York: Macmillan.

Sharma, S. S. (2019). Road map for electric vehicle implementation in India. *International Journal of Management and Commerce, 1*(4), 23-29.

Shashi, S., & Singh, R. (2015). A Key Performance Measures of Evaluating Cold S C Performance in farm industry. *Management Science Letters* .

Shaw, K., Shankar, R., Yadav, S. S., & Thakur, L. S. (2012). Supplier Selection using Fuzzy AHP and Fuzzy Multi Objective Linear Programming for developing low carbon SC. *Expert Systems with Applications*.

Shuai. (2009). Benefit Research on Price Integrated Model in Multimodal Transportation. International Conference on Transportation Engineering. 4311- 4316.

Siddharth Varma, S. W. (2007). Evaluating petroleum supply chain performance Application of analytical hierarchy process to balanced scorecard . *www.emeraldinsight.com/1355-5855.htm*.

Simchi-Levi, D., Kaminsky, P., & Simchi-Levi, E. (2003). *Designing and managing the supply chain. Concepts, strategies, and case studies.* Boston.

Simon, H. (1960). *The New Science of Management Decision.* New York: Harper and Row.

Singh, A. ((2019)). *Tests, Measurements and Research Methods in Behavioural Sciences. .* Delhi: Bharti Bhawan.

Singh, B. K., & Joshi, B. C. (2020). *https://www.researchgate.net/publication*. Retrieved from https://www.researchgate.net: https://www.researchgate.net/publication/293783115_Challenges_and_Opportunities_in_Secondary_Logistics_in_Indian_Petroleum_Industry

Singh, R. (2011). *Modelling Supply Chain Performance :A Study of Organised Non-Livestock Retail Industry.* Amritsar: Guru Nanak Dev University.

Sinha, A. K., Tiwari, M., & Chan, F. (2011). Agent Oriented SCM in Petroleum SC Coordination-Co-evolutionary Particle Swarm Optimisation based approach. *Expert Systms with Applications May'2011*.

Skulmoski, G. J., Hartman, F. T., & Krahn, J. (2007). The Delphi method for graduate research. *Journal of Information Technology Education,*, 6, 1-21.

Smyk. (2010). Comparison of Different Transportation Modes, Case OOO NVT.

Sriyogi, K. (2014). Reverse Logistics: A Comparative Study of LPG Agencies in Urban and Rural Areas . *The IUP Journal of Supply Chain Management* , Vol. XI, No. 2,.

Statistics, E. (2018).

Statman, M. a. (1987). Applying behavioral finance to capital budgeting : Project Terminations. *Financial Management*, Vol. 16 No. 4, pp. 7-15.

Stevens, G. C. (2007). Integrating the supply Chain. *Emrald backfiles*, 2.

Sung, C. T. (2009). Integration of Production Planning and Scheduling: Overview , Challenges and Opportunities. *Computers and Chemical Engineering*.

Sunil Chopra, P. M. (2013). *Supply chain management : strategy, planning, and operation* (5 ed.).

Susilawati, A. e. (2013). Develop a Framework of Performance Measurement and Improvement System for Lean Manufacturing Activity. *Internations Journal of Lean Thinking Volume 4, issue 1*.

Szucs, D., & Hassen, K. (2012). *Supply Chain Optimization in the Oil Industry:A Case Study of MOL Hungarian Oil and Gas PLC.* Jonkoping International School.

Tavasszy, L. R., Kees, R., & Igor, D. (2012). Incorporating Logistics in Freight Transport Demand Models: State-of-the-Art and Research Opportunities. *Transport Reviews Vol. 32, No. 2*, 203–219.

Tayur, S., & Ganeshan, R. (1999). *Quantitative Models for Supply Chain Management.* Kluwer Academic Publishers.

Tett, G. (2009). *Fool's Gold: How the Bold Dream of a Small Tribe at JP Morgan was Corrupted by Wall Street Greed and Unleashed a Catastrophe,.* New York: Simon and Schuster.

Thies, B. M. (2016). Outsourcing in the Persian Gulf petroleum supply chain. *Strategic Outsourcing : An International Journal*, 1.

Tomonobu, S. K. (2004). Determinationof location and capacity of power facilities by genetic algorithm. *Electric PoweComponents and Systems,* , 32(4), 375–390.

Tong, K., J Gong, Yue, D., & You, F. (2014). Stochastic programming approach to optimal design and operations of integrated hydrocarbon biofuel and petroleum supply chains. . *ACS Sustain. Chem. Eng*, 49.

Toyota. (2021). *https://learn.marsdd.com*. Retrieved from https://learn.marsdd.com: https://learn.marsdd.com/article/case-study-dell-distribution-and-supply-chain-innovation

Toyota. (2021). *https://www.inboundlogistics.com*. Retrieved from https://www.inboundlogistics.com: https://www.inboundlogistics.com/cms/article/the-evolution-of-inbound-logistics-the-ford-and-toyota-legacy-origin-of-the-species/

Udenta. (2013). Strategies to Improve the Efficiency of a Multimodal Interdependent Transportation System in Disasters.

Vargas, T. L. (2012). Models, Methods, Concepts & Applications of the Analytic Hierarchy Process. *International Series in Operations Research & Management Science* , 175.

Varma, S., Wadhwa, S., & Deshmukh, S. (2008). Evaluating Supply Chain Performance- Application of Analytical Hierarchy Process to Balance Score Card. *Asia Pacific Journal of Marketing and Logistics*, Vol. 21.

Varma, S., Wadhwa, S., & Deshmukh, S. G. (2007). Supply Chain Characteristics of Petroleum Industry-The Indian Context. *South Asian Journal of Management Vol 14*.

Varma, T. N., & Khan, D. A. (2014). *https://www.researchgate.net*. Retrieved from https://www.researchgate.net: https://www.researchgate.net/publication/313880299_Information_Technology_in_Supply_Chain_Management

Vasant. (2000). *Supply Chain Management: A New Paradigm for customer centric Organisation .*

Vasco. (2013). Rail and multi-modal transport.

Vijayaraghavan. (1999). Transportation logistics in India : problems, issues and strategies for competitive advantage.

Virendra, R. S. (2014). Decision-Making using the Analytic Hierarchy Process (AHP). *Internatıonal Journal of Scıentıfıc Research, 3,*, 3.

Viswanadham. (2000). *Analysis of Manufacturing Enterprises.* Kluwer : Academic Publishers,.

Vivek. (2013). Multimodal Transport in India-- Issues and Opportunities. .

Vrat. (1999). Supply Chain Management in India: problems & challenges .

Wadhwa. (2005). Knowledge management based supply chain.

Walters, D. C. (1993). Genetic algorithm solution of economicdispatch with valve point boding. *IEEE Transactions on Power Systems*, 8(3).

Wang. (2007). Study on Analyzing and Optimizing the Business Process of Multimodal Transport. International Conference on Transportation Engineering .

Wang. (2012). Optimization of the Path of the Multimodal Transport Operator's Transportation Decision-Making. ICLEM. 139-144.

