ANALYSIS AND MANAGEMENT OF CONSTRAINTS RELATED TO VEHICLE FILL RATE IN ROAD FREIGHT TRANSPORT FOR FMCG SECTOR

A thesis submitted to the
University of Petroleum and Energy Studies

For the award of
Doctor of Philosophy

In

Management

By

Rudrangsu Biswas

January 2024

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DECLARATION

I hereby declare that the work which is being presented in the thesis entitled "ANALYSIS AND MANAGEMENT OF CONSTRAINTS RELATED TO VEHICLE FILL RATE IN ROAD FREIGHT TRANSPORT FOR FMCG SECTOR" in fulfilment of the requirements for the award of the Degree of Doctor of Philosophy and submitted to the University of Petroleum and Energy Studies (UPES), Dehradun - India, is an authentic record of my own work carried out during the period from January, 2019 to January, 2024 under the supervision of supervisor Dr. Subhra Rajat Balbantaray, Assistant Professor (School of Business, MIT World Peace University, Pune, Maharashtra, India) and Dr. Rupesh Kumar, Associate Professor (Jindal Global Business School, O.P Jindal Global University, Haryana, India). No part of this thesis has formed the basis for the award of any degree or fellowship previously.

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CERTIFICATE

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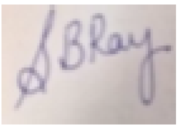

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ABSTRACT

India is one of the fastest growing economies in the world. In this growth fast moving consumer goods (FMCG) plays a vital role. FMCG creates those products which fulfil the daily needs of the people. FMCG sector is having very thin margin and highly competitive market. This competition is not restricted to Indian organizations only. For International competitiveness, job opportunity, livelihoods and clean environment, organizations need efficiency, effectiveness, productivity, cost optimization along with sustainability. Trucks and other mode of road transport handle most of the movement of FMCG products. Railways, costal, inland waterways and airways accounts for the rest. India having target to reduce the logistics cost as share of GDP from 14 per cent to 10 per cent by 2022. Apart from that less traffic on the road and reduction of carbon emissions caused by road freight transport is two major target area for India. Hence it is eminent that 'Road transport' is the focus area in India and it FMCG sector distribution is fully dependent on it. 'Vehicle fill rate' (VFR) identified as one of the important levers to achieve the above-mentioned targets.

Filling the vehicle optimally is very important since it is having multiple effect. Not only on freight cost, but it is also having impact on productivity, carbon emissions, road traffic, quality of delivery and many more. But unfortunately, in last few years vehicle fill rate (VFR) is getting importance in FMCG sector. It is still in emerging stage. The presence of constraints has obstructed the fill rate of vehicle and resulted surge in freight cost and other operational inefficiencies. Additionally, it has long term impact on the profitability of the FMCG organizations and competitiveness. Vehicle fill rate is comparatively new field in the area of research and Indian context the research work is very minimum. The implication of this study is not only applicable to one region, other developing and underdeveloped countries will also have the applicability. This study focusing on the constraints and gives integrated framework of solutions to overcome the constraints of VFR. Prior to this, no study was existed which proposed a framework to evaluate the constraints related to VFR and strategies to overcome the constraints of VFR, which was identified as a prominent research gap.

Based on the thorough review of existing literature the constraints and solutions related to VFR was identified. Delphi survey technique helped to finalise the constraints and solutions related to VFR. Decision-Making Trial and Evaluation Laboratory (DEMATEL) and Fuzzy Analytic Hierarchy Process (FAHP) helped to calculate the rank of the identified 8 main constraints and 28 sub-categories of constraints. Through this analysis 'Structural Constraints of Trucks' identified as a topmost constraint which is impacting the vehicle fill rate most. No other studies identified it as a topmost constraint. Hence in Indian context it is one of the most important constraints, which should get addressed to improve the vehicle fill rate. Hence in-depth research work shared on 'Structural Constraints of Trucks'. Linear Regression was used to predict the variability of VFR along with variability of vehicle dimension, vehicle carrying capacity. Variability of VFR is having direct relation with freight cost and carbon emissions, which was also shared with the help of simulation. 'Vehicle related constraint' and 'Inter and Intra Coordination and collaboration Related Constraints' identified as a second and third constraints out of eight identified categories of constraints.

Similarly, the Fuzzy Technique for Order of Preference by Similarity to Ideal Solution (FTOPSIS) was deployed to ascertain the ranks of the identified solutions to overcome the constraints related to VFR. 32 number of identified strategies are evaluated and ranked through FTOPSIS. 'Implementation of IT based solutions', 'Government Support through Law enforcement regarding harmonization of truck size and carrying capacity' and 'Choosing Right Truck Type' are identified as top three strategies to overcome the constraints of VFR. Integrated framework of this solutions will help to fill more material in same truck. Some of the identified solutions were practically implemented and obtained good results as a proof of evidence. This research proposes a precise and effective decision support system for step wise execution of the identified differential strategies to boost the vehicle fill rate in road freight transport for FMCG sector.

Key Words: Supply Chain; Logistics; Transportation; Vehicle Fill Rate; DEMATEL; Fuzzy AHP; Fuzzy TOPSIS; Sensitivity Analysis; FMCG.

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TABLE OF CONTENTS

Title………………………………………………………………………….. Page No

Title Page………..………………………………….…..……………………..ii

Declaration……………………………………………………………………..iii

Certificates……………………………………………………………………. iv

Abstract…………………………………………………………………………vi

Acknowledgement……………………………………………………………viii

Table of contents…………………………………………………………......ix

List of Abbreviations…………………………………………………...……...xv

List of Figures…………………………………………………………………...xvii

List of Tables…………………………………………………………………...xviii

Chapter 1 - Introduction and Background…………………………………………1

1.1 Background of the Study……………………………………………………….1

1.2 Concept and Definition…………………………………………...…………2

1.2.1 Road Freight Transport of India……………………………………….2

1.2.2 Vehicle Fill Rate (VFR)……………………………………….…………5

1.2.3 FMCG Sector………………………………………………….………6

1.2.4 Stake holders in Vehicle Fill Rate for FMCG Sector……………….....7

1.2.5 Barriers in Vehicle Fill Rate……………………………………….......9

1.3 Progress of Vehicle Fill Rate in Indian context………………………...…..10

1.4 Issues in Road Transportation in India……………………………...………11

1.5 Motivation/need for the Research…………………………….…………………13

1.6 Business Problem………………………………………………………………..14

1.7 Organisation of Thesis……………………………………………...…………15

1.8 Chapter Summary ………………………...………………….....…………...21

Chapter 2 - Review of Literature……………………………………….…………….22

2.1 Literature Review…………….………………………………….……………22

2.2 Literature review based on Themes………………...…………………...………24

2.3.1 Theme 1: Understanding of Vehicle Fill Rate –
Global and Indian Context…………………………………...……………25
2.3.2 Theme 2: Constraints of Vehicle Fill Rate in Road
Freight Transportation – Global and Indian Context………………...………30
2.3.3 Theme 3: Strategies taken to overcome the
constraints related to Vehicle Fill Rate – Global and
Indian Context……………………………………………………...…34
2.4 Theories supporting Vehicle Fill Rate…..40
2.5 Literature on Data Analysis Technique……………………………………..……48
2.6 Major inferences derived from literature review……………………………..…...50
2.7 Major gaps derived from literature review…………………………………….....51
2.8 Research Problem…………………………………..…………………………..52
2.9Research Questions (RQs)………………………………………………..……….53
2.10Research Objectives (ROs)………………….…………………………………..53
2.11 Chapter summary……………………………………………………………..…54
Chapter 3 - Research Methodology……………………………..………………55
3.1 Research Design……………………………………………………………......55
3.2 Research Methodology……………………………………………………..…..58
3.3 Data Collection Sources…………………………………………………………60
3.4 Design of Questionnaire…………………………………………………………61
3.5 Proposed research method and techniques………………………………………62
3.5.1 AHP and Fuzzy AHP technique……………………………………..……62
3.5.2 Fuzzy TOPSIS (Technique for Order Preference by
Similarity to Ideal Solution)…………………………………………..……66
3.5.3 DEMATEL……………………………………...…………………67
3.5.4 Sensitivity Analysis………………………………………………………..68
3.5.5 Chapter Summary…………………………………………..…………..68
Chapter 4 - Identification and evaluation of constraints of Vehicle Fill Rate in Road Freight Transport of FMCG sector…………………………………………69
4.1 Introduction……………………………………………………………………69
4.2. Proposed Framework……………………………………………………………70

4.3. Sampling……………………………………...……………………………71
4.3.1 Sampling Adequacy Analysis……………………………………..……75
4.3.2 Examining Reliability of Instrument……………………………………76
4.4. Identification of constraints of Vehicle Fill Rate in Road
Freight Transport for FMCG sector……………………………………………….76
4.4.1 Structural Constraints of Trucks (SCT)……………………..…………..78
4.4.2 Vehicle Related Constraints (VRC)…………………….………………79
4.4.3 Box related Constraints (BRC)…………………………………………81
4.4.4 Cargo related Constraints (CRC)……………………………………….82
4.4.5 Load related Constraints (LRC)………………………………………...83
4.4.6 Order Related Constraints (ORC)……………………………………….85
4.4.7 Packaging Related Constraints (PRC)……………………….………….86
4.4.8 Inter and Intra Coordination and collaboration
Related Constraints (ICCC)…………………………………………..…….88
4.5 Categories and sub-categories of Constraints of Vehicle Fill
rate in Road Freight Transport……………………………………………...…..89
4.5.1 Application of DEMATEL, AHP and Fuzzy AHP……………….…………92
4.6 Analysis of constraints by using DEMATEL……………………………….………93
4.7 Analysis of constraints and fixing the rank of the constraints by
using AHP and FAHP………………………….………………………...…94
4.7.1 Measure of consistency and Ranking of constraints
by using AHP………………………………………………………………..94
4.7.2 Ranking of constraints by using Fuzzy AHP…………….…………95
4.7.3 Comparison of ranking obtained by using AHP and
Fuzzy AHP approaches…………………………………………………...…96
4.7.4 Ranking of Sub-categories of the constraints…………………………97
4.8 Analysis of results and discussion……………………………………...…98
4.8.1 Discussion of Results of DEMATEL approach……...………………..98
4.8.2 Discussion of results received by using AHP and
Fuzzy AHP………………..…………………………………………101
4.9 Sensitivity Analysis…………………………………………………….……….109
4.10 Chapter Summary…………………………………………………...……111

Chapter 5 - Influence of topmost constraint on vehicle fill rate: Hypotheses testing and Model Development…………………………………………….….112

5.1 Introduction……………………………………………………………..……112

5.2 Linear Regression Modelling and Hypothesis Testing…………………………113

5.3 Data collection………………………………………………………………..114

5.4 Data Analysis with respect to Variability in Truck Size………………….….116

- 5.4.1 Initial Data Analysis for Variability in Truck Size……………..…….116

 5.4.2 Hypotheses development related to truck size variation with vehicle fill rate……………………………………………….117

 5.4.3 Research construct validity……………………………………………126

 5.4.4 Simulation building activity based on Variability in Truck Size……………………………………………….…………..127

 5.4.5 Practical Implication based on Simulation building activity based on Variability in Truck Size………………………………….130

 5.4.6 Theoretical Implication based on Simulation building activity based on Variability in Truck Size………………………………….132

5.5 Hypotheses development regarding truck carrying capacity variation with vehicle fill rate ……………………………………………………………………...134

 5.5.1 Simulation building activity based on Variability in Truck Carrying Capacity and Vehicle Fill Rate…………………………..137

 5.5.2 Findings based on simulation, related to vehicle fill rate and freight cost……………………………………………………..…139

 5.5.3 Findings based on simulation, related to vehicle fill rate and carbon emissions……………………………………...……….140

 5.5.4 Practical Implication based on Simulation building activity based on Variability in Truck Carrying Capacity………………….…142

 5.5.5 Theoretical Implication based on Simulation building activity based on Variability in Truck Carrying Capacity…………….…….144

5.6 Hypotheses development related to Usage of Angle, nut-bolt inside Truck with vehicle fill rate……………………………………………….…….145

5.7 Chapter Summary…………………………………………………….……146

Chapter 6 - Assessment of Solution and Strategies to overcome the constraints of vehicle fill rate in road freight transport………………..…..148
6.1 Introduction…………………………………………………..…………148
6.2 Proposed Framework……………………………………………………149
6.3 Identified strategies and solutions to overcome the constraints in vehicle fill rate for FMCG sector……………………………….……….151
6.4 Prioritization of the strategies and solutions to overcome the constraints related to vehicle fill rate in road freight transport for FMCG sector…………………………………..…………………………….155
6.4.1 Fuzzy TOPSIS………………...…………………………………….156
6.5 Ranking of suggested solutions to overcome the constraints………………..…160
6.5.1 Implementation of IT based solutions (IOI)……………...……………160
6.5.2 Government Support through Law enforcement regarding harmonization of truck size and carrying capacity……………….164
6.5.3 Choosing Right Truck Type (RTT)……………………………………167
6.5.4 Coordination and Consolidation Activity……………….…………..170
6.5.5 Physical loading Activity (LAP)……………………………...….172
6.5.6 Product and packaging design (PPD)……………..…………………..175
6.5.7 Order Management pattern (OPP)………………………….………177
6.5.8 Warehousing Related Changes (WRC)……………………….……180
6.6 Sensitivity Analysis of the prioritized solutions……………………….……182
6.7 Chapter Summary…………………………………………………………183

Chapter 7 – Conclusion, Recommendation and Future Research……………..184

7.1 Introduction……………………………………………………………..184
7.2 Contribution to the literature from this research work ………………………...185
7.2.1 Identification and evaluation of constraints related to vehicle fill rate in road freight transportation for FMCG sector……………185
7.2.2 Identification of the strategies to overcome the constraints related to vehicle fill rate in road freight transportation for FMCG sector……………………………………………186
7.2.3 Theoretical implications of the research…………………………....187
7.2.4 Practical implication of the research………………………………..191

7.3 Recommendations and Conclusions…………………………………………..…….194
7.3.1 Identification and analysis of constraints related to vehicle fill rate by using DEMATEL and Fuzzy AHP technique and building the relationship between the variables and vehicle fill rate through Linear Regression…………….…….194
7.3.2 An integrated framework to identify and analyse the strategies to overcome the constraints by using Fuzzy TOPSIS……………196
7.4 Limitations……………………………………………………………………..198
7.5 Scope of Future Research…………………………………………..…….198
7.6 Chapter Summary……………………………………………..……..199

References……………………………………………………………..……200
Appendices……………………………………………………………………228
Appendix 1……………………………………………………………………228
Appendix 2………..…………………………………………………………..229
Appendix 3……...……………………………………………………………..230
Research Publication……………………………………………………….…232
Brief Background…………………………………….……………………..233
Plagiarism Report…………………………………………………………...234

LIST OF ABBREVIATIONS

Abbreviations	Full Name
AHP	Analytic Hierarchy Process
BAU	Business-As-Usual
CLP	Container Loading Problem
CR	Consistency Ratio
CI	Consistency Index
DEMATEL	Decision-Making Trial and Evaluation Laboratory
FAHP	Fuzzy Analytic Hierarchy Process
FMCG	Fast Moving Consumer Goods
FTOPSIS	Fuzzy Technique for Order of Preference by Similarity to Ideal Solution
GDP	Gross Domestic Product
GPS	Global Positioning System
GVA	Gross Value Addition
GVW	Gross Vehicle weight
IT	Information Technology
HALNS	Hybrid Adaptive Large Neighbourhood Search
IPCC	Intergovernmental Panel on Climate Change
INLP	Integer Nonlinear Programming Model
KBV	Knowledge Based View
KPI	Key Performance Indicators
KMO	Kaiser-Meyer-Olkin
LBH	Length Breadth Height
LR	Literature Review
LAFF	Largest Area First Fit
LQM	Linearized Quadratic Model
MILP	Mixed Integer Linear Programming
MCDM	Multi Criteria Decision Methods
MCDA	Multi Criteria Decision Analysis
OBT	Open Body Truck
PI	Physical Internet

PBA	Permutation Block Algorithm
RBV	Resource Based View
RC	Registration Certificate
RL	Reinforcement Learning
SAP	Situation Actor Process
SEM	Structure Equation Model
SCM	Supply Chain Management
SPSS	Statistical Package for Social Sciences
TAT	Turnaround Time
TFN	Triangular Fuzzy Numbers
TMS	Transport Management system
TWPM	Time Window Priority Model
TOC	Theory of Constraints
TOPSIS	Technique for Order Preference Similarity to Ideal Solution
VFR	Vehicle Fill rate
WSP	warehouse service provider