Wang. (2012). Based on Multi-Objective Programming Container Multimodal Transportation Research. ICLEM. 117-122.

Wang, F., Lai, X., & Shi, N. (2011). A Multi Objective Optimisation for green supply chain network design. *Decision Support Systems 51* .

Wang, K. J. (2009). A fuzzy-knowledge resourceallocation model of the semiconductor final test industry. Journal of Robotics andallocation model of the semiconductor final test industry. *Journal of Robotics andComputer-Integrated Manufacturing,* , 25(1), 32–41.

Wei, J., Ende, L. V., & Lin, B. (2009). Customer Vocussed E-Business Model for the Oil Industry . *Journal of Computer Information Systems Spring*.

Weick, K. E. (1968). Systematic observational methods. *Handbook of Social Psychology*, 357-451.

Wisner, J. D., G. K., & Keah-Choon Tan, ,. (2005). *Principles of Supply Chain Management: A balanced approach.* Thomson South western.

Working Group. (2006). *Report of the Working Groupon Petroleum & Natural Gas Sector for the XI Plan .*

World Bank. (2011). *Transportation of Petroleum Products in India* . Retrieved from PPIAF Website, World Bank: http://www.ppiaf.org/freighttoolkit/sites/default/files/casestudies/Petroleum-products-to-India.pdf

Yang. (2015). Optimization of Container Multimodal Transport Service Based on Segmented Procurement, Dynamics in Logistics. Part of the series Lecture Notes in Logistics . 483-493.

Yang, Y. L. (2014). *Measuring external oil supply risk: A modified diversification index with country risk and potential oil exports.* Energy.

Yin. (2012). Evaluation of Index System of Multimodal Transport Corridor. 847-853 .

Yoon. (2008). Multimodal Transport and Land Bridges in the Global Supply Chain: The Case of the ALB.

Yu, Q. (2011). The Research of Simulation and Optimization of Multimodal Transport System Based on Intelligent Materials on Container Terminal Job Scheduling, Volume 104. Advances in Computer Science Intelligent System and Environment. 104, 479 - 483.

Zavitsas, K. (2012). *The vulnerability of the petroleum supply chain.* London: Imperial College London.

Zeng. (2013). The Transportation Mode Distribution of Multimodal Transportation in Automotive Logistics.

Zhang, F. (2016). Integrating multimodal transport into forest-delivered bio-fuel supply chain design.

Zhang, M., Chen, Z., Zhang, S., & Zhang, M. (2013). Optimization Study of Transportation Assignment for Oil Product Secondary Distribution . *Advances in information Sciences and Service Sciences(AISS)*.

Zhang, X. H. (2008). Simultaneous configuration of platform products andmanufacturing supply chains. . *International Journal of Production Research,* , 46 (21), 6137–6162.

Zhang, X., & Armstrong, M. (2008). Genetic algorithms and the corridor location problem: multiple objectives and alternative solutions. *Environment and Planning*, 35, 148–168.

Zhao, X. (2005). Study on the Choice of Transportation Mode for Regional Logistics.

Zhi-Hua. (2011). A container multimodal transportation scheduling approach based on immune affinity model for emergency relief.

(

Appendix - I

Questionnaire

Identification of Factors Affecting Optimisation - Google Forms

Dear Sir/Madam,

I am studying 'Secondary Logistics of MS and HSD in North India' as a part of my thesis and need your expert opinion for identifying the factors of optimisation. Please spare a few minutes to respond to the survey form available in the link.

Bhuwan C Joshi

Q1 email address:

Q2 Discipline

Q3 Experience in Supplies

Less than 10 Year

10 Years to 20 Year

20 Years to 30 Year

More than 30 Year

Results: The profile of respondents is as under:

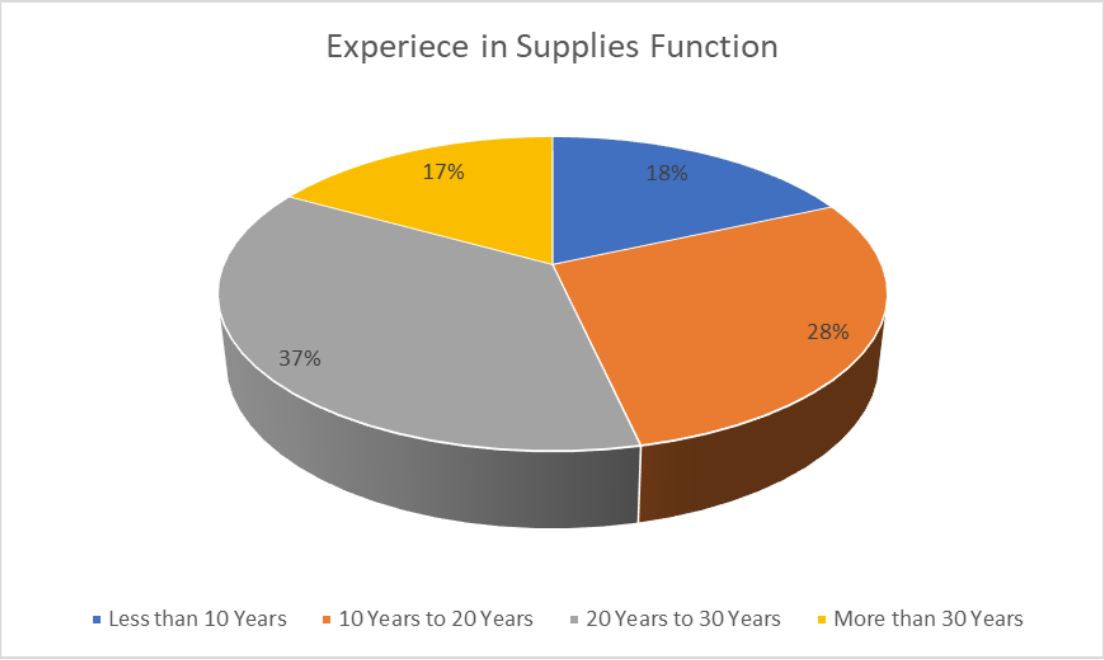


Fig A.1

Factors Identification

Secondary Logistics in downstream petroleum industry is that part of Supply Chain which delivers product from Storage Terminals to Retail Outlets. The present study is to identify the factors of optimisation for MS and HSD supplies in North India. You are a Subject Matter Expert and your opinion has been sought in the following questions. Please answer the questions in context of secondary logistics of MS and HSD in North India. Please indicate your opinion on the statements given by selecting one most suitable response against each.

1 - Strongly agree

2- Somewhat Agree

3- Neutral

4- Somewhat Disagree

5- Strongly Disagree Experience

Q4 The objective of secondary logistics should be to minimise cost of placement of product at the market.

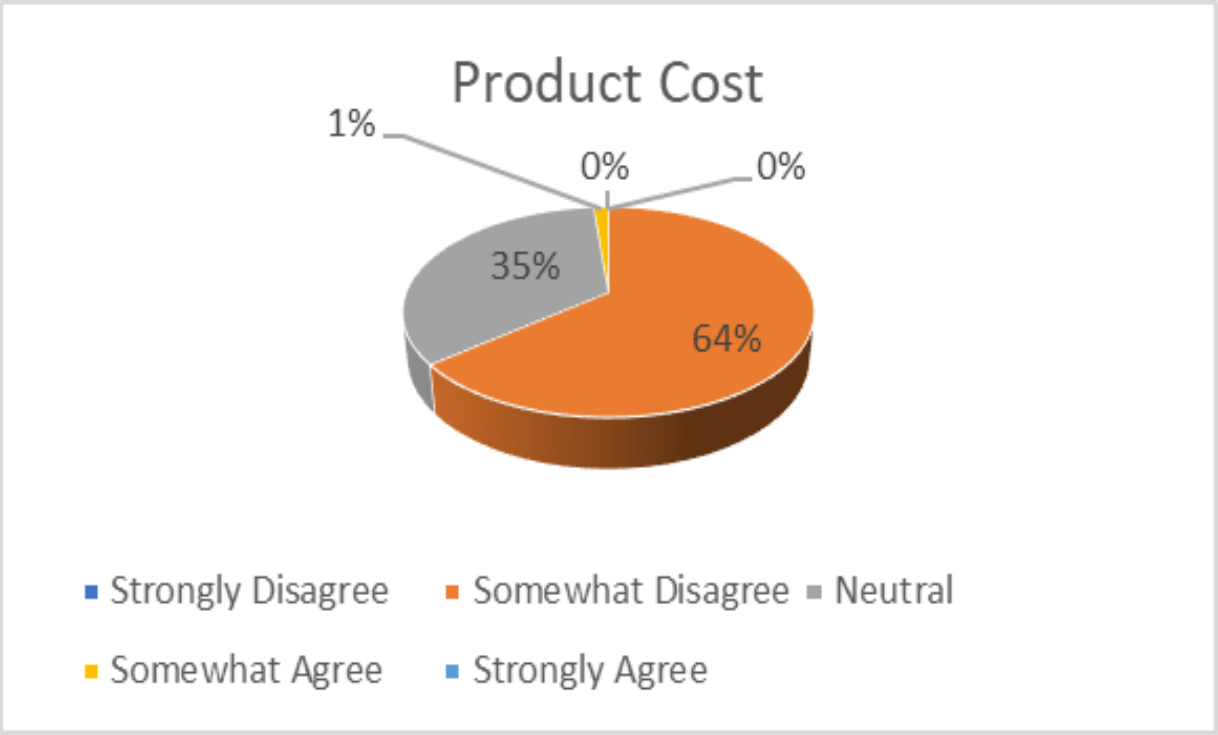


Fig A.2

Q5 Lead time of Product delivery is an important criterion for supply point selection and logistics Optimisation

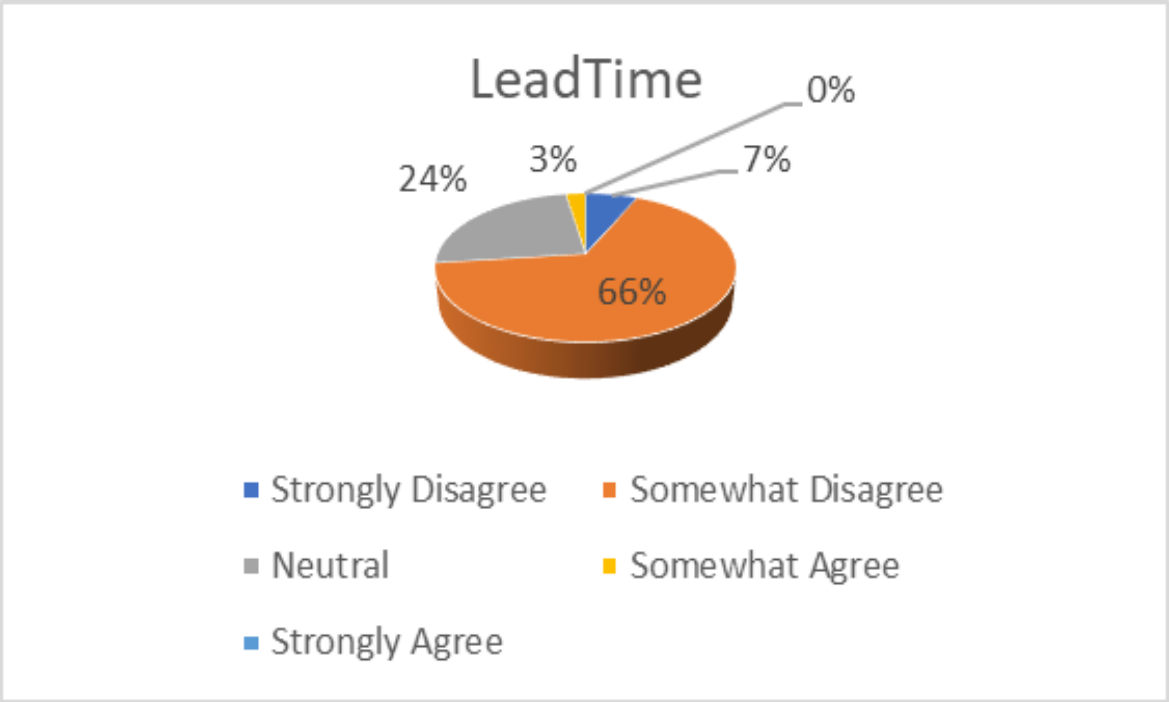


Fig A.3

Q6 Profitability of the stakeholders has bearing on the logistics of auto fuels.