LIST OF FIGURES and SNAPS

Figure 1.1: - Mode wise split of Indian freight in 2020…...…………………….…….…3
Figure 1.2: – Indian road freight transport cost components……………...…………..4
Figure 2.1: – Research Gap identification...………………………………………….22
Figure 3.1: Flow Diagram of research design……………...…………..…………….56
Figure 4.1: – Proposed Framework for Objective 1……………….…………..…….71
Figure 4.2: This figure described the percentage of Actors
Interviewed…………………………………………..……………………….73
Figure 4.3: Result of KMO and Bartlett's Test………………………………………75
Figure 4.4: Constraints related to vehicle fill rate in road freight transportation of
FMCG sector……………………………………………………...…………….77
Figure 4.5: Cause and effect diagram of the constraints……………………………100
Figure 4.6: Results of sensitivity analysis for criteria………………..……………..111
Figure 5.1 – Graphical presentation of VFR before loss and
after loss due to structural issue in a truck………………………………………….146
Figure 6.1: Proposed framework for this research thesis……………………..……149
Figure 6.2: Results of sensitivity analysis for solutions…………………………….183
Snap 5.1: Identical Loading Pattern for 5 number of Standard
vehicles……………………………...…………………………………………133
Snap 5.2: Different loading pattern for non-standardized vehicle……………….……133
Snap 5.3: Loading pattern of XYZ company……………………………………...…..142
Snap 6.1: Tailor made double deck vehicle………………………...……………168

LIST OF TABLES

Table 1.1: Organization of the Thesis……………………………………………..……21
Table 2.1: Table on Theme wise literature review summary…………………….……..39
Table 2.2: Suitability check of theories for the study……………………………….42
Table 2.3: Table illustrates different types and names of the models/techniques and studies which were used in past for analysis in SCM……………….…………………………………………………………….48
Table 3.1: Scale for pairwise comparison……………………………………………64
Table 3.2: Average number index……………………………………………………65
Table 3.3: 5 point Scale for Sensitivity Analysis…………………………………….68
Table 4.1: Types and number of actors contacted and responded………………..….73
Table 4.2: Respondents profile……………………………………………………….74
Table 4.3: Experience of the respondents…………………...……………………….74
Table 4.4: Sampling Adequacy Results……………………..……………………….76
Table 4.5: Categories and sub-categories of constraints related to vehicle fill rate…………………………………………...…………………91
Table 4.6: Comparison Scale for DEMATEL method………………...…………..93
Table 4.7: Total relation matrix…………………………………………...…….93
Table 4.8: Exhibits the cause-and-effect relationship of the eight key criteria……………………………...……………………………..……..93
Table 4.9: presents the TFNs (Triangular Fuzzy Numbers) used for evaluating the criteria under the AHP and Fuzzy AHP methods………………………….....……94
Table 4.10: Normalized Weights of the key criteria (AHP)……………………..……95
Table 4.11: Criteria Weights and corresponding Ranks……………………..……..95
Table 4.12: Fuzzy Weights of Geometric Means - wl, wm and wu……………...…..96
Table 4.13: Criteria Weight Ranks for AHP and FAHP (comparison)…………..…..96
Table 4.14: the Potential Constraints in Sequence…………………………………..96
Table 4.15: Fuzzy Weights of Geometric Means - wl, wm and wu for sub-criteria……………………………..………………………………97
Table 4.16: Structural constraints' Ranking………………………………….….…101
Table 4.17: Vehicle Related Constraints' Ranking………………………………102

Table 4.18: Inter and Intra Coordination and Collaboration Related Constraints' Ranking…………………………………………………………………….….103
Table 4.19: Order related constraints' Ranking…………………………………….104
Table 4.20: Cargo related constraints' Ranking…………………………….....…..106
Table 4.21: Packaging related constraints' Ranking………………………………..107
Table 4.22: Load related constraints' Ranking……………………………………..108
Table 4.23: Box related constraints' Ranking………………………………………109
Table 4.24: Sensitivity analysis of main criteria with "SIT" criteria weight changes from (0.417*0.9 … 0.417*0.1)……………………………110
Table 5.1: Truck Measurement Format……………………………………………..115
Table 5.2: Summary of sample Truck size variation………………………………..116
Table 5.3: The regression relationship between volumetri capacity and Vehicle Fill Rate for 7.5 Ton vehicle………………………..……..118
Table 5.4: The regression relationship between Length, width, Height of truck and Vehicle Fill Rate of 7.5Ton Truck…………………………..………119
Table 5.5: The regression relationship between volumetric capacity and Vehicle Fill Rate for 9 Ton vehicle………………………...………120
Table 5.6: The regression relationship between Length, width, Height of truck and Vehicle Fill Rate of 9Ton Truck………………………………120
Table 5.7: The regression relationship between volumetric capacity and Vehicle Fill Rate for 16 Ton vehicle…………………………...……………121
Table 5.8: The regression relationship between Length, width, Height of truck and Vehicle Fill Rate of 16Ton Truck……………………..……122
Table 5.9: The regression relationship between volumetric capacity and Vehicle Fill Rate for 21 Ton vehicle……………………………….123
Table 5.10: The regression relationship between Length, width, Height of truck and Vehicle Fill Rate of 21Ton Truck………………..…………124
Table 5.11: The regression relationship between volumetric capacity and Vehicle Fill Rate for 25 Ton vehicle……………………...………..125
Table 5.12: The regression relationship between Length, width, Height of truck and Vehicle Fill Rate of 25Ton Truck……………….………….125
Table 5.13: Result of Durbin-Watson test for all the Truck Types…………...….127
Table 5.14: 21 MT Vehicle dimension at Plant B…………………………..……128
Table 5.15: Transportation Cost Comparison between Plant A

and Plant……………………………..……………………………………………130
Table 5.16: Comparison between Plant A and Plant B in
terms of case shipped, volume utilization and weight utilization…………………..130
Table 5.17: The regression relationship between weight
wise capacity and Vehicle Fill Rate…………………………………………………...136
Table 5.18: comparison of VFR for standard carrying capacity
vehicle with actual carrying capacity-based vehicle……………………..………136
Table 5.19: Vehicle dimension and weight carrying capacity details
along with Freight cost for ABC and XYZ company respectively……………..…138
Table 5.20: Vehicle carrying capacity, total despatch quantity,
along with vehicle utilization for ABC company……………………………..…138
Table 5.21: Vehicle carrying capacity, total despatch quantity
along with vehicle utilization for XYZ company…………………………….…..139
Table 5.22: Comparison of freight per ton, freight per case
between the vehicle used by ABC and XYZ company respectively………………..140
Table 5.23: Relation between VFR before loss and after loss
due to structural issue in a truck…………………………………………...……..145
Table 6.1: 32 strategies to overcome the constraints of vehicle fill
rate in Road freight transport along with source of the literature……………….…151
Table 6.2: Constraints, sub-categories of constraints, category of
solution and sub-categories of solution for vehicle fill rate in road
freight transport…………………………………………………..……………153
Table 6.3: Score of linguistics variable…………………………………………..156
Table 6.4: Score matrix for the solutions………………………………..…….157
Table 6.5: Fuzzy score matrix for the solutions……….……………………………157
Table 6.6: Normal Fuzzy matrix for the solutions…………………………...…..157
Table 6.7: Weighted Fuzzy matrix for the solutions…………………….…….158
Table 6.8: Weighted Fuzzy matrix with FPIS and FNIS for the
Solutions……………………………………….………………………………158
Table 6.9: Distance from FPIS for the solutions……………………...……….159
Table 6.10: Distance from FNIS for the solutions…………………………...…..159
Table 6.11: Ranking for solutions…………………………………….………….159
Table 6.12: Sensitivity Analysis……………………………………...…………..182
Table 7.1: Freight benefits comparison from Double Deck Vehicle………………194

Chapter 1

Introduction

Overview

Chapter One shares the general information about vehicle fill rate. Chapter one illuminates the relevant concepts which are essential for understanding of this thesis. This Chapter discuss about the road freight transport in Indian context along with First Moving Consumer Goods (FMCG) Sector and the relevance of vehicle fill rate in FMCG sector. The stake holders who are involved in filling the vehicle for FMCG sector was also discussed in this chapter. The development of vehicle fill rate in Indian context is also discussed along with the barriers. Multiple issues related to Indian road transportation is also discussed in this chapter.

1.1 Background of the Study

India is world’s fifth largest economy, among the fastest growing economy worldwide and Logistics Industry acting as an enabler to India’s economic growth. The movement of goods within the country and outside the country created the importance of transportation. India’s logistics cost is 14% of India’s Gross Domestic Product. In comparison to those other developed countries, having logistics cost 8% to 10%. To enhance the competitiveness at all the sectors efficient logistics system is needed, which will help to bring down the logistics cost along with supply chain efficiency. As per analysis of RMI Today, logistics sector of India is demonstrating for five per cent of India’s GDP. As per Aritua et al. (2018), India is handling 4.6 billion tonnes of goods every year which is costing INR 9.5 lakh Crore annually. Under these goods many domestic industries and products are there. Out of this various industry once of the important and focused industry in India is FMCG sector. Indian FMCG sector is growing at high speed, but profit margin is very thin, hence, to improve the margin one of the focus areas is Transportation. In India most of the goods movement is happening through road transportation. Followed by Rail movement, coastal and inland waterways movement, movement through pipelines and movement by airways.

In India since most of the goods movement within the country happening through road transport hence road transport chosen as our area of research. India's logistics related spend is mostly related to transportation and within transportation road transport having the major share hence freight spend in road transportation is highest. Logistics costs are high since the trucking industry is fragmented by nature, old trucks running on road and non-standardized assets like trucks. As a result, we are having inefficiency like overloading of trucks, underutilized trucks and higher empty running of trucks in absence of return load and gap in demand and supply across geography. All these inefficiencies are creating adverse effect like increase in logistics costs, increasing carbon emissions and increasing traffic on roads. Vehicle Fill Rate or VFR is comparatively new thing for India but gaining focus – importance rapidly. Efficiency of VFR is low in India due to presence of our internal constraints. Not only that due to these constraints stakeholders and players in FMCG sector are losing money and became non-competitive in global market. Compared to global context there is hardly any literature on Vehicle Fill Rate on Road freight transportation in Indian context. This study provides a perspective on the vehicle fill rate in Indian context, also manages and analyse the constraints of Vehicle Fill Rate on Indian Road Freight Transportation for FMCG sector. Through this study our primary aim is to find out and evaluate the constraints and comprehend the relation between vehicle fill rate and the constraints. It followed by the impact of the barrier and strategies to overcome the same.

1.2 Concept and Definitions

Prior to sharing the data for understanding and methods of analysis it is essential to know the related concept and definitions. In this segment we have demonstrate concepts like road freight transport, vehicle fill rate, FMCG sector, Players in road freight transport in context of Vehicle fill rate and Constraints for Vehicle Fill Rate in Road freight Transport.

1.2.1 Road Freight Transport of India

As per Meller et al. (2012), to have sustainable economic growth rates we need efficient freight transport as one of the enablers. The process of moving the goods to the consumer is depending upon transportation. Transportation is a part of Logistics, where movement and storage of goods both are taking place. Once it is produced at the manufacturing unit, it needs to be moved to consumer. Depending upon the distance and material type mode of transport or type of vehicle was chosen. Five modes of goods transport are available – Road, Rail, Air, Water, and pipeline. Compare to road transport rail transport is better for long haul as it is more cost efficient, having less emissions and will help to reduce the congestion on road. In most of the cases for rail, air and water transport supporting of road transport is required to reach the doorstep of the customer. Hence multimodal transport plays a vital role. As per report of Niti Aayog (2021), in India 71% of goods are transported by Road in 2020 and second-best mode - Rail is having share of only 17.5%. Heavily skewed modal share was observed in India.

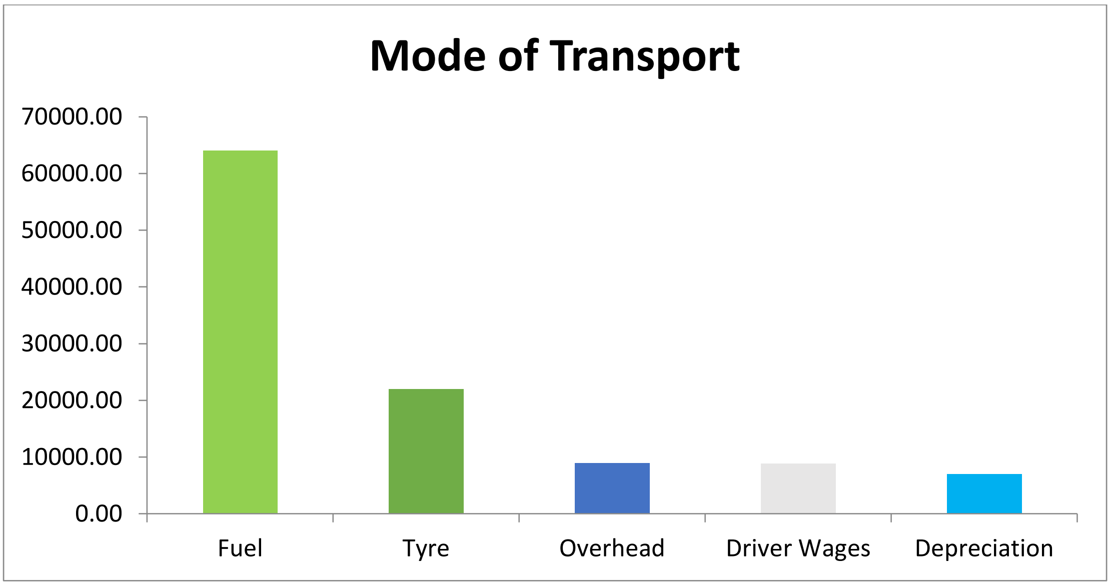


Figure 1.1 – Mode wise split of Indian freight in 2020

Source - Niti Aayog report (2021)

As per Aritua et al., (2018), from commercial activities in Indian economy yearly generates around 4.6 billion tonnes of freight shipments which will cost around INR 9.5lakhs Crore. Compared to rail and water, road transportation is costlier, energy consuming mode of transport. Hence CO_2 emissions are also high compared to other mode of transportation. In road transportation fuel cost is the major cost. As per Aritua et al., (2018) fuel contributed 51% of total road freight cost, followed by tyres and other cost. From figure No. 1.2 one can understand how much emissions are happening from this major transport mode. It is not only because of road condition and congestion; it is also because of usage of old vehicles. Aritua et al., (2018) shared the Freight cost component below -

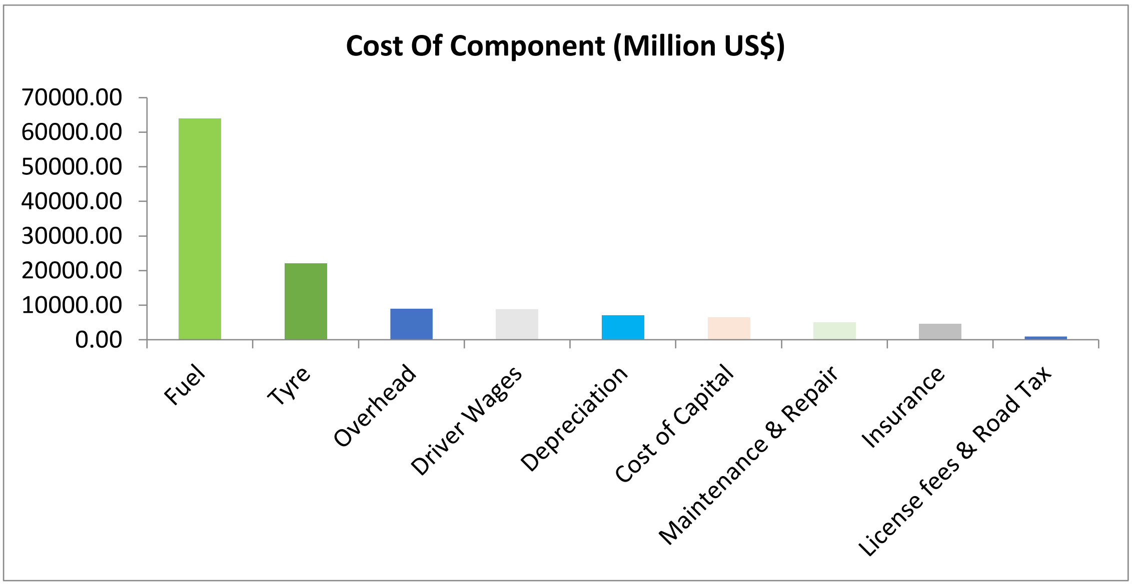


Figure 1.2 – Cost components related to Indian Road freight

Source: Aritua et al. (2018)

Dependency is very high on Road transportation for Indian context hence modal shift towards rail is very much necessary, but it will take time. High dependency through trucks movements leads to higher cost, higher carbon emissions, higher number of accidents on road and traffic congestion. Overloaded trucks are also one of the major reasons behind that. Not only accidents, overloading having economic effects also. As per Pais et al. (2013) overloaded trucks resulted more erosion of roads and for that the pavement costs increased by more than 100%. As per Krebs and Ehmke (2021); overloaded axles lead to increased erosion on the road surface, having impact on energy consumption and resulting more number of accidents. In India operational efficiency of road transportation is much lesser comparing to other developed nations. As per report of Niti Aayog (2021), apart from overloading of trucks 28 per cent to 43 per cent of trucks are running empty due to gap in demand and supply. Due to infrastructural issue in India trucks can run maximum 300km in a day compared to global standard of average of 500km to 800 km per day. Compared to Global standard India's annual truck utilization or vehicle fill rate is 40 per cent to 50 per cent lower, resulting higher transportation cost and higher carbon emissions.

1.2.2 Vehicle Fill Rate (VFR)

As per Birasnav (2013), to get sustainable competitive advantage organizations are striving to implement Supply Chain Management (SCM) Practices. One of those important practice is Vehicle Fill Rate (VFR). In general term Vehicle Fill Rate (VFR) means filling the vehicle with material or utilization of the vehicles like trucks/ container. Utilization is calculated based on the carrying capacity of the vehicle with respect to weight and volume. As per Parkhi and Kumar (2015), truck utilization is defined as the percentage of truck capacity that is filled with goods. Outside India it is often called as Container Loading Problem or box packing problem. India majority of the goods moving vehicle is open body truck, not container we have taken it as Vehicle Fill Rate (VFR) instead of Container Loading Problem (CLP). In operation research literature container loading problem (CLP) is an oft-repeated topic. As per Kanniga et al. (2014), Container Loading Problem is packing similar sizes boxes into containers to optimize the load. As per Ramos et al. (2014), it is a combinatorial optimization problem. For optimizing spatial arrangement of cargo inside containers is required, so that space usage is maximized. Similarly, 'Load Factor' term also often used for vehicle fill rate. As per Rogerson and Sallnas (2017), load factor is the ratio between maximum load given compared to maximum load carrying capacity of a load unit.   In general, two types of cargo available some of them covering the volume of the vehicle first but covering less weight and other category is covering the weight capacity of the vehicle first since they are heavy by nature. Similarly in a vehicle two types of carrying capacity are there – volumetric carrying capacity and weight carrying capacity of a vehicle or container. For calculating Vehicle Fill Rate, in general three types of utilization are taken into consideration – weight utilization, volume utilization and footprint utilization. Footprint utilization is measured with the help of pallets or slip-sheet. Since in Indian FMCG sector, the usage of pallets or slip-sheets are restricted, we have not considered it in our study. Container carrying capacity can be measured based on weight and volume. For weight utilization of container, maximum weight loaded is compared with permissible container weight carrying capacity. For volume utilization of container, maximum volumetric capacity loaded is compared with permissible container/ truck volumetric carrying capacity.

1.2.3 FMCG Sector

Fast Moving Consumer Goods (FMCG) sector is one of the important and crucial sectors which supports the economic growth of India. FMCG industry is India's fourth largest sector. This sector can be categorised into three divisions – Personal care and household, health care and packaged foods. As per report of FICCI (2020), personal care and household care contributed 50% of total industry, medical care contributed to 31% and 19% is contributed by food and beverage division. Based on the contribution to GDP, the importance of the sector is identified. Growth rate of FMCG sector is very much noticeable, even after pandemic scenario growth continues. By 2025 it was expected that FMCG sector in India will grow at a CAGR of 14.9% and it will reach US$ 220 billion. The growth of FMCG industry in India causes growth of volume. To cater that extra volume, greater logistics activity is needed. As FMCG sector is highly competitive with thin margin of profit, all organizations in this sector focus on logistics cost management and its efficiency for higher profitability. Growth trend of FMCG industry forced to bring more and more efficiency in logistics activities. It forced to reduce logistics cost by bringing efficiency. For the Indian FMCG sector the focus and significance of Vehicle Fill Rate (VFR) has grown in recent year. As per Singh and Achrya (2013), strength of the FMCG sector is dependent on the strong distribution network. As per Anupama et al. (2022), along with other factor robust logistics facilities gives FMCG sector superiority compared to other industry in India. As per Lin et al. (2014), in supply chain to handle the material, products are distributed through various handling units like packed in bags or jars. But in most cases a rectangular shaped, stackable box is used. Very often we called it as carton or case. Organizations must bring down the logistic costs though the volume is increasing for one unit delivery. This is applicable for the e-commerce business, and in fast-moving consumer goods (Meller, 2012).

FMCG organizations are having complex network and day by day the price of raw material and other costs are increasing. Though India is having cheaper labour compared to other developed countries but rest of the cost making them non-competitive in global market. Hence FMCG Organizations in India forced to rethink their logistics strategies to remain competitive and efficient. In transportation many inefficiencies already exist, mainly in primary movement – factories to warehouse or warehouse to warehouse. These inefficiencies should get identified, measured and analysed. One of the inefficiency and major challenge which was identified in FMCG organizations in India is filling the vehicle load optimally. Cost of distribution having two components, fixed and variable. Sub optimum vehicle load directly impact the variable distribution cost. All the FMCG organizations giving strong focus on vehicle fill rate to reduce the variable distribution cost. Due to pressure on cost, organizations are trying to review their existing business processes, services they are providing, operations and revising according to the need. In transport business to become competitive, optimum utilization of offered vehicle capacity is proved as a useful and economical way. (Christopher, 1999; Dorer and Calisti, 2005; Kashav et al., 2021).

At India FMCG sector average net weight based loadability varies between 88% to 93%. Still there is a gap/inefficiency of 7% to 12%. As per annual reports of FMCG organizations, many big Indian FMCG organization having annual primary freight spend of more than 100 Crore. If they can improve the Vehicle fill rate by 0.5% only, then the organization can save around INR 50 lakh. From this figure we can easily identify the potential of Vehicle Fill rate. Only 0.5% improvement in Vehicle File fill rate can make a huge difference in the bottom line and help the organization to become competitive. Apart from that VFR is having direct relation to logistics efficiency in terms of delivering the material in good condition, which indirectly enhance the customer satisfaction and reduce the loss due to damages.

1.2.4 Stake holders in Vehicle Fill Rate for FMCG sector

Products of FMCG is related to daily human consumption hence the margin of FMCG industry is very thin and highly competitive by nature. FMCG industry itself is very cost sensitive. To bring the raw material for production or to send the finish goods from factory to warehouse or to customer transportation plays a vital role in FMCG sector. FMCG sector transportation is largely depending upon road freight transportation since majority of the FMCG products are consumed locally then exported to other countries. Since the consumption of most of the FMCG products within market is very high hence the transportation acting a very important role in fast movement of the goods. In FMCG sector the key to success in marketplace is delivering the material in right quantity and right quality on time at a competitive freight cost. To ensure the delivery of right quantity, right condition (Quality of delivery, without damages), within the right time and at right freight, vehicle fill rate plays a significant role for FMCG sector through road freight transportation. One of the major factors for efficient road freight transportation for FMCG sector is vehicle fill rate. More you fill the vehicle (truck) the better you get the result, but it should be within the regulations of the country in terms of carrying capacity of the vehicle. Fill rate issue is not only impacting the FMCG sector it is also impacting the profitability of the partner or stakeholder involved in FMCG sector. The excellent vehicle fill rate in road freight transportation is determined by the impact of the constraints and level of integration between the participants. Hence before moving towards constraints of vehicle fill rate, there is a need of detecting and understanding the role of stake holders in vehicle fill rate in road freight transportation.

In vehicle fill rate mainly six important stake holders are there, who plays significant role - Sender or Shipper, Receiver or Customer (internal and external), Medium or Transporter, loader, Truck manufacturer and Government.

Sender or Shipper – who sends the material to customer. For them objective is to send maximum material with minimum number of trucks. It will not only reduce the logistics cost, but it will also help to minimize the product damages in transit, ensures good quality material reached at the market for sell. They should focus upon vehicle utilization in full based upon their priorities. But most of their loading and unloading related activities are outsourced to third party warehouse service provider, hence found a big gap in coordination activity since ownership is missing. Pressure on cost at FMCG sector bring the focus on vehicle fill rate at Indian FMCG sector irrespective of outsourcing.

Receiver or Customer – who receives the material. It may be end consumer or retailer/ distributor or warehouses. Warehouses are the internal customer for any organization since it is not sell of material. It is goods transfer within the organization. Demand should be generated in such a way so that vehicle is optimized. In some case from factory or warehouses goods despatched directly to the customer or consumer. Ordering pattern should be as per vehicle availability in that particular market so that vehicle usage will be maximum. Order management is important part in vehicle fill rate.

Medium or transporter – who transported the goods from factories or warehouses to customers. Transporter means owner of the vehicles or aggregator of the vehicle. In

India, more than 75 per cent of truck owners having ownership of less than 5 vehicles and only 10 per cent of the transporters having more than 20 Trucks. Transporters are very much fragmented by nature hence in current scenario aggregator playing a vital role. Aggregators having financial capability to invest compared to truck owners. Important point is transporters are not taking steps to improve the vehicle fill rate since they are getting freight for full vehicle or assured per ton freight. Once assured per ton freight is removed and only per ton freight is paid then only proactive cooperation of transporters are visible. In India most of the trucks are Medium Commercial Vehicle (MCV) or having less than Medium Commercial Vehicle (MCV) capacity. Usage of Heavy Commercial Vehicle (HCV) is less than Medium Commercial Vehicle (MCV). Transporters plays a vital role in Vehicle Fill Rate because they are the creator of the trucks. Truck manufacturers only selling the chassis and transporters are making the body of the trucks. In India majority of the FMCG organizations are using containerized trucks which are fully fabricated by the transporters.

Truck Manufacturers – who are manufacturing the trucks. They are also equally responsible for Vehicle Fill rate as they are defining the truck type. As per nature of the product they are creating the truck types, which may not be always suitable for FMCG industry. Truck Manufacturing organizations are not only making trucks for FMCG organizations hence variation in truck size and truck capacity is highly visible and it is playing a vital role in vehicle fill rate in FMCG sector.

Government – Government creating the rules and regulations pertaining to transportation sector. Vehicle carrying capacity and vehicle dimensions are decided by the Government. Nation wises it is varying even in case of India procedure of truck registration is varying by state. They are also playing a very crucial role by fixing the standard of our assets to have good vehicle fill rate.

All of these stake holders playing a vital role in Vehicle fill rate.

1.2.5 Barriers in Vehicle Fill Rate

We are in the age of technology and automation but to use that and get the full befits out of those technologies we need efforts. However, in Indian context bringing those technologies live is not that easy due to the barriers we are having in Indian road freight transportation and vehicle fill rate. Because of these barriers the efficiency, utilizations and productivity of the assets creating hindrance of competitiveness in global market. Because of the barriers cost are going up along with carbon emissions, congestions on road, road accidents and quality of delivery of the goods. In the whole process of vehicle fill rate many times these constraints will show up. In coming chapters, the presence of these constraints in Vehicle Fill Rate (VFR) for road freight transport is confirmed by reviewing exiting literature and response of experts.

1.3 Progress of Vehicle Fill Rate in Indian context

Logistics cost of India as a part of the GDP is 14 per cent, compared to those other developed countries ranging between 8 per cent to 10 per cent. Our logistics cost is higher compared to global standard and transportation plays a vital part in it. As per report of Niti Aayog (2021), in total logistics cost of India 62 per cent of spend is from Transportation only, followed by inventory cost of 34 per cent. As per report of Mckinsey and company (2010), If we compare the Road transportation cost of India with United States, we can find that the cost of road transport in India is 30 per cent higher. Puri and Ranjan (2012), identified logistics as a vital part of the business economic system. As per them 10 per cent to 15 per cent product cost are related to logistics only. As per Saripalle (2018), India is having one of the topmost transportations spend due to inefficiencies in road transportation. Road transportation in India is fragmented and unorganized by nature. Hence to improve efficiency of logistics of India we need to improve the efficiency of transportation. In India Since dependency on road transportation is much higher hence efficiency in Road transportation is very important.

In 2020, out of total CO_2 emission in transport sector more than 90 per cent was contributed by Road freight transport and it will continue to increase due to high dependency on road transportation. As per report of International Energy Agency (2019), In 2018 out of total global carbon emission the transport sector is contributing 25 per cent through fuel consumption. Transportation sector taking third position in generating of CO_2 in India. Out of that 90 per cent is contributed by road transportation. Freight transport will play a major role here. Truck carrying capacity and vehicle fill rate having direct relationship with carbon emissions. Mckinnon (2007) also discussed about carbon emissions and transportation in their study.

Road freight transport is the major reason behind road congestion and one of the cause of accidents. In 2018, as per report published on road accidents in India by the Ministry of Road Transport and Highways, third highest group of vehicles which are causes for road mishaps (12.3 per cent) and road-accident fatalities (15.8 per cent) are trucks. As per report of Ministry of Environment Forest and Climate Change (2018) 10 per cent of total accidents, 12 per cent of fatalities and 27 per cent of injuries are reported due to overloaded trucks. In 2019 it was observed overloaded vehicles caused 7.9 per cent of total accidents, 9.5 per cent of total fatality and 8.2 per cent of the injuries.

Vehicle Fill Rate (VFR) is in focus for last few years. Government of India also understood the need since it is having direct impact to Indian economy. They supported the need of the industry and bought revision of safe axle weights for transport vehicles on 7th August 2018. After 33 years Government of India made changes on gross vehicle weight (GVW) on vehicles with different axle combination. Due to this change in policy, it was expected that same vehicle will carry 25 per cent more load compared to earlier. On 26th June 2020 Government of India has published a notice of amending Rule -93 which is connected to dimensions of motorized vehicles. Through these amendments government tried for standardization in the vehicle dimensions, and it will follow the international standards and improve logistics efficiency of India by increasing the capacity of the vehicle. However, companies not fetching the full benefits due to non-standardized weight carrying capacity of trucks or containerized vehicle.

Since Indian economy is having upward trend, the demand for road transportation is also having upward trend and it will continue for years. Modal shift is necessary to bring efficiency in Logistics, but road transport will remain the focus area of Indian logistics. To have cost effective, environment friendly, efficient logistics system we need to focus on better utilization of trucks.

1.4 Issues in Road Transportation in India

Road transportation is having very high contribution to the national economy of India. As per Road Transport Yearbook, After America, India is having second largest road network in the world - 63.86 lakh Km. Indian trucking industry is fragmented by nature. Hence it is very much clear that most of trucks are lying with the small owners who are not having capacity to grow and control the trucking market.

Compared to other developed countries in India usage of smaller trucks or MDV is much higher. Hence the logistics costs are on higher side compared to other developed countries where usage of HCVs are more. Road Infrastructure is also not supporting the usage of bigger capacity trucks in India.

Transport Industries in India is struggling with the shortage of truck drivers. Truck drivers are the main strength of trucking industry. Without them Indian road transport industry will not exist. Moreover, literate truck driver per cent is even lower. Even country like United States of America also suffered due to shortage of truck drivers, when Donald Trump was president of USA. It was highlighted in the daily newspaper and President Trump praises the contribution of truck driver in public.

Compared to other developed countries the road infrastructure is not up to the mark. In other countries if trucks can ply 400 KM to 500 KM in a day. In India it is around 200 KM to 250 KM due to poor road condition. Earlier waiting time at toll plaza was very high but now a days issue was resolved after issuance of E-Waybill and introduction of E-Tag. Even the road infrastructure is also developing fast compared to earlier. It will help the truck drivers to reach the destination earlier and it will also help in truck rotation for the transporter. But still road infrastructure is not adequate.

Cost of fuel is having increasing trend, which is impacting the road transportation for India. Freight cost is going high, which is impacting the FMCG industry badly.

Raghumram (2015) shared a detailed review for Indian Trucking Industry. During that time he identified overloading as a major issue but high penalties helped to reduce the overloading problem in recent past. But still it is not adequate. He pointed Government policies as one of the concern area for trucking industry.

Safety and pollution is one of the concern areas for Road transportation of India. Road accidents are highest compared to other mode of transport and Road transportation is one of the major cause for air pollution.

In India, usage of old vehicles is very high hence the carrying capacity is not increased as per expectation after the amendment of the carrying capacity of GVW in

2018. Usage of technology is very minimum hence not getting efficiency in transportation section. To use technologies, India needs standardization of their assets.

1.5 Motivation/need for the research

In Indian context very limited number of literatures is available on Vehicle Fill Rate. Most of the literatures are related to optimization of vehicle fill rate by using the technology but pre requite to use the technology part is missing. Technology is definitely a key enabler for Vehicle Fill Rate (VFR) but other constraints are equally important to improve Vehicle Fill Rate. Hence to enrich the literature this research work is very much needed. Not only it will be applicable to all FMCG organizations in India, but it will also be applicable for other developing countries where such type constraints exist.

Very few studies covered vehicle fill rate from shippers' perspective. This study shared a new dimension on vehicle fill rate by exploring outward movement of material from shipper's side. Structural issue related to trucks along with coordination at the time of loading influencing the Vehicle Fill rate and it has a direct impact on transportation cost any quality of logistics services. We know that along with variation in truck carrying capacity fill rate varies but there is no certainty about the degree of changes due to this variation. This study helps to bridge the gap between theoretical and practical knowledge on vehicle fill rate in Indian context.