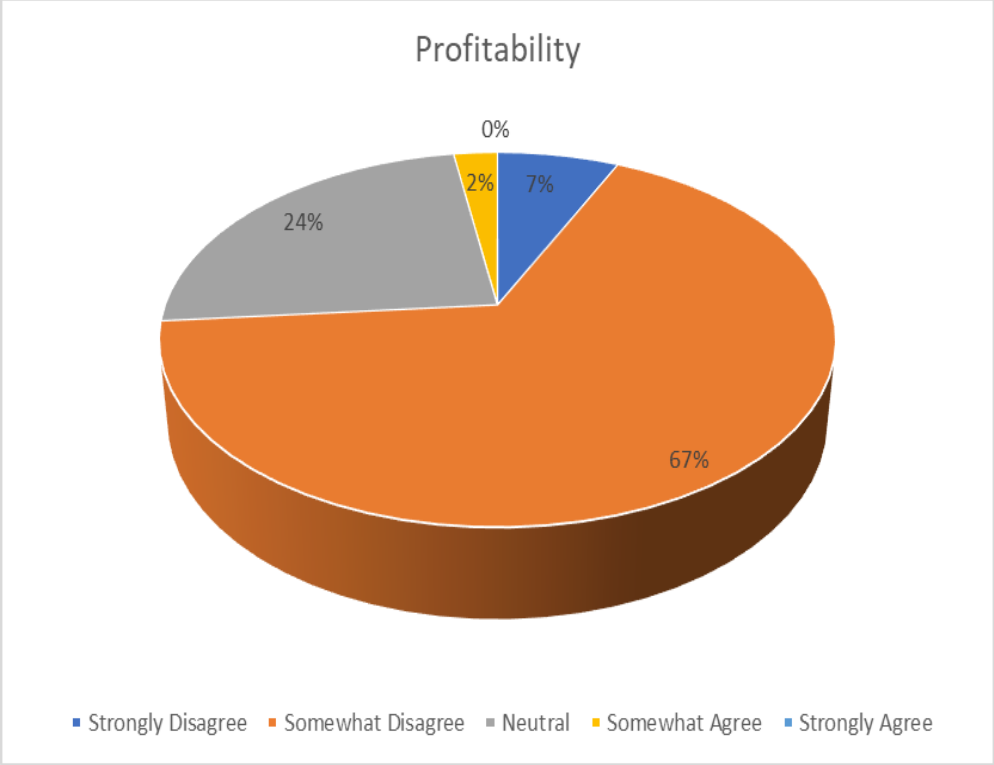


Fig A.4

Q7 The distance between supply point and the market may affect the responsiveness to the customer demands. Responsiveness should be included as a factor of optimisation.

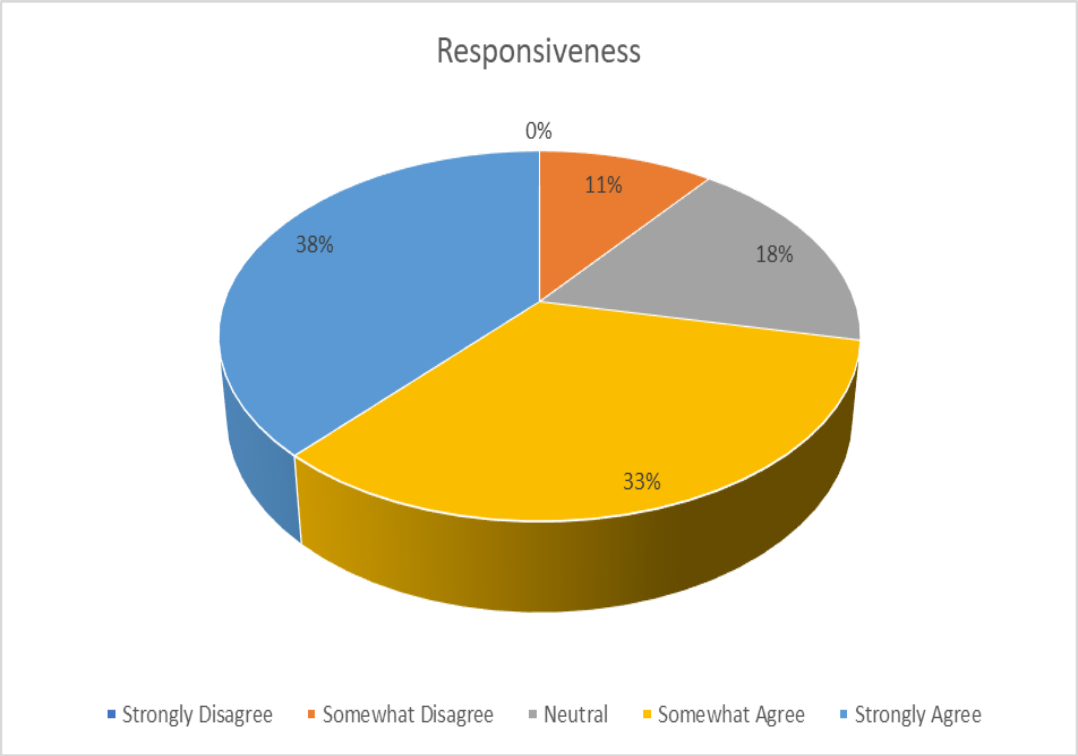


Fig A.5

Q8 The reliability is defined as the number of times the service delivery has met its standard performance criteria. It is an crucial item in logistics operations.

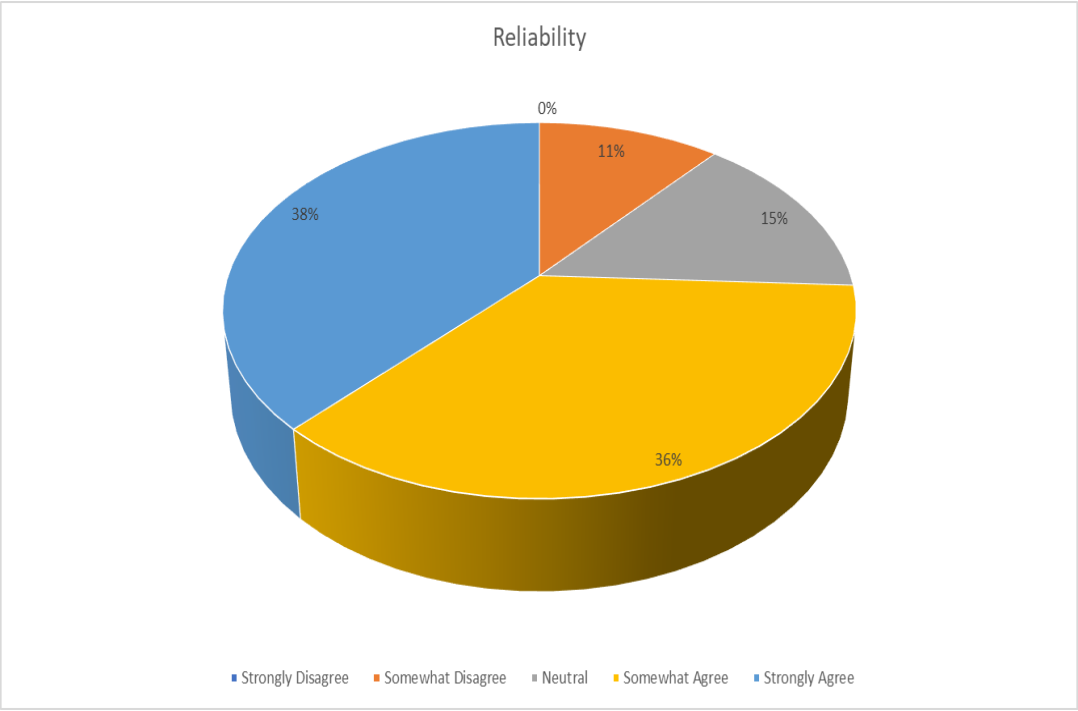


Fig A.6

Q9 Viability of the business for the stakeholders has significant effect on the logistics of auto fuels.