If all the stake holders of Road transportation can identify the constraints before loading activity, it will help to uplift the Vehicle Fill Rate. They can grasp the situation in a better manner and act to overcome the constraint as per their need of the business. It will help them to become competitive. The existence of various type of constraints in Vehicle Fill Rate leads to inefficiencies that hinder the progress of economy as well as cost.

The purpose of this study is to differentiate all the constraints pertaining to Vehicle Fill Rate (VFR), so that all the possible constraints is identified and assessed critically. Identification and assessing the constraints is not adequate it is also important to overcome the constraints with the probable strategies. It is also important to prioritize the constraints, strategies based on the degree of impact on Vehicle Fill Rate, so that strategies will be implemented one after another. This analysis will help all the stake holders related to transport operation to better manage the operational issues.

The identified categories and subcategories will help to set a model to find the severity of the constraints and it will help the government in modifying the policy so that in longer run India getting the benefits in the economic growth through reduction of logistics cost.

The model will also assist the government, other policymakers to assess the importance of constraints and the strategies, which will help to reduce the carbon emission, road congestion and number of road accidents.

Moreover, this model will help all the FMCG organizations assess the asset utilization and need of Vehicle Fill Rate for their business and overcome the constraints related to vehicle utilization and optimize their logistics cost to become competitive in global market. It will also ensure the quality of delivery to the shelf for the consumer.

1.6 Business Problem

Recognising the critical role of Transportation sector, Government of India pursuing many actions to improve the logistics performance. As per report of Niti Aayog 2021, by 2050 national freight activity will grow five times. To support the priorities of India, India's freight transport system will play a crucial role. Government of India want to build a cost effective, efficient, and optimized freight transportation system in India. To reduce logistics cost, carbon emissions and less traffic on the road they have identified few levers. One of the important levers is optimise truck usage. The new freight model will support to have higher economic growth, better public health, a greater number of employments, and enhancement of logistics productivity. It is in line with the many of India's development goals.

As per draft National Logistics policy (2020), Logistics costs in India is 14 per cent of the GDP, which is very high. Raghuram G (2015) identified these high costs are due to fragmented truck market of India, lack of standardised asset like trucks. It resulted low logistics efficiency in India. Due to these factors two of the impacted are low truck utilization and overloading of trucks. By optimising truck usage, logistics function can have less emission- and cost intensive.

Business Problem Statement – Logistics cost of India is around 14 per cent of the GDP, compared to other developed countries which is high, and it is creating barriers for the progress of Indian economy. FMCG sector in India plays a vital role for growth of Indian economy. In this sector margin is thin and in global market competition is very much intensive in nature. Indian FMCG sector till time not fully recognised the relevance and importance of Vehicle Fill Rate for the growth of their business. Till time measurement of VFR is not standardized across FMCG Industry.

1.7 Organisation of Thesis

This research work is organised in seven chapters. Sharing the details of each chapter in tabular form:

Chapter 1
Introduction
	• Overview
	• Background of this study
	• Concepts and definitions
	    • Road Freight Transport of India
	    • Vehicle Fill Rate
	    • FMCG Sector
	    • Stake holders in vehicle fill rate
	    • Barriers in vehicle fill rate
	• Development of vehicle fill rate in Indian context
	• Issues in Road Transportation in India
	• Motivation/ need for the research
	• Business Problem
	• Organization of Thesis
	• Summary of Chapters

Chapter 2 Review of Literature	• Overview • Literature Review • Literature review based on themes • Theme 1: Understanding of vehicle fill rate – Indian and Global Context • Theme 2: Constraints of Vehicle Fill

	Rate in Road Freight Transportation – Indian and Global Context • Theme 3: Strategies taken to overcome the constraints related to Vehicle Fill Rate – Indian and Global Context • Theories supporting Vehicle Fill Rate • Literature on Data Analysis Technique • Major inferences drawn from literature review • Major gaps drawn from literature review • Research Problem • Research Questions • Research Objectives • Chapter Summary

Chapter 3
Research Methodology
	• Overview
	• Research Design
	• Research Methodology
	• Data Collection Sources
	• Design of Questionnaire
	• Proposed research method and techniques
	    • Fuzzy AHP technique
	    • Fuzzy TOPSIS
	    • DEMATEL
	    • Sensitivity Analysis
	• Chapter Summary

Chapter 4 Identification and evaluation of constraints of Vehicle Fill Rate in Road Freight Transport of FMCG sector	• Overview • Introduction • Proposed Framework • Sampling • Sampling Adequacy Analysis

	• Examining Reliability of Instrument
	• Identification of constraints of vehicle fill rate in road freight transport for FMCG sector
	  • Structural Constraints of Trucks
	  • Vehicle Related Constraints
	  • Box Related Constraints
	  • Cargo Related Constraints
	  • Load Related Constraints
	  • Order Related Constraints
	  • Packaging Related Constraints
	  • Inter and Intra Coordination and Collaboration Related Constraints
	• Categories and sub- sub-categories of Constraints of Vehicle Fill rate in Road Freight Transport
	• Application of DEMATEL, AHP and Fuzzy AHP
	• Analysis of constraints by using DEMATEL
	• Analysis of constraints and fixing the rank of the constraints by using AHP and FAHP
	• Measure of consistency and ranking of constraints by using AHP
	• Ranking of constraints by using Fuzzy AHP
	• Comparison of ranking obtained by using AHP and Fuzzy AHP approaches
	• Ranking of Sub-categories of the

	constraints
	• Analysis of results and discussion
	  • Discussion of Results of DEMATEL approach
	  • Discussion of results received by using AHP and Fuzzy AHP
	• Sensitivity Analysis
	• Chapter Summary

Chapter 5
Influence of topmost constraint on vehicle fill rate: Hypotheses testing and Model Development
	• Overview
	• Introduction
	• Linear Regression Modelling and Hypothesis Testing
	• Data Collection
	• Variability in Truck Size
	  • Initial Data Analysis for Variability in Truck Size
	  • Hypotheses development related to truck size variation with vehicle fill rate
	  • Research construct validity
	  • Simulation building activity based on variability in truck size
	  • Practical Implication based on Simulation building activity based on Variability in Truck Size
	  • Theoretical Implication based on Simulation building activity based on Variability in Truck Size
	• Hypotheses development variability in

	truck carrying capacity • Simulation building activity based on Variability in Truck Carrying Capacity and Vehicle Fill Rate • Findings based on simulation, related to vehicle fill rate and freight cost • Findings based on simulation, related to vehicle fill rate and carbon emissions • Practical Implication based on Simulation building activity based on Variability in Truck Carrying Capacity • Theoretical Implication based on Simulation building activity based on Variability in Truck Carrying Capacity • Hypotheses development related to Usage of Angle, nut-bolt inside Truck with vehicle fill rate • Chapter Summary
Chapter 6 Assessment of Solution and Strategies to overcome the constraints of vehicle fill rate in road freight transport	• Overview • Introduction • Proposed Framework • Identified strategies and solutions to overcome the constraints in vehicle fill rate for FMCG sector • Prioritization of the strategies and solutions to overcome the constraints related to vehicle fill rate in road freight transport for FMCG sector

	• Fuzzy TOPSIS
	• Ranking of suggested solutions to overcome the constraints
	  • Implementation of IT based solutions
	  • Government Support through Law enforcement regarding harmonization of truck size and carrying capacity
	  • Choosing Right Truck Type
	  • Coordination and Consolidation Activity
	  • Physical loading Activity
	  • Product and packaging design
	  • Order Management pattern
	  • Warehousing Related Changes
	• Sensitivity Analysis of the prioritized solutions
	• Chapter Summary

Chapter 7
Conclusion,
Recommendation
and Future Research
	• Overview
	• Introduction
	• Contribution to the literature from this research
	  • Identification, evaluation of constraints related to vehicle fill rate in road freight transportation for FMCG sector
	  • Identification of the strategies to overcome the constraints related to vehicle fill rate in road freight transportation for

	FMCG sector • Theoretical Implication of this Research • Practical Implication of this Research • Recommendation and Conclusions • Identification and Analysis of constraints related to vehicle fill rate by using DEMATEL and Fuzzy AHP technique and building the relationship between the variables and vehicle fill rate through Linear Regression • An integrated framework to find, analyse the strategies/ Solution to overcome the constraints by using Fuzzy TOPSIS • Limitations • Scope of Future Research • Chapter Summary

Table 1.1: Organization of the Thesis

(**Source:** Author's composition)

1.8 Chapter Summary

The objective of chapter one is to portray a picture about Road freight industry of India which is acting as a support function to deliver the FMCG material across India. The role of vehicle fill rate in FMCG sector and motivation behind this research shared here.

Chapter 2

Review of Literature

Overview

The purpose of this chapter is to explore Vehicle Fill Rate (VFR) in depth and review relevant literature related to constraints of VFR in Road freight transport and also the strategies suggested by the literature to overcome the constraints globally and Indian context. To make the review process systematic we have divided the relevant literature based on three themes. Literature related to existing theories is also discussed in this chapter. From this existing literature we have derived the inferences and find out the research gaps which helped to move forward in the research work. In the existing literature various constraints were discussed along with the solutions which we tried to analyse for this research work.

2.1 Literature Review

Literature review is an important step for any study to explore what is available in the existing literature which will help to create a base for research. Based on the existing literature one can draw inferences to move forward on his study. Based on existing literature researcher must find out the gaps in existing literature and tried to fill the gaps. As per Watson and Webster (2020), to get conceptual and theoretical understanding exiting literature is reviewed in detail. All identified gaps are not possible to cover through one study due to various reasons; hence future scope of work is also identified for the researcher to move it forward in future.

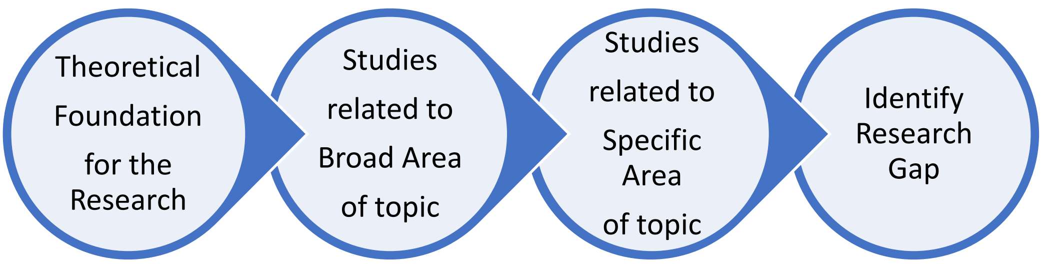


Figure 2.1Research Gap identification

Figure 2.1 explains that from ocean of existing Literature funnelling down to one specific is area based on theoretical framework is important. Hence, researcher will start with the broader part of the study, which is the theoretical foundation for the research. This foundation will help to find the broader area of study for the research. From this broad area, it will percolate down to specific area of study. Then from that specific area of study finding the research gap is the objective, which will help to progress in research work and help to add value to existing literature.

Container loading problem (CLP) is popular research areas in global context, which is in line with the basics of Vehicle Fill Rate. But in Indian road transportation till date most available vehicle is Open body truck (OBT), not container hence vehicle fill rate or load factor, or truck load building is more preferred term to Container loading problem. Though this topic is very much prevalent to the practitioners of the industry but there are very limited number of literature available in context of India for Vehicle fill rate since this area is new for Indian logistics sector compared to global context. Further when we are focusing upon the constraints of Vehicle fill rate there is hardly any literature available in Indian context. Hence it is important to review the articles which will help to understand the vehicle fill rate in Indian context and identify the relevant research gaps in this area of research.

In Vehicle Fill Rate (VFR) We have funnelling down our area of research to Road transportation only out of five modes of transport. It is evident that fill rate of vehicle for goods is very much different compared to passenger travelling by road. After gone through the literature it was understood the scope of work is wide hence the author restricted the scope to goods transportation only in road freight transportation only.

For literature review we have gone through the databases such as Science Direct, Springer, Elsevier, Sage, Taylor and Francis, Google Scholar, Ebsco, Emerald and Scopus. We have taken following key words to search the relevant literature – Container loading, Vehicle Fill Rate, Bin packing, Knapsack problem, 3D cutting and packing problem, load factor.

2.3 Literature review based on Themes

Very limited amount of research work available with respect to vehicle fill rate in FMCG organization in Indian context. Vehicle fill rate is not a very old area of research and though there are number of studies on it, most of the studies done in general context, not for any specific sector. Hence, it becomes very important to review the research papers which will support to have better understanding of this specific area and help to identify the research gaps related to this topic. To have holistic view both old as well as recent topics related to this area are reviewed. This review of literature considered both quantitative and qualitative aspects to have a good perception of the content which is relevant for this research area. Inferences and gaps are identified through extensive literature review, which inspire to conduct the research. Hence whatever literature is reviewed it broken into three specific themes based on the nature of the literature, keeping the business problem into consideration. Themes are created based on a logical flow of research work. It starts with basic understanding of vehicle fill rate considering both Indian and global context. Indian context is important since this study is based on Indian perspective. Once basics of vehicle fill rate is cleared and understood through literature review, the constraints of vehicle fill rate should get identified through the literature review. Constraints may not be same for Indian context compared to global context. Hence India is focus area along with rest of the world. Post constraints identification existing literature will help to identify the strategies applied to improve vehicle fill rate. Hence focusing on the business problem themes are identified for literature review.

Literature is reviewed based on three major themes along with the literature on Theories which are aligned with the study. Literature collected as per above mentioned described process and segregated as per following themes –

Theme 1 **-** Understanding of Vehicle Fill Rate – Indian and Global Context

Theme 2 – Understanding of Constraints of Vehicle Fill Rate in Road Freight Transportation – Indian and Global Context

Theme 3 – Understanding of Strategies taken to overcome the constraints related to Vehicle Fill Rate – Indian and Global Context

Apart from three identified themes, theories related to supply chain taken into consideration and extensive literature review also done to understand the existing theories with respect to our research area. Various data analytics techniques were reviewed from existing literature to find the best fit for analytics purposes.

2.3.1 Theme 1: Understanding of Vehicle Fill Rate – Indian and Global Context

As per Tsao and Lu (2012), in supply chain operation transportation of products plays a significant role. Like India many other countries having road transport as a dominant mode of transport. Study of Lindqvist, et al., (2020) is based on Sweden. There road transportation is most dominant mode of transport and having right type of truck is challenged to have good fill rate. They also shared how right truck type in form of High-Capacity Transport (HCT) will impact the transportation cost and CO2 emissions.

Mckinnon and Ge (2004), defined the fill rate from transportation perspective. It is the ratio of actual material loaded compared to the maximum load carrying capacity for that vehicle. As per Gürbüz (2009), to reduce transportation cost more packages should be transported in lesser number of vehicles and boxes should get packed in a optimum way.

As per Abate and Kveiborg (2013) based on the economic theory, vehicle capacity is underutilized hence constant challenge is coming up to match the capacity from freight movement.

Our study is closely associated to container loading problem (CLP). George and Robinson, in 1980 shared the container loading problem (CLP), since then it is one of the popular research areas in the operation research literature. Ngoi et al., (1994) suggested loader must follow either a bottom-to-top approach or a back-to-front approach while loading the container. In the classic Container Loading Problem, one need to load different size of packages in a rectangular shape container. In container loading problem we must optimize the utilization of the volume and weight of a container so that we can send maximum number of cargos in minimum number of containers. Most of the cases material packed and despatched in rectangular shape cargo (Bortfeldt and Wascher, 2012). Dychhoff, (1990), shared the similar view through his survey. Sharing some of the definition which are related to Vehicle Fill Rate.

Axle weight: Axle weight is related to the axle of any vehicle that transmitted the total weight through multiple wheels which are attached with the axle to the surface on which truck rests.

Gross Vehicle weight (GVW): The total weight of the vehicle and registering authority certified and registered that load.

Unladen Weight: The weight of a truck which included all the equipment which are generally used in the vehicle while working but it excludes the weight driver or attendant.

For a truck McKinnon (2010) suggests five measures of load factor. Those measures are based on weight, volume, tonne-km, coverage area of loading deck and empty running level of a vehicle.

As per Jugović (2020), container is identified as a transport unit and it is defined by the height, width and length of the container and load carrying capacity of the container as per permissible limit. As per him, usage of maximum available container capacity is a real challenge keeping the overall transportation cost as low as possible for per cargo is a main problem.

Alonso et.al. (2017), used integer linear model taking vehicle dimension and weight carrying capacity of the vehicle into consideration. Moreover, they have also taken maximum weight carrying capacity in each axle into consideration while doing the optimization. They have taken palletized load only during optimization. They have also used concept of centre of gravity and placement of pallet inside trucks. They have taken real instances into consideration while proving the optimization capabilities. In 2019, Alonso et. al., extended their working by adding dynamic stability as third constraint. Their first two constraint was geometric constraints and axle weight carrying capacity constraint along with centre of gravity. In this work they have focused more on palletized cargo stability while vehicle is on move along with heavy material despatch. 44 number of real instances taken to prove the model used for optimization. Sitompul and Horas (2021) focused on the dimensions of the goods as well as dimensions of the vehicle to have better vehicle fill rate. In their study they have considered all the three dimensions of loading constraint. Those are Length, width, and height (L, W, H) of the vehicle and the material loaded in the vehicle. Jugović (2020), also focused on height, width, length, and weight of the goods which are impacting the transportation cost. Apart from that fifth component which is impacting the transportation cost is manner of loading a container. As per Olsson at al. (2020), practical constraints helped to enrich container loading problem. As per them, cargo stability along with stacking and positioning of the material acted as a constraint in filling the vehicle. Nishiyama (2021) also discussed about cargo stack ability during loading and transportation.

Container Loading Problem (CLP) is a very old problem which is evident across the world. Many researchers worked upon the same. But in Indian context research work is very few since In Indian road transport dominant is open body truck not container. However, the base of both problems is the same. Container Loading Problem (CLP) will also give input to improve the vehicle fill rate in Indian context. Ramos et al., (2014) given a comprehensive definition of Container Loading Problem (CLP). As per them Container loading problem (CLP) is a combinatorial optimization problem. To optimize spatial arrangement of goods inside containers is required, so that space usage is maximized. There are many focus areas in terms of CLP. They have focused upon arrangement of cargo. Their paper tried to reduce the discrepancies between scientific outcomes and practical needs firstly by cleansing the perception about cargo stability and developing a new static stability assessment function within the Container Loading Problem and secondly, through determining sequence of the actual loading for a packing arrangement, taking into account static stability and loading operations efficiency constraints.

Ramos et al., 2014, give a comprehensive definition of Container Loading Problem (CLP). As per them, spatial arrangement of cargo inside the vehicle is required so that space usage is maximized. They have focused upon arrangement of cargo inside the container. Their paper aims to minimise the difference between scientific outcomes and practical needs, focusing upon cargo stability and developed assessment of static cargo stability. They also focused on sequence-based loading function. Santén (2014), to calculate volume-based load factor used load metres and height used to load the cargo in a vehicle as an input.

As per Landschützer, et al. (2015), in the field of logistics for FMCG goods, two different trends are observed for arranging the boxes inside the vehicle. Pragmatic way is one of them. Here arranging best-fit case from a given pool to the goods is one of the ways of loading. From the first observation it seems to be the best way to load the vehicle. It leads to Stability constraints of the cargo/ boxes. Stability of stacking not only optimizes the space inside the truck but also ensures the quality of the product by reducing the damages in transit. Hence stability constraint is another important issue in CLP.

Abate and Kveiborg (2013), shared their view of utilisation based on economic theories such as the objective of the firm is to maximise the profitability and considers how multiple firm and haul (market) influencing the vehicle utilisation. As per their studies, based on economic theory - vehicle capacity is always underutilised hence constant challenge to match the capacity with demand arising from freight movement imbalances between the regions and market access cost differential between operators. It becomes evident through the review of existing literature that due to incorrect arrangement of goods and sub-optimal utilisation of space, goods get damaged, and vehicle fill rate remains low.

From recent literature it was observed that information technology capabilities helped to match capacity with demand through enabling carriers to keep their trucks on the road and loaded a greater number of times by lowering down the market access costs. From this research it was evident that information technology will play a vital role in the Container Loading Problem (CLP). From this Literature review one key input we have received is that capacity utilisation may change depending on the specific setting in which vehicles are used. The degree of utilisation may vary for identical trucks also because of extraordinary heterogeneity of load in terms of weight and volume.

Bortfeldt and Wäscher (2012), - interpreted Container Loading Problem with geometric assignment problem: three-dimensional box or cargo to be packed and despatched in three-dimensional rectangular big object - Container. They focus not only container but also on trucks. Container is a covered box but In Indian context dominating vehicle for transportation is open body truck (OBT). OBT is non-covered trucks from the top. Here container refers to a loading space inside the truck. Container Loading Problem in general talks about arrangement of rectangular shaped boxes inside the containers to achieve the objective of maximizing the space utilization and minimising the total idle space within the containers, along with the constrains related to loading (Moura and Oliveira, 2005). Most literature consider rectangular shape box as a cargo in Container Loading Problem. Other than rectangular shape box there are a few more cargo such as, cylindrical drums, tins and sacks exist which are hardly used in the Indian FMCG sector. Eliminating the total idle space is equivalent to increasing space utilisation, and literature related to Container Loading Problem is generally discussed about these two points only. CLP is often discussed with 3-dimensional (3D) loading problem.

Gürbüz et al. (2009) present this as a 3D packing problem. They argue, that to despatch more packages in a lesser number of vehicle packages should be packed optimally. It will help in reduction of transportation costs. The problem of packing all packages in a container is called the 3D packing problem. The problem of setting the boxes which are different in sizes and in weight from each other or the same to each other into a big container optimally, is called a three-dimensional packing problem. The 3D packing problem is very complex. Along with the increase in number of boxes, the difficulty of the problem is also growing.

Rogerson and Sallnas (2017), focused on high load factor (an important aspect related to transport efficiency) which is possible to achieve through the coordination activities within shippers' organisations. Case study method was used for their study. Load factor defined as a ratio of load transported compared to the maximum load that could be loaded in each load unit. To have high load factor a multiple-case study was conducted to address how the activities will be coordinated within shippers' organisations.

Parkhi and Kumar (2015) focused on the secondary distribution network of retail supply chain. Their main objective is to optimize the logistics cost. Based on filling of goods in a truck, utilization of truck is defined which was represented by percentage. Truck capacity is defined based on the volume or tonnage with respect to type of goods transported. Transport planner's main objective is to utilize the truck capacity in full. They are focusing on load planning and network optimization.

Isdarayanto et al., (2019), focused on Truck Utilization for Retail Distribution. In retail business since the margin is very thin the first thing taken into consideration is transportation cost. Truck Utilization, Turnaround Time (TAT), Route Optimization, and Backhauling all this are acted as a Cost factor that affect the transport cost in retail distribution. Their research work focuses on transportation cost reduction through improve truck utilization. They showed 12 % of truck utilization improvement which can minimize transportation cost by 0.05%.

Theme 1 - Research gaps

The exiting literature shows there is no specific study on Vehicle Fill Rate in Indian context. Most of the study is on general context.
Due to absence of studies it proposes to improve the understanding on integrated perspective of various constraints existing in the Vehicle Fill Rate in Indian context. Vehicle fill rate is investigated from different perspective by different players. Shipper, Receiver, Transporter and Government having various view on vehicle fill rate. From Shippers perspective there is hardly any study found in literature. Most of the study is on general context.

Studies have considered either logistics cost in general or environmental impact in general. There are not many studies considering financial impact to business and environmental impact due to Vehicle Fill Rate. In Indian context it is even lesser.

2.3.2 Theme 2: Understanding of Constraints of Vehicle Fill Rate in Road Freight Transportation – Indian and Global Context

Bortfeldt and Wäscher (2012), described many types of constraints related to Container Loading Problem (CLP). Sharing few of them here, Constraints related to weight limits, weight distribution inside a vehicle, priority wise loading of a cargo, cargo orientation of the material inside the truck, cargo stacking permissible limit, full shipment, allocation related constraints, material positioning related constraints, cargo stability related constraints and complexity constraints.

One of the primary types of constraint in container's carrying capacity is with respect to volume. Many others identified dimension as a constraint for CLP (Che et al. 2011; Respen and Zufferey, 2017; Tian et al. 2016;). Dereli and Das, 2010; discussed about the container's load carrying capacity, which has a limitation of weight and volume, focused on maximum volume utilization along with maximum weight utilization, which leads to an optimization problem. Some other researchers have treated weight limit as a constraint (Liu and Chen, 1981; Liu et al. 2011; Terno et al. 2000; Gehring and Bortfeld, 1997; Egeblad et al., 2010; Chan et al. 2006).

During review of literature, it was found that most of the literature review was focusing on static stability not on dynamic one. (Bortfeldt and Wascher, 2013). But Ramos et al. (2017) tried addresses the static stability. They are focusing at the cargo stability during loading pf container.

Van Hoek et al. (2008), selected the case study method. They are supporting the case study methos as a suitable method for capturing the complexity involved in internal coordination. They have focused upon the coordination part to increase the load factor. They discussed about the coordination activities within shippers' organisations to have high load factor. They are focusing on the need for coordination. They have also explained the same by sequential and reciprocal interdependencies between activities when delivering customer orders and when ordering from suppliers. As a part of coordination mechanisms, they have also shared the nature of coordination.

Load stability ensured through proper stacking. During stacking gaps will be there between the stacks and that should be filled up by using filler items. Using body of the truck to ensure the load stability is also important. Bischoff, 1991; Eley, 2002; Pisinger, 2002; Moura and Oliveira, 2005; de Castro et al., 2003; Parreño et al. 2008; Egeblad et al. 2010; Junqueira et al. 2012 - also shared similar view of stacking constraint for optimization in container loading problem (CLP). As per Abdou and Elmasry (1999), for vertical stability related issues that the cargo should be supported either total or partially by the body of the vehicle or through extra support from the top. As per literature full support at base guarantees the stability of the stack which are static by nature, but partial support on the base not guaranteed static Stability. As per Carpenter and Dowsland (1985), contact area to fall between the range of 95–75%. But for Christensen and Rousoe (2009), require a minimum of 80%. As per Gendreau et al. (2006) and Fuellerer et al. (2010) it is 75%. Gehring and Bortfeldt (1997), estimated 70%, Mack et al. (2004) 55%. Since cargo is moving along with the container vertical stability and horizontal stability both are important.

As per Santén and Rogerson (2014) six groups of factors are there that are influencing the load factor. Those are warehousing, order and delivery, packaging and loading, transport operations, information sharing and information technology (IT), and regulations.

Gajda et al. (2022) suggested some practical constraints for Container Loading Problem like ensuring safety while handling cargo, priority wise despatch to customer, load balancing, load stability, stacking height constraints, multi shipment deliveries and cargo movement inside the vehicle, material positioning related constraints.

As per Schöneberg et al. (2011) decisions on the frequency of deliveries influenced load factor. But as per Treitl et al. (2014), routing related decision, collaboration between routing and frequency of delivery, were helped to increase the load factor.

Klundert and Otten (2010), focused on Improvement of LTL Truck load utilization. They explore different real-life problem settings by capturing various models. It demonstrates by using online freight exchanges model how truck utilization rates are increasing which may contribute to improve the situation.

As per Liljestrand et al. (2015) load factor in transportation having direct impact on environment. Aronsson (2006) supported the view of increase in vehicle fill rate help to reduce the environmental stress.

Filella et. al., (2022), discussed about multi-drop container loading problem (MDCLP) which is related to delivery of material at multiple drop points without re arranging the material inside the truck. It is related to unloading constraints which is a hard constraint.

Reil (2018) identified few constraints like vehicle routing problem (VRP), empty running of trucks, loading constraints. In 2018, Ramos et al. identified balancing of load in a truck as constraint. Static stability and load balance is a practical problem for volume utilization of container loading. Krebs et al. (2023), identified loading constrains and vehicle routing in their study. Mejía et al. (2019), also conducted similar study on vehicle routing and vehicle loading operation constraints. As per Ahmad et al., (2022) inefficient packaging design of the material leads to lower fill rate. Packaging having direct relation with freight transport. Safak and Erdo˘gan (2023) discussed about the constraints like weight limit, loading priorities, stability of the stacks, orientation. Saraiva et al. (2019) focused on orientation constraints and stability constraints while discussing single container loading with heterogenous boxes. Oliveira (2020) identified horizontal cargo stability as a constraints in container loading problem. Kurpel et al. (2019), addressed multiple container loading problem, along with that they have also worked upon the box orientation related constraint, separation of boxes and stability of the load.

Zhao et al. (2016), identified practical constraints like box orientation, stacking of the material, stability of the load, distribution of weight, weight carrying capacity, multidrop deliveries, delivery prioritization and strength of packing boxes.

Eidhammer and Anderson (2014), focused on development of a framework which brings cost benefit analyses from social aspect on standardized trucks. They have also expressed issue related to loading docks and findings based on numbers on lorry dimensions and loading dock. Their study was based on several Norwegian cities. They also believe that this same framework will be applicable for many other cities. As per their report there is an inclination towards delivery in small loads. Concept like "just-in-time" deliveries increased number of deliveries and demands from the transporter for using bigger trucks for deliveries. Based on Efficient Consumer Response (2000), in many European cities there is restrictions on the usage of big trucks. This framework of harmonization of trucks of does align well with the requirement in the Indian context.

Theme 2 - Research gaps

From literature review it was observed that good numbers of research work performed on the Vehicle Fill Rate (VFR) in road freight transportation but there is hardly any evidence of a study directed to differentiate constraints for Vehicle Fill Rate (VFR) in road freight transportation of India.
No study found which evaluated the constraints of Vehicle Fill Rate (VFR) in road freight transportation of India.
Hardly there is any analytical studies on the integrated perspective of various stages of Vehicle Fill Rate (VFR) in road freight transportation in India.

2.3.3 Theme 3 - Understanding of Strategies taken to overcome the constraints related to Vehicle Fill Rate – Indian and Global Context

Fugate et al., (2009), suggested carriers should invest in more standardized vehicle sizes compared to non-standardized vehicles which will eventually cost more. Very limited loading/ unloading executors having the know-how of full utilization of vehicle. Islam et al. (2019), suggested truck sharing to minimize the empty run.

Hameed and Prathap, 2018, shared their view on truck load distribution which helped in longer life for the pavement. As per them general concept is loaded trucks should have equal distribution of load between the axle and it was supported by technical specifications of truck manufacturing company and highway agencies. They have also shared some examples, the loading pattern for double-axle truck will be 1:2 between front and rear axles. It is prescribed to be safe loading pattern. To have mutual benefit of shipper and truck operators, Truckers should follow this loading pattern.

Santén and Rogerson (2014), also described some influencers of load factors like orders of customer, delivery of material, packaging of the material, loading of the material, transport related operations, passing information related to loading, usage of information technology along with rule and regulations.

As per Schöneberg et al. (2011), how many times the material delivery will be scheduled will influenced load factor. For Treitl et al. (2014), routing of delivery and along with that delivery frequency were able to increase load factor.

As per Hajlaoui et al. (2022) for Single Container Loading Problem, deep Reinforcement Learning model is suitable.

Krebs and Ehmke (2021), focused on axle weight constraint, container loading problem with vehicle routing. After placement of each item, they have evaluated the axle weight constraint. They have used algorithm like 'Deepest-Bottom-Left fill' to solve the container loading problem. Karabulut and Inceoglu (2004), proposed the same 'Deepest-Bottom-Left fill' algorithm and they have also used hybrid genetic algorithm for regular 3D strip packing.

Treitl et al. (2014), suggested routing of material delivery and delivery frequency which will help to influence the load factor.

For model, heuristics wall building, or layer building is two most preferred approach. George and Robinson (1980), Moura and Oliveira (2005), Bischoff and Marriott (1990) proposed 'Wall building approach'. In wall building, while loading putting the boxes inside the container one by one like creating a wall, taking support of container body. Layer building approach is used by Bortfeldt and Gehring (1997), Portmann (1990), Bischoff et al. (1995). In layer building approach while loading creating the layer one by one by putting the boxes on the container bed so that container is used optimally. Lim et. Al. (2013) proposes an integrated heuristics solution approach with linear integer programming models along with GRASP wall building algorithm to solve container utilization along with constraints in axle weights. Velez-Gallego et al. (2020), used greedy heuristics to have advantages of better quantification for adopting the mixed integer linear formulation to maximizing the weighted sum of the product delivered and minimizing the number of trucks. Amico et al. (2020), used three number of heuristic algorithms for optimizing the load – 'Greedy', 'H-Rolling' and 'H-Diving'. Araújo et al. (2018), deployed two renowned packing heuristics. 'Deepest Bottom Left' with Fill combined with 'First Fit Decreasing' heuristics to solve the constraints related to box packing.

Landschu¨ tzer et al. (2014), while discussing CLP focus on Physical Internet (PI) for fast-moving consumer goods industry. Both simulation-based and a field-based proof of concept used. Gradually tested and implemented the key functions of interconnected logistics. Then involving all key stakeholder groups through all development and implementation phases.

Many researchers suggested algorithms to solve the problem. Optimization algorithms are required to design to utilize the maximum occupancy of the container. To find the optimal solution, Genetic algorithm is also the best way. But few drawbacks are there. It is not applicable to the close container format. Ant colony algorithm mimic the behaviour of "simulated ants". They are walking around the search space representing the problem to be solved. ‘Branch and Bound’ algorithm is used by Martello et al. (2020) for optimizing the load. Hifi (2004), used dynamic programming algorithm to overcome the orientation constraint. Fekete (2007), used two-level tree search algorithm to optimize the load. Some approximation algorithm was used which gives near to optimum solution. Bansal et al. (2006), Li and Cheng, (1990, 1992), Jansen and Solis-Oba (2006); Miyazawa and Wakabayashi (1997, 1999, 2007, 2009) used these types of approximation algorithm to optimize the load.