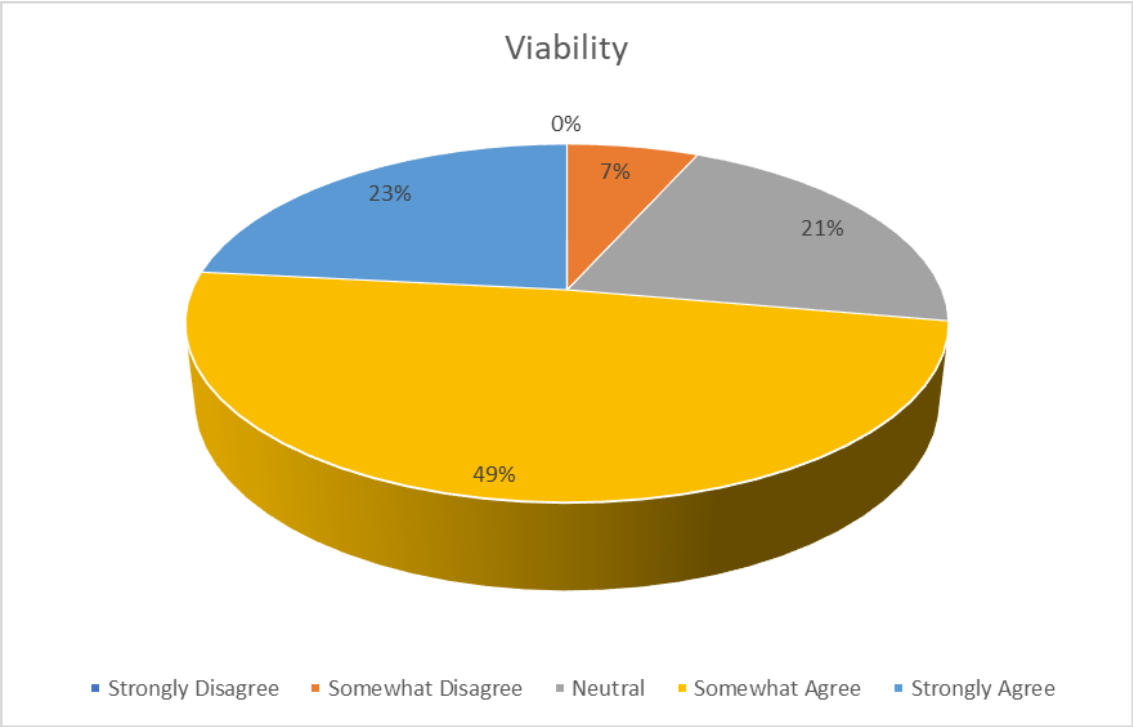


Fig A.7

Q10 The logistics of auto fuels has to factor in transport cost as an important element.

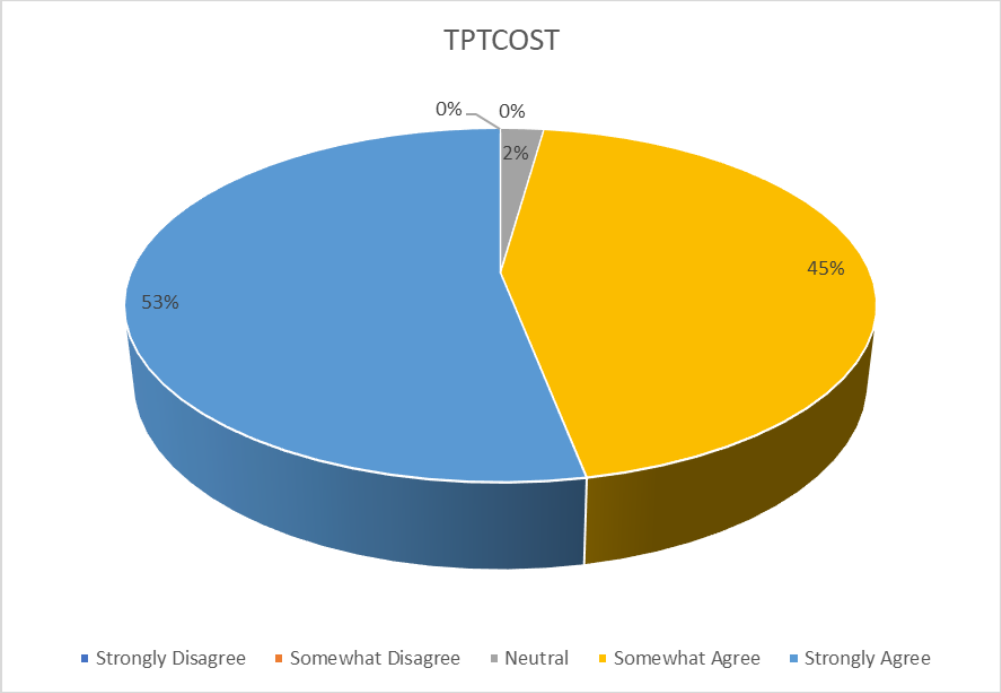


Fig A.8

Q11 There has to be flexibility in secondary logistics so that the market is not dependent on a single source. Hence flexibility is an objective of optimisation.

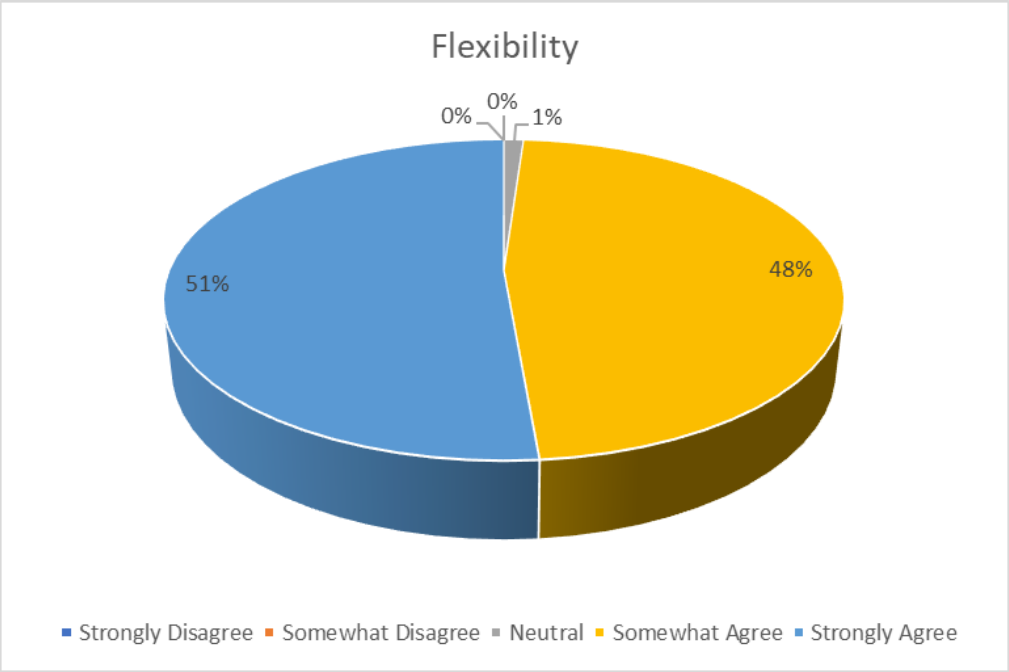


Fig A.9

12 The distance travelled by the tank trucks determines the usage and turnover of the transporter. This mileage of the mode of transport must be considered as a factor of optimisation in secondary logistics.