EI- Ashmawi and Elminaam (2019) used ‘squirrel search algorithm (SSA)’ heuristic method for optimization of load. Feng et al. (2020), used ‘Grasshopper Optimization Algorithm’ (GOA) enhanced version for bin packing problem. To solve bin packing problem Wei et al. (2019), proposed a new ‘Branch-and-Price-and-Cut’ algorithm.

Patil and Patil (2016), is focusing upon optimization algorithms for container loading problem. Algorithm like Largest Area First Fit (LAFF) and LAFF along with Weight taken into consideration by them. The LAFF algorithm is designed based on container dimension - length, height, and breadth. The LAFF algorithm considers the unlimited height of the container i.e., the container is open. Also there is no consideration of weight of the boxes in LAFF.

For the load optimization Kanniga et al. (2014), used the permutation block algorithm applied with wall layer approach. But they have considered only the equal sized boxes. Layeb et al. (2017), used multiple realistic limitation of the algorithm used for container load optimization like weight distribution, positioning of the material. They have focused on the loading of square boxes only. Pino et al. (2013), used genetic algorithm for container loading problem. They have suggested to use largest and heaviest material while stowing and used smaller packages to fill up the gap and balancing the material. Kucukyilamz and Kiziloz (2018), suggested using Grouping Genetic Algorithm (GGA) for optimization. For optimization of bin packing, they have used Island-parallel GGA (IPGGA).

Gehring and Bortfeldt (1997), used the genetic algorithm and suggested to load same type of boxes in a container. To run the algorithm stability, balance constraints taken into consideration. Orientation, Top Placement and Weight constraints are factored in for heterogeneous sets of cargo. For the 3D packing problem Gürbüz et al. (2009), proposed a heuristic algorithm. In this proposed algorithm heuristics strategy was used. According to that, boxes with largest surface area placed first to minimize height from the bottom of the container. Assumption for this algorithms are - the height of the container is unlimited and no restriction is there on the orientation of boxes. In the best way the algorithm helps to place boxes. The wasted space will increase If the types of boxes increase. Placing the different sizes of boxes are more difficult to the container than that of the same sized boxes.

Kanniga et al. (2014), also supported the algorithm to optimize CLP. They are using the Permutation Block Algorithm. But they have focused upon similar sizes of boxes only. To them, Container Loading Problem consists of similar sizes of packing boxes into available space of container in such a way to optimize an objective function. For the Load Optimization of equal dimension boxes, they have applied ‘Permutation Block Algorithm’ in the wall layer approach. A number of technologies, logistics plans and automated systems are used as a part of new special logistic process. to handle a great number of containers efficient containerization system was used. For logistics automation to fulfil specific requirements computation appears as an important tool.

Jose et al. (2013), is focused upon Dynamic Programming and Comparative Software Study for Cargo loading. They have pointed out factors like cargo size, cargo weight, container space and sequence of loading and unloading activity while creating the loading plan of cargo.

Theme 3 - Research gaps

In existing literature solutions was provided to vehicle fill rate in general, to overcome constraints. But no study was found to understand and analyse solutions or strategies to overcome constraints for Vehicle Fill Rate in road freight transportation in Indian context.

In Indian context there is no study exists that offers an integrated framework to conquer the constraints of vehicle fill rate in road freight transportation. When discussion comes to Indian context, vehicle fill rate found as an unexplored domain and hence there is no study available that determines and assesses strategies using an integrated framework.

Plase find the summary of theme wise literature, inferences and Gap derived from the literature in tabular format –

Themes	**Major Inferences**	**Major Gap**
Understanding of Vehicle Fill Rate and it's impact – Indian and Global Context	Calculation mechanism of Vehicle Fill Rate or load factor for Road freight Transport. Specific constrains impacting the logistics cost, carbon emission, loading unloading activity. Some industry specific insight of Vehicle Fill Rate.	Limited studies at industry level on Vehicle Fill Rate in Road Freight Transportation. All the Vehicle Fill Rate calculation mechanism is not applicable in Indian context. No study was conducted in this context to check the effect of constraints on the stakeholders related vehicle fill rate in Road freight transportation.

Themes	**Major Inferences**	**Major Gap**
Understanding of Constraints of Vehicle Fill Rate in Road Freight Transportation – Indian and	Vehicle Fill Rate related models and techniques are tested based on data with different methods. Their results are obtained with various	Limited studies found to build a framework which will assess all the constraints available in the Vehicle Fill Rate and its effect on the stakeholders. In Indian context no studies was found which is building a framework to assess

Global Context	levels of accuracy of prediction. Identification of some of the constraints which are impacting the Vehicle Fill Rate and their impact on logistics cost or in carbon emissions. Models and techniques used to identify the constraints are analysed.	the constraints in Vehicle Fill Rate for Road freight transport and their effect on the stakeholders.
Understanding of Strategies to overcome the constraints related to Vehicle Fill Rate – Indian and Global Context	Various technique or methods used to overcome specific constraints related to Vehicle Fill Rate in road freight transport. Focused on system-based techniques to optimize the vehicle fill rate.	Limited number of studies to build a framework to assess constraints and their strategies to overcome the constraints, present in the Vehicle Fill Rate and their effect on the stakeholders. In Indian context no studies was available to build a framework for assessing the Constraints their strategies to overcome the constraints, in the Vehicle Fill Rate for Road Freight Transportation and their effect on the stakeholders.

Table 2.1 – Table on Theme wise literature review summary

Source – Composition of Author

2.4 Theories supporting Vehicle Fill Rate

To construct the theoretical premises for this study, different theories were studied. These theories helped to build the theoretical foundations for different area related to supply chain. Those theories include – Agency Theory, Knowledge Based View theory, Resource Based View theory, Resource Dependency theory, Stakeholder Theory, Institutional theory, Theory of constraints, Network Theory, Transaction Cost Analysis, Relational Exchange theory, Strategic Choice Theory and Systems Theory.

Extensive literature review was conducted for the above-mentioned theories which are related to supply chain and tried to seek the applicability of these theories for this study. Details of theories are shared in tabular format along with applicability regards to this research work

Theory Name	Justification for application of these theories	Suitability for this study
Agency Theory	Agency theory is a part of economics, which looks at conflicts of interest between people with separate interests for the same assets. Primarily it discussed about the conflicts between managers and shareholders of companies. In Supply chain it is mostly used for outsourcing, sourcing, and collaboration work in supply chain Focusing on behaviour of individual or groups.	No
Resource Based View theory	As per resource-based view a firm's continued with competitive advantage is because of its rare, valuable, incomparable, and non-substitutable resources (Barney, 1996). The competence of firms to create or obtain these resources impacts their performance and competitiveness compared to their competitors. Focusing on value creation from tangible resources	Yes
Knowledge Based View theory	Knowledge-based view theory of the firm is a management concept of organizational learning that provides organizations strategies or solutions to achieve competitive advantage. For the organisation, knowledge recognised as the most strategically significant resource. Compared to other tangible resource, it emphasises on knowledge resources. Focusing on value creation from collaboration activities like intangible resources like knowledge	Yes

Resource Dependency theory	Resource dependence theory is all about how the external resources of organizations impacting the behaviour of the organization. For any company procuring external resources is an important principle from the point of view of both the tactical and strategic management.	No
Stakeholder Theory	The stakeholder theory is a part of organizational management and business ethics that accounts for several communities affected by business entities like employees, suppliers, local communities, creditors, and others	No
Institutional theory	Institutional theory is a theory in organizational studies, which talks about the deeper and more robust aspects of social structure. For social behaviour it considers the processes by which structures, including schemes, rules, norms, and routines, become established as authoritative guidelines. External pressure plays a significant role to make organizational strategy related to Supply chain. Focusing on collaborative opportunities and best practices.	No
Transaction Cost Analysis (TCA)	TCA is an economic theory that gives an analytical framework within a supply chain to examine the governance structure of contractual relations. As per Williamson (1979, 1986), Transaction cost theory suggests that by minimizing the costs of exchange one can achieves economic efficiency through optimum organizational structure. As per this theory each type of transaction generates coordination costs of monitoring, controlling, and managing the transactions.	No
Theory of constraints (TOC)	TOC is a part of management model that assess any manageable system as being limited in achieving more of its goals by a very small number of constraints. TOC is a methodology to recognise the most vital restraining factor (i.e., constraint) that stands in the way of accomplishing a goal and then systematically refining that constraint until it is no longer the restraining factor.	Yes

Network Theory	The network theory is mainly applicable for purchasing and supply management, mostly focusing on inter-organizational relations. Network theory is mainly considered to describe the relation in which companies, customers, suppliers, or buyer are involved.	No
Relational Exchange theory	Relational Exchange Theory is based on the concept that parties to an exchange are in common contract that the consequential results of the exchange are greater than those that could be achieved through other forms of exchange	No
Strategic Choice Theory	Strategic Choice Theory focused to solve political forces and strategic problems related to supply chains as a whole compared to functional approach regarding individual supply chain companies. Mainly focusing on external issues like Government related activities and political activities and their impact	No
Systems theory	This theory focused on streamlining the complex organizational structures and to classify the stakeholders in the organization. Main attention is on role of processes and efficiency.	No

Table 2.2 –Suitability check of theories for the study

Source: Author's Composition

Theory of Constraints (ToC)

A 'constraint' is defined by Theory of Constraints. Constraint is something that stops the system or process to accomplish the goal. Recognising and analysing of the constraints and their criticality are supported and allied with the Theory of Constraints (ToC) which proposes that if we diminish the effect of constraints available in a process or system then this may help to elevate the performance of the whole process. In Theory of Constraints, it was assumed that every system or process there must be at least one constraint. If it is false, then in an actual system profitmaking organisation would get limitless profit. As per Goldratt (1988), A constraint - "is anything that limits a system from achieving higher performance versus its goal". Theory of Constraints helps to identify the most vital restraining factor i.e., constraint, that stands in the way of accomplishing an objective and then systematically refining that constraint until it is no longer act as a restraining factor. The Theory of Constraints follows scientific method for improvement. It assumes that in all complex system multiple connected actions are there, one of them acts as a constraint in the whole process. Constraint activity is the "weakest link in the chain".

Rahman (1998) shared his view ToC. The presence of constraints signifies chances for improvement. ToC considered constraints as positive, not negative since constraints regulate the act of a system, a gradual upliftment of the system's constraints will help to progress its performance. Şimşit et al. (2014), shared their view on literature of ToC progression by its five era - the optimized product technology era, the goal era, the haystack syndrome era, it's not luck era and the critical chain era. As per Gupta et al, (2008), ToC is a theory of Operations Management. In their paper they explore the connection between ToC and the core concepts of operations management (OM). They also show how operations management concepts can be combined with ToC by picking examples from the available literature on ToC. The objective of their study is to show that as a theory ToC, having all the critical properties which is important to be good theory.

Simatupang et al., (2004), tried to show how the Theory of Constraints can be utilised to depict an intrinsic collaboration related dilemma and create collective replenishment policy and collective performance metrics so that members in a chain can work together to improve supply chain profitability.

One of the most important features of the Theory of Constraints (TOC) is that it intrinsically giving priorities to improve actions. It always gives top priority to present constraint. When there is an urgent improvement needed, TOC gives a highly focused procedure to have a rapid improvement. The fundamental thought of the Theory of Constraints is each process has a single constraint, and that total process output can only be progressed when the constraint is eliminated. A very significant corollary to this is that devoting time improving non-constraints will not give substantial paybacks.

In this research we are using the core concept of Theory of Constraints. We are focusing one single constraint and the standardized throughput of Vehicle Fill rate will only improve when the constraints improve. The fundamental power of TOC flows from its ability to generate an extremely robust focus for a single goal (i.e. Cost reduction) and to eliminating the principal obstacle (the constraint) to achieve more of that goal. As per Goldratt ‘focus’ is the main spirit of TOC.

In this part research techniques and the methodology are discussed which were deployed for this study, to accomplish the goal of the research. The research methodology entails the way by which the study is taken forward. From the research methodology standpoint, it seems that most of the contributions are conceptual and theoretical by nature, which helps the discoveries of vehicle fill rate. It is a comparatively new field of research in Indian FMCG context. Hence, validating the theoretical contributions empirically is essential. The main objective of the study is how to influence fill rate and how vehicle fill rate influence other logistics performance indicator. Hence it leads to exploration of fill rate measurement from various angel and exploration of relationship between truck size, carrying capacity with vehicle fill rate and exploration of impact of change in process to have high load factor influencing the cost factor, factor related to carbon emission.

Resource - based View Theory

Resource utilization is an important factor for any organization. Organizations utilize resources as inputs which are finally came out as an output for certain services. The link between Vehicle Fill Rate and RBV suggests that by prioritizing VFR organizations will develop the knowledge and skills that can help to progress the performance of the organization.

Resource-based view (RBV) explains how intangible and tangible resources helped organizations to accomplish a sustainable competitive edge over their competitor (Penrose, 1959; Kumar 2015, 2020; Prahalad and Hamel, 1990; Priem and Swink, 2012; Grant, 1991;). In this particular study trucks are treated as tangible resource and knowledge of load building for truck and loading the vehicle is intangible resource. Those organization who are having standard vehicle with standard carrying capacity will get more return from this tangible resource compared to those who are using non-standardized truck. Load forming and execution of loading activity will be easier if trucks are having same carrying capacity. Regular practice or activity with standard carrying capacity will help to reap the benefit from this intangible resource and helped to get competitive advantage over the companies who are using non standardized vehicle. Those who are using vehicles with various carrying capacity either landed with underload since at last phase of loading load increase is not possible or they have to drop the load if vehicle is having lesser carrying capacity compared to standard carrying capacity of a truck. In India majority of the vehicle is non-standardized by nature hence compared to other developed country India is unable use their tangible resource properly to get the competitive advantages. Hence to get competitive they have modified the rules of carrying capacity in 2018 after 33 years and targeted the segment of increasing the load in each truck which is captured in Niti Aayog report published in June 2021.

Knowledge is a critical resource, which one can earn through regular exercise. Skills of loading the material can be treated as implicit resources; this type of resources are not noticeable but can get through continuous practice and learning (Kumar et al. 2010; Hart, 1995). In this current digital world, knowledge of vehicle loading has proven to be a implicit resource, as effective application of loading depending upon the skills of the loader and people engaged with execution. In this study, the authors claim that external factors, force organizations to organise key tangible resources and skills of the loading executors to develop vehicle filling competences and gain a competitive edge (optimizing transportation cost, lowering the damages occurred in transit, reducing carbon emission). It would be interesting to investigate the impact of institutional pressure on tangible resources and skills of the workforce in the adoption of targeted vehicle Fill Rate.

In Supply Chain Management applications of Resource Based View (RBV) focused on structural analysis (Miller and Ross, 2003; de Oliveira and Fensterseifer, 2003) and acknowledgement of the background for competitive edge in the supply chain (Pandza et al.,2003; Barratt and Oke, 2007; Pearson et al., 2010, Lewis, 2000;). In this research also we are focusing on one of the applications of RBV - structural analysis of Vehicle which will bring competitive advantages through Vehicle Fill Rate in Supply Chain. As per above mentioned discussion, the purpose of this study is to check how vehicle size pressurise to shape tangible resource and loading skills to improve of Vehicle Fill Rate (VFR) and impact logistics cost. We focused on practical vehicle loading scenario with constraint such as vehicle dimensions. This study will also evaluate the practical applicability of the research. As a resource, Knowledge – including logistics expertise can help to create competitive advantage

(Olavarrieta and Ellinger, 1997). Knowledge of loading is an intangible resource for any firm. Knowledge of loading is gained through regular practice only. This knowledge of loading gained through regular practice will exist till the time variance in vehicle size exist. Hence this intangible asset knowledge is interdependent on vehicle size. Fugate et al., (2009), suggested carriers should invest in more standardized vehicle sizes compared to non-standardized vehicles which will eventually cost more. Very limited loading/ unloading executors having the know-how of full utilization of vehicle. Resource based view (RBV) theory conveys the connection between the resources, capabilities, and competitive edge (Barney, 1996, 2001). The Resource based view also helped to get the understanding of operational issues faced by the shippers and transporters. In collaborative process Resource Base View can be stretched to find how both the parties together deploy internal resources in the executional level, with the goal of generating competitive edge for both parties. (Fugate et al., 2009).