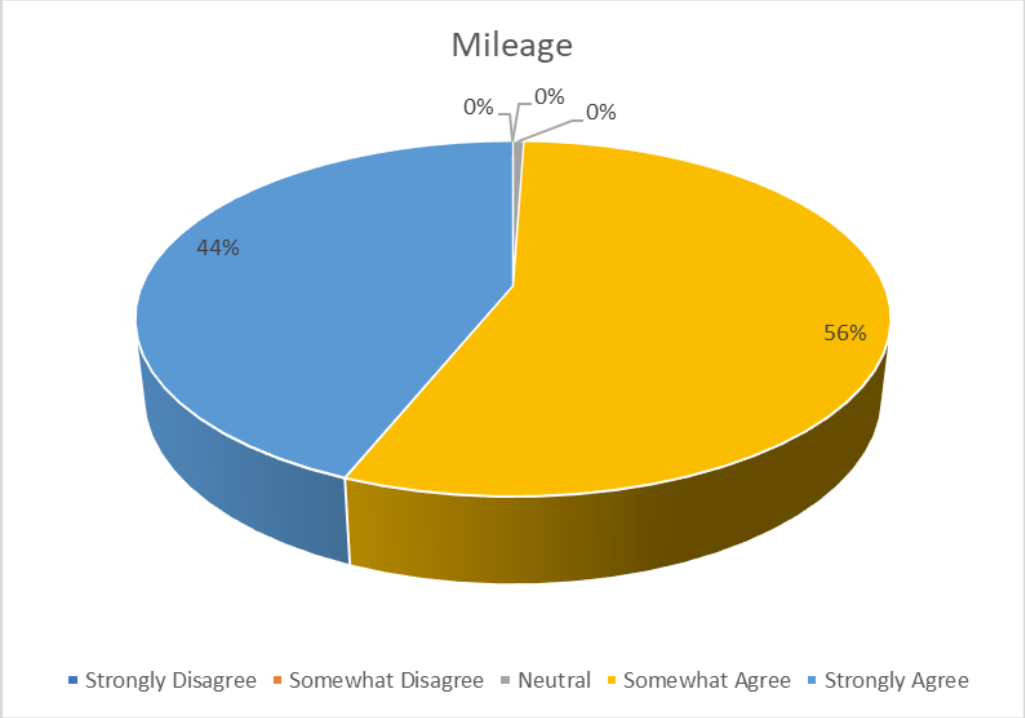


Fig A.10

Q13 The transporter involved in the logistics has to be compensated for the services rendered. The amount of compensation has to be considered while framing the optimisation model.

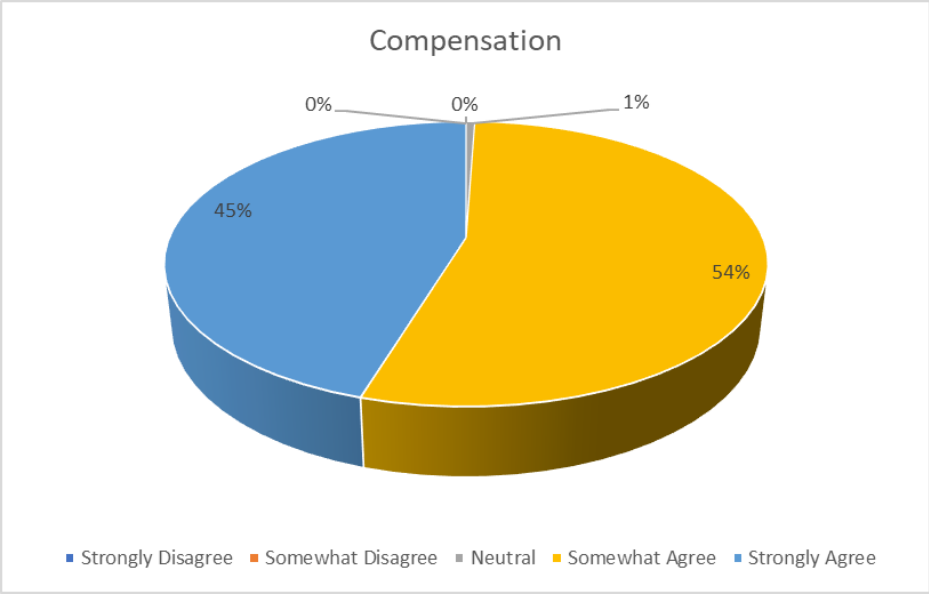


Fig A.11

Q14 The customer and the public residing in the vicinity of locations expect the OMC to be participant in their development. The community development is required as an element in logistics model.

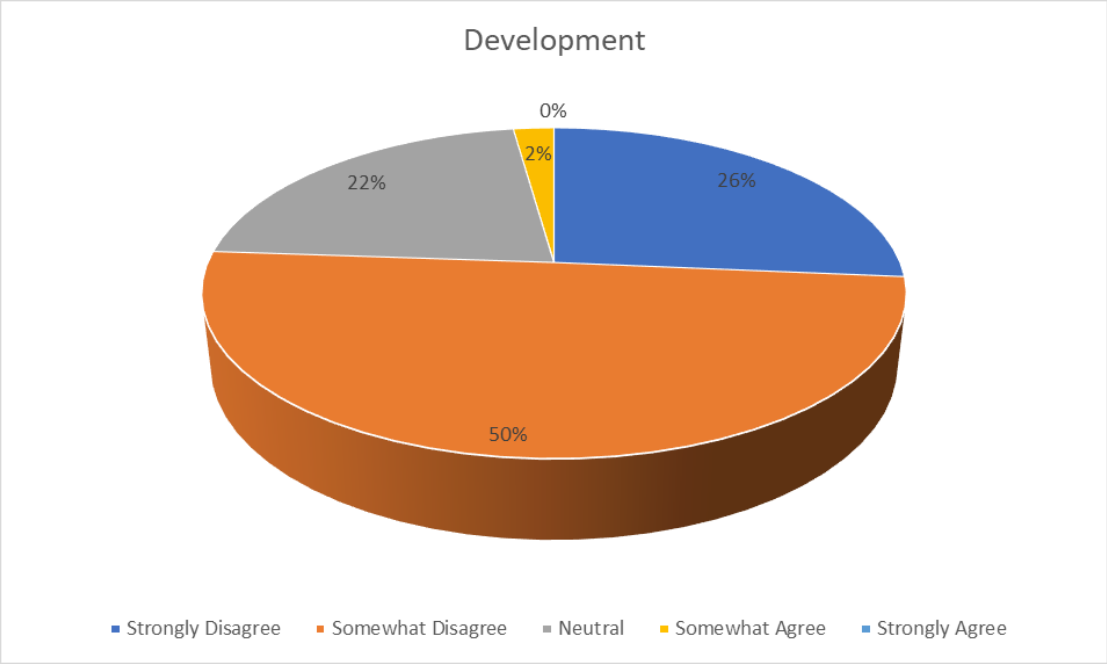


Fig A.12

Q15 The customers expect value for their money and the society expects value additions to the resources sacrificed by them. It is important to consider the final value added in the secondary logistics operations.