Knowledge-based View

This research work can also contribute to Knowledge Based view. From various scopes several authors contributed for the development of Knowledge Based View. These scopes are organizational learning, evolutionary economics, organizational capabilities, innovation, and competencies. To attain the organizational goals, the knowledge-based view encourages the sharing of knowledge. This view gives the indication of creation of value by sharing the knowledge internally and externally organizational supply chain collaboration from the supply chain management perspective. In organizations' outcomes, it also demonstrates the utilization of this view to describe the result of knowledge sharing across supply chain. Gaining the competitive advantage is possible through Knowledge. Creating the value in supply chain is possible by exchanging the knowledge. As per Curado (2006), Knowledge-based view by producing, transferring, and altering the knowledge organizations are getting competitive advantages, which is one of the strategies to get competitive advantages. Gaining knowledge is very important for any organizational learning. In this competitive world to become effective knowledge plays a vital role. As per Nonaka (2007), only knowledge brings the true lasting competitive advantages. In their study Craighead et al. (2009), explains that supply chain was driven by knowledge, innovation-cost strategy, and performance at the organization level. Hult et al. (2004), also shared the similar view. As per them along with knowledge-based view, information sharing will generate better result is supply chain management. In this age of technology knowledge is available for all of us. Generation of knowledge, sharing knowledge and gaining knowledge is equally important for all the organization. Gaining knowledge from other developed counties on VFR will help to bring competitive edge for Indian FMCG sector. In this research, knowledge sharing will play a vital role to decide and fix a standard process to have High Vehicle rate. For an example many transporters and organizations are suffering due to empty running due to non-availability of information. Sharing the knowledge of load availability through portal will help many FMCG organization. Load sharing through flowing of information between the organization will also add value to knowledge base theory. This research work will contribute to knowledge base theory.

Gap Identification through Literature Review based on Theoretical Premise

From the research gap on Theory of Constraint it was found that the usage of theory of constraint is minimum to service sector hence not getting more valuable insight on TOC from service sector. Since this research work will work on transport sector which is a service sector only, it will add value to theory of constraint from service sector point of view. This research work will empirically test the TOC, which was also identified as research gap. Through Theory of Constraints (ToC), this study also distinct how the existence of constraints create obstacle to have good fill rate of vehicle in FMCG sector.

Resource based view is focusing on value creation through collaboration activities. It shares the strategy to have competitive advantages through resources, where multiple number of parties are involved. In transportation industry trucks are treated as tangible asset and human resources are also treated as tangible assets. Both are creating value and making the differences and creating competitive edge in vehicle fill rate. Hence resource-based view will act as an underpinning theory for this study and this study will show applicability of Resource based view theory.

From the theoretical perspective of Knowledge Based View, it was found that less care has been paid to define the process by which knowledge sharing can certainly affect the organizational throughput. Lavassani and Movahedi (2010) shared the same view. From the research gap it was evident that Knowledge Based View theory given less attention to call the process by which knowledge sharing is possible and can impact the organizational productivity. But from this study we will be able to share the process which will be very helpful for another researcher. There are very few studies available on the application of knowledge-based theory, hence loading expertise along with other knowledge will create value in vehicle fill rate. Knowledge based theory has been used to propose green SCM, however, use of this theory can be extended to vehicle fill rate in transportation.

2.5 Literature on Data Analysis Technique

Models/ Techniques used in SCM	**References related to this study**
Mixed Integer Linear Programming (MILP)	Velez-Gallego et al. (2020), Padberg. (2000), Hakim and Abbas, Sawik, (2018), (2019),Chen et al. (1995), Moura and Oliveira (2009), Erbayrak et al.,(2021), Lin et al. (2014), Sawik B. (2018), Oelschlägel and Knust (2020), Huang et al. (2016), Gonçalves and Wäscher (2020)
Linear programming Model	Junqueira et al. (2012)
integer linear model	Alonso et al. (2017), Nascimento D.X.O. et al, (2020), Saraiva et al. (2019), Oliveira et al. (2020), Bortfeldt (2012)
integer nonlinear programming model (INLP)	Kilincci and Medinoglu (2022)
DEMATEL approach	Fontela (1976), Kaur et al. (2018), Costa et al. (2019), Bhatia and Srivastava (2018), Singh et al. (2020), Singh and Sarkar (2020), Trivedi et al. (2021), Liu et al. (2018),
AHP	Pusporini (2020); Buyukselcuk (2020); Xiong (2019); Faisal (2011); Joshi (2011); Ho (2012), Handfield et al. (2002), Nguyen et al. (2015), Soh (2009),
FAHP	Zhang and Lam (2019), Tseng and Cullinane (2018), Göçer et al. (2019), Mangla et al. (2017), Vishwakarma et al. (2019), Kumar and Kansara (2018), Lamba et al. (2020), Othman et al. (2020)
Time Window Priority Model (TWPM)	Sitompul and Horas (2021)
Dynamic Optimization technique	Patil and Patil (2016)
two-level metaheuristic	Olsson J. et al., (2020)
Sensitivity Analysis	Slob N., (2013)
linearized quadratic model (LQM)	ElWakil et al., (2022)
Ranking	Islam et al., (2019)

prototype column generation	Wei et al., (2014)

Table 2.3 – Table illustrates different models, techniques and studies which were used in past for analysis in SCM

Table 2.3 shares the techniques and references which are used in Supply chain Management and relevant for vehicle fill rate. Hakim and Abbas (2019) took Mixed Integer Linear Programming (MILP) approach to optimize truck utilization. They have also suggested an increased usage of trucks with large carrying capacity to decrease the number of trucks and increase truck utilization. Their research work is focused on Outbound logistics and cost optimization of Outbound logistics. In their research work, based on Mixed Integer Linear Programming (MILP) an optimization model has been created, to arrange the planning of finished goods delivery. Through this, they have suggested to select the truck type and number of trucks used per period as well as the total optimal finished goods loaded in each truck to cut the total cost of outbound logistics. They have also shown how the total outbound logistics costs decreased, compared to the previous total outbound logistics costs by using this optimization model.

Sawik (2018), used mixed-integer programming for optimization. They have considered bi-objective vehicle routing problems. Optimization models like weighted-sum approach are framed with the use of mixed-integer programming. They have not only focused upon optimization; they have also discussed fuel consumption and environmental impact. They have taken a heterogeneous fleet of trucks for their study. Different types of trucks having different capacities and having different amounts of fuel consumption for operations. Based on framed optimization model computed results show some balance between truck types, fleet size, and fuel utilization, carbon emission, and noise production. AMPL programming language along with CPLEX solver computational experiments were performed. There is a relation between fleet size, their capacity, distances, driving times, and obtained values of environmental objectives. This relation demonstrate the requirement for consideration of all these facets of transportation together in bi-objective models based on obtained results the relationship between size of truck (capacity and engine parameters) versus consumption of fuel, carbon emission, and noise is the following: larger trucks require less amount of fuel per km, produces less carbon emissions, but produces more noise.

Erbayrak et al. (2021) also suggested MILP for 3D bin packing problem with multi objective along with load balance for the products. Like them, Velez-Gallego et al., (2020), Hakim and Abbas (2019), Chen et al. (1995), Padberg. (2000), Moura and Oliveira (2009), Lin et al., (2014), Sawik, (2019), Oelschlägel and Knust (2020), Huang et al. (2016), Gonçalves and Wäscher (2020) also seconded MILP.

Other than that, many authors take help of Heuristics, followed by algorithms, which we have already discussed in Literature review section.

To assess the constraints one of the very popular and widely used method is DEMATEL. It is very effective and used in many sectors across the countries. Costa et al. (2019), Kaur et al. (2018), Singh et al. (2020), Bhatia and Srivastava, (2018), used DEMATEL for their studies to assess the constraints. Singh and Acharya (2014) proposed DEMATEL to identify and evaluate flexibilities in supply chain for Indian FMCG sector.

AHP / FAHP and DEMATEL were employed to prioritise the issues and their sub-categories as well as examine the inter-influence of the issues. In 1980, Saaty suggested the Analytic Hierarchy Process (AHP). This statistical investigation method is used for decision making and it is applicable for both quantitative as well as qualitative qualities.

Sensitivity Analysis used by Slob (2013), for similar type of study of Vehicle Fill Rate of P and G.

2.6 Major inferences drawn from literature review

- The three areas where research seems to be significantly growing are logistics cost, Carbon emissions due to transport sector and Vehicle Fill rate/ container loading problem.
- Load factor is defined as the ratio of load carried compared to the maximum load carrying capacity in each load unit. The aim is to rise the utilization by accepting extra loads for road transportation activities which was already planned.
- Focus on VFR and their impact on logistics cost is still an area of concern. Inefficient VFR leads to high logistics cost and higher carbon emissions.

- The space gets wasted inside the truck due to improper arrangement of cargo and unavailability of proper optimization techniques. Also transit damage of goods is happening.
- The space inside the truck will also having more waste if the types of boxes increase. Compared to same size boxes it is more difficult to place the different sized boxes in a truck.
- In developing countries standard truck size is still an area of concern but not much literature is available on this.
- To improve VFR coordination plays a significant role. It is not only coordination within the truck at the time of loading, but also coordination between logistics and other function.
- Most of the study focused upon resolving the container loading problem with various algorithm.

2.7 Major gaps drawn from literature review

- Studies have considered vehicle fill rate in general. Not much attention has been given to possible constraints of vehicle fill rate. There is no formal methodology or structure which detect key constraints of Vehicle Fill rate in road freight transportation. Extensive research needs to be conducted in this area with respect to Vehicle Fill rate in road freight transportation.
- Various constraint, and challenges need to be identified in Vehicle Fill Rate. Less focus on all the constraints available for Vehicle Fill Rate in road freight transportation.
- No model-based study exist that determine and examines constraints in the Vehicle Fill Rate in road freight transportation.
- In Indian context literature is almost nil on Vehicle Fill rate in road freight transportation. Need more research on this area.
- Many stake holders are involved in Vehicle Fill Rate but there is hardly any literature from shippers' perspective.
- Most of the studies have been conducted considering a specific issue of vehicle fill rate in road freight transportation and are conceptual or review studies with very few empirical studies conducted.

- Literature mostly focusses on the algorithms to optimize the vehicle, process mapping, constraints identification, prioritization of constraints discussed in very few literatures.
- In this topic no analysis found through SAHP/FAHP, DEMATEL.
- There is hardly any study done considering both constraints and strategies and solutions to overcome these constraints together. In case any study is done, it concentrates on specific issue category and discusses only IT solutions. Hence, there is no study done suggesting solutions, both IT and Non-IT.
- From theoretical perspective in Knowledge Based View, it was observed less care has been paid to demonstrate the process by which knowledge sharing can positively affect the organizational throughput.

  Vehicle fill rate is a very important performance measurement concept and it was investigated from different perspective by different players. Transporter, User, Government having various view on vehicle fill rate, no standard definition was available to measure vehicle fill rate. Vehicle fill rate having direct financial impact to business, having environmental impact as well as impact on product quality. Despite having many important impacts lack of academic study was found in this area. In Indian context it is even lesser.

2.8 Research Problem

The Vehicle Fill Rate in Road freight Transportation is sub optimum by nature due to presence of the constraints or barriers. The presence of the constraints creating number of issues for FMCG industries which we have discussed in earlier sections. Vehicle Fill Rate is discussed in a very general way but how the constraints are impacting the FMCG sector of India is not discussed in depth due to absence of primary data. The relevant stake holders and Government bodies failed to realise the existence of the constraints and their cruciality in Indian context. Global context may not be fully relevant and matching Indian context. Similarly, constraints related to India may have relevance with other developing countries.

From the theoretical gap it is clear that, there is inefficiency to overcome the impact of the constraints. From lower vehicle utilization, high logistics cost it is evident that constraints are impacting the FMCG sector. Identification and analysis of the constraints and the severity are braced with Resource Based View (RBV) which suggests that if one can use the resource of logistics optimally it will competitively edge over the competitor who are unable to use the resources in an optimized way.

On Vehicle Fill Rate different stake holders in logistics having different view and perceptions. There are no proven methods to measure and manage Vehicle Fill Rate. In absence of primary data very few detailed studies were conducted on Vehicle Fill Rate in Indian context. Organizations are managing the vehicle fill rate by their own and based on their own understanding and need of business. But there are no academic proven methods for their models for Vehicle Fill Rate. Very limited publication on robust Identification of constraints and strategies to overcome all the constraints. Moreover, during literature review only one relevant paper was found which was related to structural constraints of trucks which are very similar to Indian context. After doing the in-depth literature review, the most important gap which has been identified is there is no studies which had advised and prioritised the solutions to overcome the constraints of Vehicle Fill Rate (VFR) in Road freight transportation.

2.9 Research Questions (RQs)

Research Questions are following –

Q1 – What are the various constraints affecting the vehicle fill rate in road freight transport of FMCG sector in India?

Q2 – What are the Strategies to overcome the constraints of vehicle fill rate in road freight transport of FMCG sector in India?

Q3 – Based on the identified strategies to overcome the constraints what will be the suitable solutions that can be used to build an integrated framework to overcome the effect of identified constraints?

2.10 Research Objectives (ROs)

Literature review helped to find the research gaps and helped to develop following research objective:

Research Objective 1 – To understand the nature and status of the constraints affecting the vehicle fill rate in road freight transport of FMCG sector in India.

Research Objective 2 – To identify the solution / strategies to overcome the constraints of vehicle fill rate in road freight transport of FMCG sector in India.

Research Objective 3 – To develop and test an integrated framework to overcome the constraints of vehicle fill rate in road freight transport of FMCG sector in India.

2.11 Chapter summary

The objective of chapter two is to conduct exploratory study based on relevant literature which helped to identify and recognize the gaps in research. The various literatures were reviewed based on three major themes: Understanding of Vehicle Fill Rate; Constraints of Vehicle Fill Rate in Road Freight Transportation; Strategies taken to overcome the constraints related to Vehicle Fill Rate. For all the three themes, the inferences drawn based on existing literature. Also theme wise research gaps have been identified. In this chapter we have discussed on the theoretical underpinning and how they can contribute to overcoming the constraints in Vehicle Fill Rate. Also, a review of literature is done on the models or techniques utilized in the assessment constraints in Vehicle Fill Rate. In the next chapter focus is on the Research Methodology taken for the research work.

Chapter 3

Research Methodology

Overview

In this chapter the research methodology was discussed in detail which was deployed for this study. Research design was discussed in details. In this chapter we shared the methods which are chosen and deployed to rank and analyse the constraints and strategies. This chapter also explain how the study will be driven and the methodology used to collect the data and analyse the data.

3.1 Research Design

To conduct research and achieve research objective, designing the research in a logistical way is very important. Research Design is the overall strategy to organize the research in a systematic way. Research design is the blueprint to collect, measure and analyse the data in a structured way. As per Creswell (2014), "Research design are the specific procedure involved in the research process: data collection, data analysis, and report writing". There are three types of research design –Explanatory, Exploratory and Descriptive. In this study exploratory research was used to assess an undefined problem, for an example, barriers in the vehicle fill rate in road freight transportation. Descriptive research depicting and analysing a particular situation on an event or any specific person. For an example, this study focused upon what is happening to Vehicle Fill rate. Through explanatory studies explaining and establishing a causal relationship between the variables by focusing upon a particular problem. This study focusing upon the 'why' part also, like cause-and-effect relationship build between the variables which are acting like a constraint for Vehicle Fill rate in road freight transport. Hence for this study combination of all research design is used to achieve research objective. Mixing of research design helped to build a structured and systematic view for the research problem. The step-by-step research design as follows –

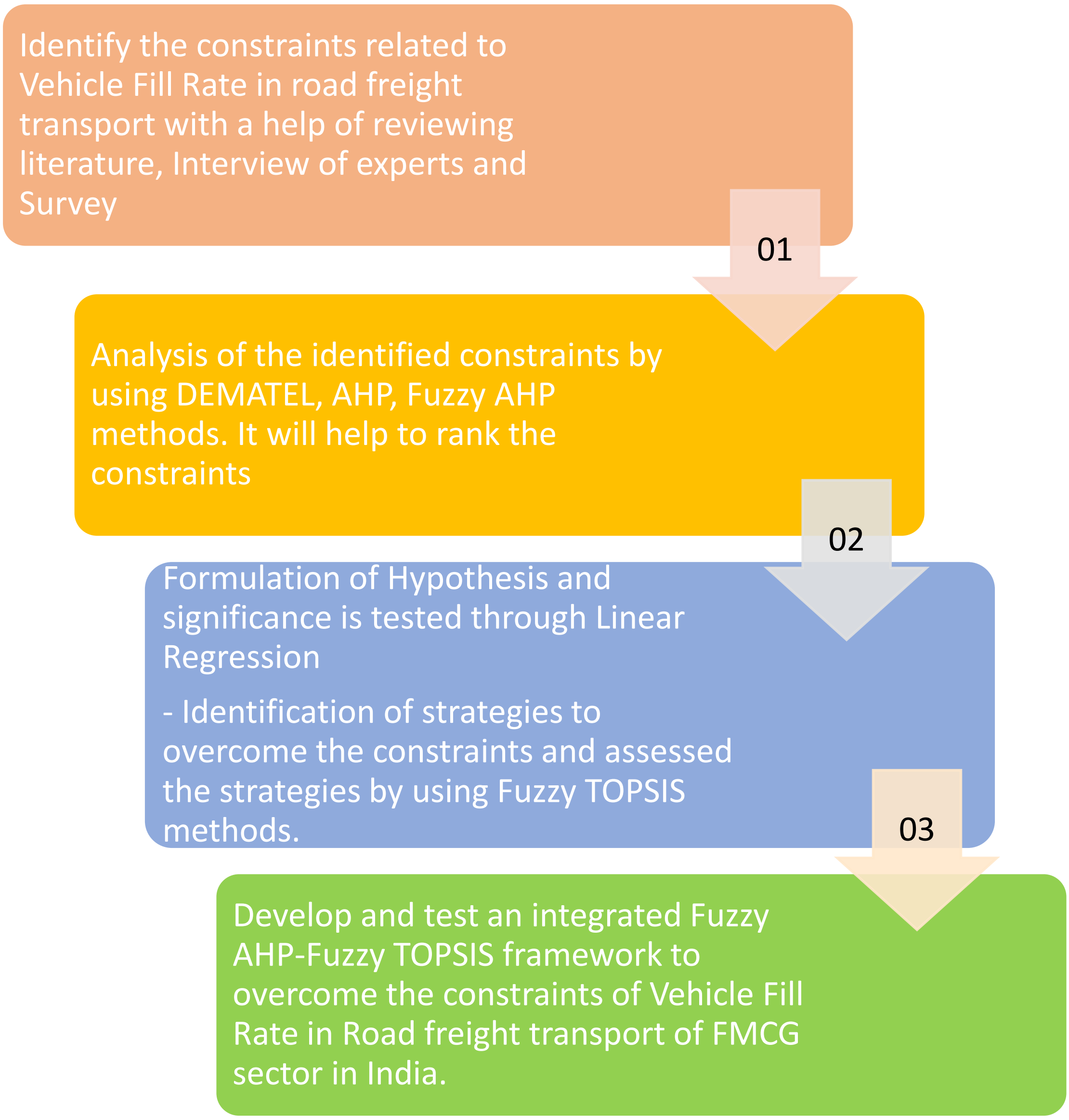


Figure 3.1 Flow Diagram of research design

Step 1:

The study helps to understand the Vehicle Fill rate for road freight transportation and identify the existing constraints from various sources. Based on previous studies, a review of constraints in the Vehicle Fill rate for road freight transportation was conducted. Key categories and sub-categories of constraints were identified in this study for Vehicle Fill rate in road freight transportation. For this study, primary data was composed through survey and secondary data was taken from reports, journals, articles available in newspapers, Magazine, or other sources like Government of India websites, websites of truck manufacturer and many more. Categorisations of constraints are discussed in details in Chapter 4.