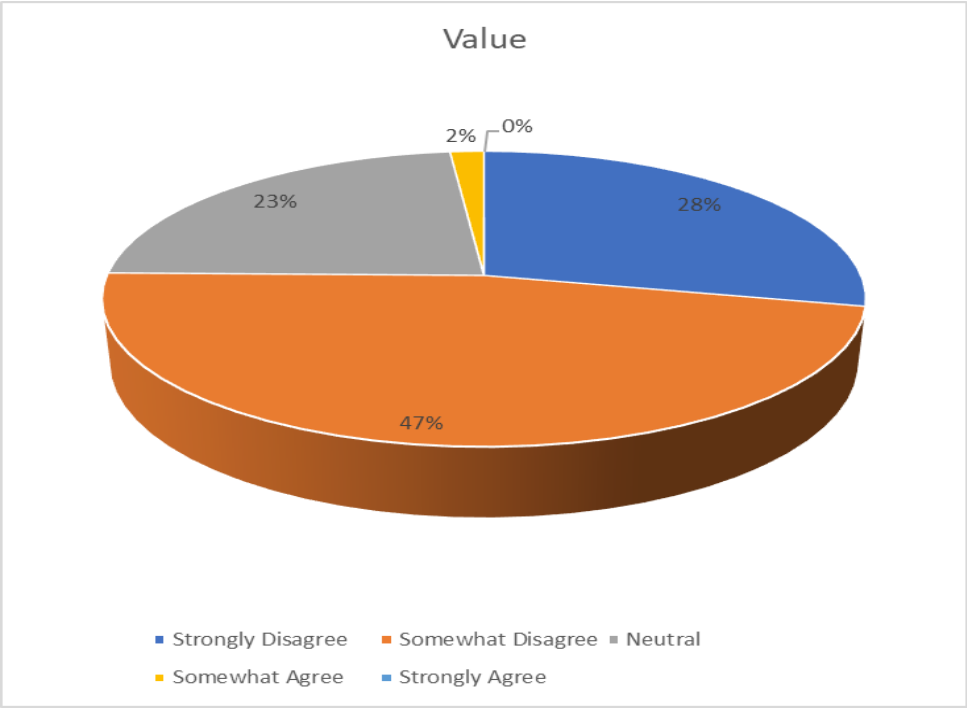


Fig A.13

Q16 The experience of the customer at the interaction point is the sum of all the supply chain activities carried out to provide the right quality and quantity of the product to the customer at the right time. Hence customer experience should become a factor in optimisation framework.

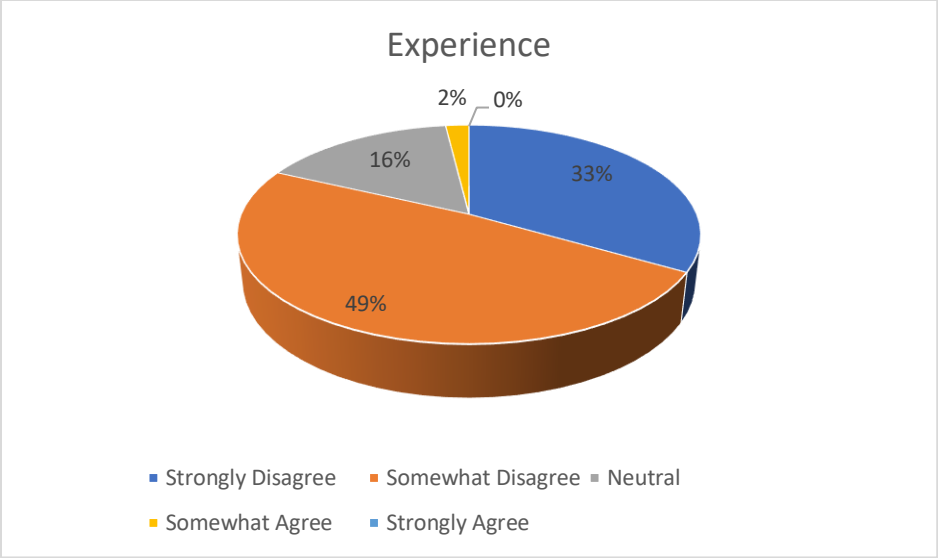


Fig A.14

Q17 The optimisation model should endevour to increase the market reach of the Oil Market

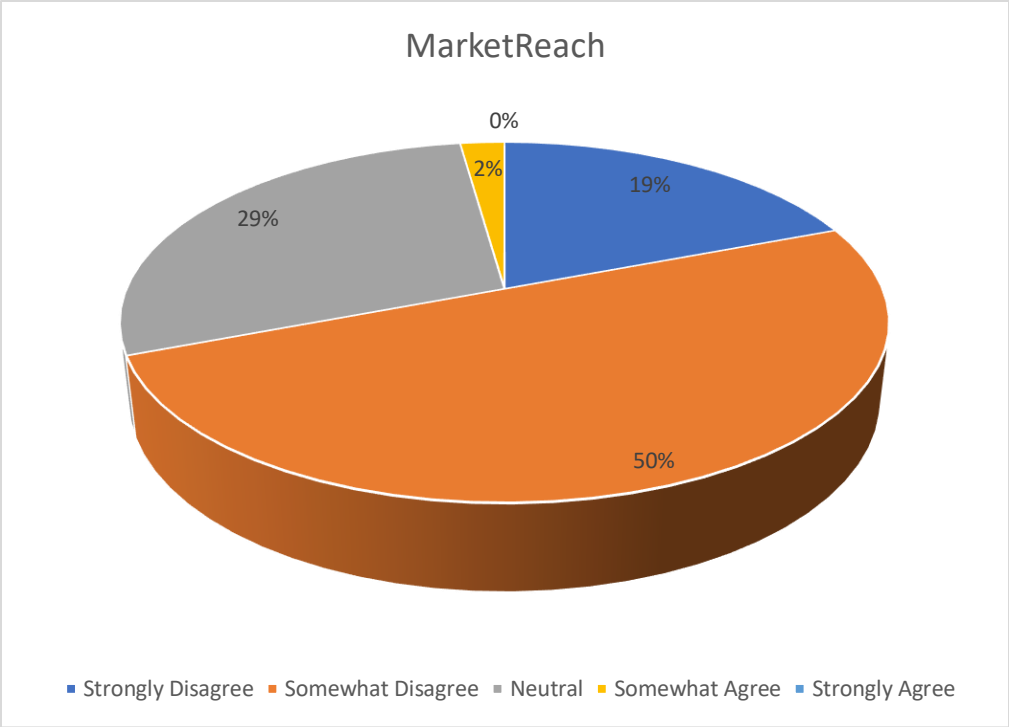


Fig A.15

Q18 Service level defined for the location has high impact on the logistics performance.

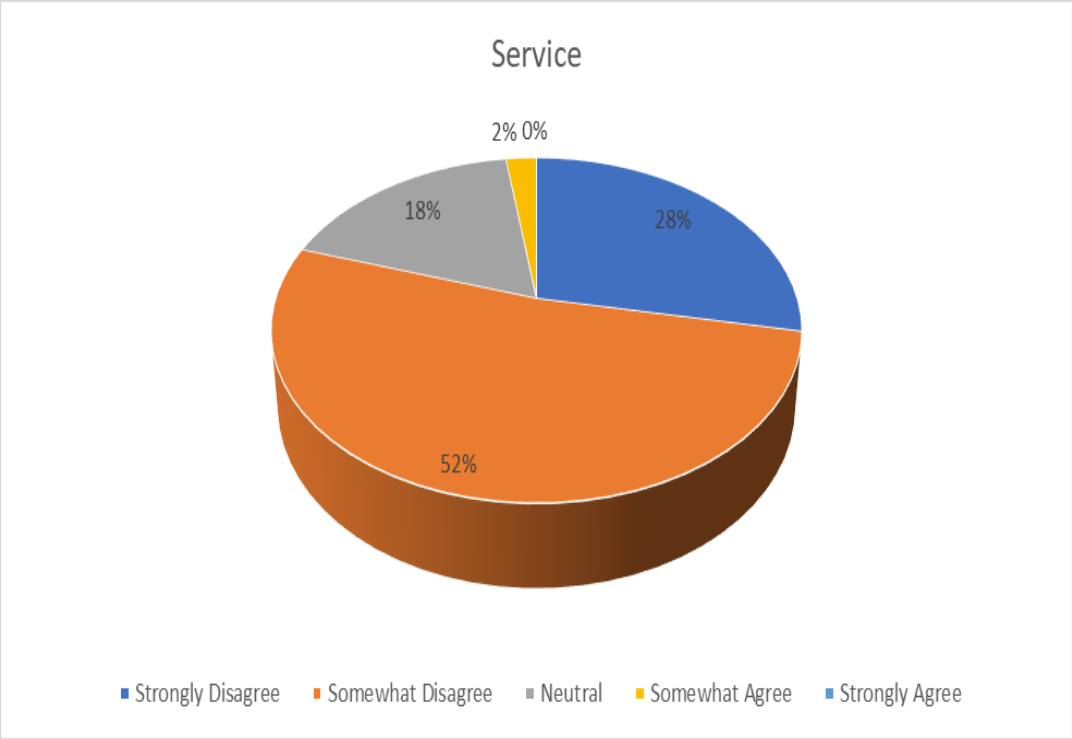

Service
2% 0%
18%
28%
52%
Strongly Disagree
Somewhat Disagree
Neutral
Somewhat Agree
Strongly Agree

Fig A.16

Appendix II

QUESTIONNAIRE FOR PAIRWISE COMPARISON IN AHP

Determining Relative Weight of the Factors of Optimisation in Secondary Logistics of MS and HSD in India

Dear Sir / Madam

I am studying 'Secondary Logistics of MS and HSD in North India as a part of my thesis and need your expert opinion for determining relative weight of the the factors of optimisation. The description of factors identified has been given as under :

1. Cost: Providing flexible logistics at least transportation cost.
2. Service: Providing best Product Quality with high Responsiveness while ensuring Reliability
3. Performance: The ability to deliver product at least Lead time of delivery and minimum overall cost to company.
4. Value: The ability to provide value to customer and locality

Please spare a few minutes to respond to the survey form available in the link.

Bhuwan C Joshi

Email address *

Valid email address

This form is collecting email addresses. Change settings

Discipline *

- Operations
- Supplies and Distribution
- Sales
- Other...

Experience *

- Less than 10 Years
- 10 Years to 20 Years
- 20 Years to 30 Years
- More than 30 Years

Secondary Logistics in downstream petroleum industry is that part of Supply Chain which delivers product from Strorage Terminals to Retail Outlets. The present study is to determine the relative weight of the the factors of optimisation for MS and HSD supplies in North India. You are a Subject Matter Expert and your opinion has been sought in the following questions. Please answer the questions in context of secondary logistics of MS and HSD in North India. Please indicate your opinion on the statements given by selecting one most appropriate response against each.

1 - Very Strongly agree means first factor is 5 times more important than the second

2- Strongly Agree means first factor is 4 times more important than the second

3- Agree means first factor is 3 times more important than the second

4-Slightly Agree means the first factor is 2 times more important than the second

5-Neutral means first and second factor are equally important

6- Slightly Disagree means second factor is 2 times more important than the first

7- Disagree means second factor is 3 times more important than the first

8-Strongly Disagree means second factor is 4 times more important than the first

9- Very Strongly Disagree means second factor is 5 times more important than the first.

Cost is more important than Service

	1	2	3	4	5	6	7	8	9	
Very Strongly Agree	○	○	○	○	○	○	○	○	○	Very Strongly Disagree

Cost is more important than Performance

	1	2	3	4	5	6	7	8	9	
Very Strongly Agree	○	○	○	○	○	○	○	○	○	Very Strongly Disagree

Cost is more important than Value

	1	2	3	4	5	6	7	8	9	
Very Strongly Agree	○	○	○	○	○	○	○	○	○	Very Strongly Disagree

Service is more important than Performance

	1	2	3	4	5	6	7	8	9	
Very Strongly Agree	○	○	○	○	○	○	○	○	○	Very Strongly Disagree

Service is more important than Value

	1	2	3	4	5	6	7	8	9	
Very Strongly Agree	○	○	○	○	○	○	○	○	○	Very Strongly Disagree

Performance is more important than Value

	1	2	3	4	5	6	7	8	9	
Very Strongly Agree	○	○	○	○	○	○	○	○	○	Very Strongly Disagree

Performance is more important than Value

	1	2	3	4	5	6	7	8	9	
Very Strongly Agree	○	○	○	○	○	○	○	○	○	Very Strongly Disagree

I

ORIGINALITY REPORT

9%	8%	3%	1%
SIMILARITY INDEX	INTERNET SOURCES	PUBLICATIONS	STUDENT PAPERS

PRIMARY SOURCES

1	www.ijstr.org Internet Source	4%
2	baadalsg.inflibnet.ac.in Internet Source	1%
3	link.springer.com Internet Source	<1%
4	www.isl21.org Internet Source	<1%
5	Rongrong Li, Yee Leung, Bo Huang, Hui Lin. "A genetic algorithm for multiobjective dangerous goods route planning", International Journal of Geographical Information Science, 2013 Publication	<1%
6	mospi.nic.in Internet Source	<1%
7	www.emerald.com Internet Source	<1%
8	espace.etsmtl.ca Internet Source	<1%
9	Johanna Trujillo Diaz, Mario Martinez Rojas, Carlos Franco Franco, Andres Tarcisio Velasquez Contreras et al. "Criteria for decision-making in transportation logistics function", 2015 International Conference on Industrial Engineering and Operations Management (IEOM), 2015 Publication	<1%
10	hdl.handle.net Internet Source	<1%
11	trid.trb.org Internet Source	<1%
12	hj.diva-portal.org Internet Source	<1%
13	pt.scribd.com Internet Source	<1%
14	Submitted to Pondicherry University Student Paper	<1%
15	Submitted to University of Western Australia Student Paper	<1%