Step 2:

To assess the important and critical constraints in vehicle fill rate in road freight transportation the Multi Criteria Decision Making (MCDM) method is used. Multi-criteria decision making (MCDM) is a part of operations research. It helped in decision making by assessing the differentiated contradictory criteria. To find out the ranking for constraints and solutions MCDM is preferred, since it is more suitable for practical applications. In this study some of the constraints and solutions are not quantifiable hence usage of general statistical techniques is not possible, keeping optimization in mind and considering all the constraints, solutions. For this study since both quantitative and qualitative parameters are there, MCDM technique helped to handle both quantitative and qualitative aspect of constraints and strategies to overcome the constraints. These MCDM techniques not only able to analyse the cause-and-effect relation, but it also helped to rank the constraints and solutions to get more precise results for this study. This study is complex and advanced, and domain is new in Indian context hence for overall analysis and prioritization of strategies MCDM was chosen. Domain experts helped to gather the importance and the rank the constraint based on their impact on the vehicle fill rate in road freight transportation. AHP/ Fuzzy AHP technique deployed based on the categories and subcategories of the constraints to reach at the final list of priority. The technique also helped to calculate preference weights and ranks of the categories and subcategories of the constraints. For this study DEMATEL also used to understand the inter-influence among the constraints.

Step 3:

In this step, considering the constraints, strategies to overcome the constraints are determined. For strategies Fuzzy TOPSIS methods used to rank the strategies based on their impact to overcome the constraints related to vehicle fill rate.

Hypotheses formulated and tested significance of the issues on the vehicle fill rate understood.

Step 4:

In this last step, considering the constraints in vehicle fill rate in road freight transportation in FMCG sector in India, solutions to resolve the constraints are suggested. Solutions includes IT solution and non-IT solution both, to achieve high vehicle fill rate. The constraints with highest rank should be treated as priority. Hence the strategy with best rank should get first priority for implementation, with the intention of prioritizing the most important constraints. By using the MCDM method - Fuzzy TOPSIS solution will be prioritised for clarity on understanding of the preference and usefulness of the strategies to improve vehicle fill rate in road freight transportation.

3.2 Research Methodology

To achieve the research objectives, objective wise following steps taken –

<u>Research Methodology for Research Objective 1</u>

Research Objective 1 is to comprehend the nature and position of the constraints affecting the Vehicle Fill Rate. Initially Exploratory research to explore the constraints. Descriptive and explanatory research followed to analyse the identified constraints. Expected outcome is to identify the constraints with their categories and sub-categories impacting the vehicle fill rate in road freight transport of FMCG sector in India. For this objective data collected through literature review, expert interviews, and field visits.

<u>Steps taken for RO1</u>

- Literature Review
- Unstructured interview with five working professionals to frame the questionnaire.
- Questionnaire preparation-based input received from Literature Review and unstructured interview.
- Likert Scale used for questionnaire.
- Finalize the Questionnaire

- Data collection by using survey Questionnaire.
- Purposive sampling technique with a sample size of 302
- Data Analysis with a help of AHP, Fuzzy AHP, DEMATEL
- Reliability test of the responses received through survey questionnaire by using Cronbach Alpha

Research Methodology for Research Objective 2 and 3

Research Objective 2 is to understand to classify the solution/ strategies to overcome the constraints of Vehicle Fill Rate in Road freight transport of FMCG sector in India Initially Exploratory research to explore the strategies to overcome the constraints.

Research Objective 3 is to develop an integrated framework to overcome the constraints of Vehicle Fill Rate in Road freight transport of FMCG sector in India.

Descriptive and explanatory research followed to analyse the identified strategies. Expected outcome is to identify the strategies to overcome the constraints that impacting vehicle fill rate of FMCG sector in India. For this objective data collected through literature review, expert interviews, and field visits.

- Field visit to collect primary data related to vehicle.
- Literature Review to get the strategies to overcome the constraints.
- Collect secondary data from truck manufacturer.
- Feedback from domain experts from Industry through interview
- Categorisation and ranking for the strategies.
- For ranking of strategies taking help of fuzzy TOPSIS
- Hypotheses formulation
- Hypotheses testing

In this study we need to identify various constraints related to Vehicle Fill Rate of FMCG sector in India and suggest strategies/ solutions to overcome the constraints. For objective 1 primary and secondary data plays a vital role. Through literature review and questionnaire survey helped to find the constraints related to vehicle fill rate in road freight transportation. It also helped to find out the strategies to overcome the constraints. In this study Multi Criteria Decision Making (MCDM) technique was deployed to find out the ranking of the constraints. To achieve 2nd objective

DEMATEL, Fuzzy AHP was deployed to ascertain the rank of the constraints related to vehicle fill rate. Based on the ranking of the constraints hypotheses were formulated and tested. Linear regression was used to build the relationship between the variables. Linear regression also helped to predict the fill rate with respect to the constraints, here fill rate is dependent variable and rest are independent variables. Linear regression is preferred to calculate the same over other techniques, since the constraints having a linear relationship with vehicle fill rate and regression having better predictability compared to others. Multiple linear regression is used since the number of variables (constraints) are more than one. These constraints are quantitative by nature and outcome of variable is numeric, hence statistical technique like correlation, and regression is preferred to find out the relationship and the predictability between the constraints and fill rate. Collection of primary data through field sturdy and secondary data on trucks from manufacturer plays a significant role. To achieve 3rd objective Fuzzy TOPSIS was used to analyse the strategies to overcome the constraints. Along with the analysis priority list of the strategies also finalized. To ensure the reliability and consistency of the result in this study sensitivity analysis was used.

3.3 Data Collection Sources

To achieve objective 1,2 and 3 data collection was organized. All three objectives are fully dependent upon the data. For the constraints and strategies to overcome the constraints we collected primary and secondary data both.

Primary Data

Primary data sources for categories and subcategories of constraints and strategies are the domain experts from whom we have taken feedback through questionnaire survey. Interview of experts were conducted to get the primary data. Experts are belonging to logistics professional from industry and academics, professional belongs to truck manufacturer, Logistics consultant, Warehouse loading specialist. Data related to actual vehicle dimension is not readily available hence field study is important to collect the primary data. The responses collected were analysed statistically. The final survey responses collected between June’2022 to Nov’2022.

Secondary Data

Through in-depth literature review secondary data were collected to ascertain the constraints and strategies. Truck manufacturer official website also helped to collect secondary data related to trucks. A wide range of research paper and journals are studied which were written for a long time span. In addition to that Government notifications related motor vehicles are reviewed along with the laws related to Indian motor vehicles, focusing on trucks. Recent reports of Government of India, Niti Aayog department also helped to get data support related to vehicle fill rate. It was also observed that very little research work done on Vehicle Fill rate in Indian context.

3.4 Design of Questionnaire

Based on literature studied and feedback received from domain experts questionnaire is developed keeping the set objectives in mind. From the literature and experts view 28 subcategories of constraints are identified. After consultation of experts all the subcategories are clubbed into 8 major categories of constraints. These 8 major categories finalized for analysis. Questionnaire is designed in such a way so that pairwise comparison is possible to find out the influence of the constraints in vehicle fill rate for road freight transport. During construction of questionnaire focusing upon wording plays a significant role. Wording and formation of the questions helped the responder to understand the question in a better manner to response with full understanding.

The goal of the survey is to recognize the constraints and their influence on vehicle fill rate in FMCG sector at India. These constraints need to be resolved not only at organizational level, but it is important to resolve them at various level in India to get an impactful outcome. Not only it will give a pathway to resolve National level constraints regarding vehicle fill rate, it will also help other developing countries who are having similar problem. Similar to the constraints 32 numbers of strategies were identified to overcome the constraints through in-depth study of existing literature. In this way data is collected to achieve all three objectives from the sample of 302 domain experts. Not only existing literature subject matter experts also helped to identify some of the constraints which are not available in existing literature. These constraints they have identified through their practical experience and untouched area for the researcher to work for.

To check the relevance and getting the right response of the questionnaire five pointer Likert scale was used where 1 is not important, 2 is less important, 3 is ok, 4 is important and 5 is very important. All questions are close ended by nature to get an easy and prompt response from the responders. Before circulating the questionnaire with all the subject matter experts of industry and academics, questionnaire shared with 2 number or academician and 3 number of experts from industry. They have given their input to the questionnaire so that more accurate information will flow from the survey. The question is designed such a way so that all the constraints related to vehicle fill rate is captured in Indian context and assessment of relevance of the constraints also can captured through this survey.

3.5 Proposed research method and techniques

Basis on data gather from primary and secondary sources first objective of the study is achieved which was discussed earlier in the study. Based on existing literature and survey questionnaire identified the constraints of vehicle fill rate in road freight transportation and strategies to overcome the constraints.

To rank the identified constraints multi-criteria-decision-making (MCDM) method deployed. From MCDM technique, Fuzzy AHP has been deployed to rank the constraints because this method helped to convert Fuzzy input received from domain experts to ranks. Fuzzy AHP techniques help to build the list of priority which is our second research objective for this study. Post that for ranking the strategies to overcome the constraints for vehicle fill rate Fuzzy TOPSIS is deployed. Methods are discussed in next session.

3.5.1 AHP and Fuzzy AHP technique

From decision making point of view, to consider quantitative and qualitative aspect of any study Analytic Hierarchy Process (AHP) technique can be considered and it comes under multi criteria decision making (MCDM) process. Saaty (1980), created the technique with an aim to deal with a problem where multiple criteria are involved, and problem is complex by nature. AHP technique is a decision-making technique, by which we can help to define the hierarchy of the decision-making criteria which are impacting or influencing the decision. AHP technique is a widely used technique in the research work for its simplicity of usage and adaptability to the researcher. The AHP technique helps in pull to pieces the complex unorganized condition to basics segments; then organizing this basic segment to hierarchical sequences; combine the decision to find out which variable will have highest priority and should considered as first priority in a sequence of impact to the end result. As per Kahraman (2008), AHP summarizes the result of pairwise comparisons and try to find out which attribute is more important compared to other one. For supply chain related problem AHP is among the most preferred techniques. Ho (2012) shared the steps of AHP – graphically represent the development of hierarchical structure; pairwise comparison matrix; synthesis; consistency validation; ranking based on priority of weights.

As per Saaty (1980), in conventional AHP nine-point ration scale is used for a pair wise comparison for representing the preferences of decision makers. After having a crisp 9 pointer scale also it is difficult to get an exact number for pairwise comparison because of fuzziness or the uncertainties of human decision-making process due to absence of knowledge or information. As per Soh (2009), due to lack of knowledge/ information, complex and uncertain environment for decision making and haziness of human thought process in many practical scenarios decision markers are not precise about their own level of preferences. Hence to the decision makers it is become difficult to put the exact numerical number on pairwise comparison decision. To overcome this limitation, it is suitable to use fuzzy sets because it is suitable in representing the uncertain decision of human. For that only, for this study fuzzy AHP is deployed to determine the constraints and hierarchy of the constraints based on their impact on overall result. Zadeh in 1965, introduced fuzzy set theory. As per Kahraman (2008), when human knowledge and evaluation is needed fuzzy sets approaches are suitable. In many studies AHP and fuzzy set theory was combination and used by the researchers.

As per Ahmed and Kilic (2018), in fuzzy AHP weights are used and calculated from fuzzy comparison matrix. This fuzzy comparison matrix is also used to rank the each identified constraints. In comparison matrix fixing the weight for all the constraints is an important step for Fuzzy AHP process.

Saaty (2008) shared the step wise AHP method –

Define problem and structure decision hierarchy – to use AHP technique problem should be broken down into hierarchical structure. First and foremost, thing is to finalise the decision goal (for this study decision goal is achieving vehicle fill rate at FMCG sector). Then finalising the criteria (here finalizing the constraints as per the problem identified). Post that finalizing the sub criteria (identifying the sub constraints within the constraints as per identified problems). Post that identifies the alternatives to reach to reach the decision goal identified earlier (for this study it is the strategies and solutions we have identified).

Pairwise comparison – based on responses of the subject matter experts' pair wise comparisons are made between the constraints to get the relative significance between the constraints. Within the constraints there are sub constraints. Pairwise comparison also conducted between the sub constraints within the constraints. Pairwise correlation grid was prepared between the constraints and their sub constraints. To set an overall priority weighted value to be added in each element in the level below. This weighing and adding process will continue until the final priorities of the alternatives till the bottom most level is obtained.

To do comparison between the constraints nine-point Saaty (2008) scale used for pairwise correlation. Based on the responses of the expert's final matrix was drawn from the pairwise comparison. Table 3.1 exhibits the scale –

GRADE	**SEMANTICS**
1	**Equal Importance**
2	**Slight weak**
3	**Moderate Importance**
4	**Moderate plus**
5	**Strong importance**
6	**Strong plus**
7	**Very strong importance**
8	**Very very Strong**
9	**Extreme Importance**

Table 3.1 – Pairwise comparison Scale

Source – Saaty (2008)

Normalized pairwise comparison matrix AHP, makes use of ratio scale to normalize the pairwise comparison. It is the value in corresponding cell divided by the summation value of that column of that particular criterion (constraints). Because it is based on experts opinion consistency of opinion is not guaranteed. According to Saaty (2000), to ensure consistency pairwise comparison consistency ratio should be calculated. The coefficient vector for criteria weights for the criteria is estimated after calculating geometric means, summation and corresponding reciprocal. Calculated the Consistency Ratio (CR), the CI (Consistency Index) value dividing by RI. For RI value refer to the table 3.2. Once CR is found less than 0.10, then expert judgements can be produced for prioritizing the criteria for decision making.

n	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
RI	0	0	0.58	0.9	1.12	1.24	1.32	1.41	1.45	1.49	1.51	1.48	1.56	1.57	1.58

Table 3.2 – Average number index (Source – Saaty, 2008)

Fuzzy AHP

For supply chain and logistics related problems AHP is one of the preferred and appropriate technique. AHP is having some shortcoming due to fuzzy environment hence to address the imperfection Fuzzy concept is integrated with AHP (Prakash and Barua 2015, 2016a, 2016b). In decision making process, Zadeh (1975) developed the fuzzy logic which determine to manage the uncertainty and vulnerability. Fuzzy logic is based on human reasoning and as per that everything cannot be categorised between one and zero only. In between values may exist. Fuzzy logic employs a number ranging zero to one. Out of many memberships function triangular is the popular among the researchers. The triangular fuzzy number N, often denoted as TFN (1, m, n), where lower value is 1, highest value is n and medium value is m. So, l ≤ m ≤ n. Due to involvement of experts the decision-making process is become extra effective. Fuzzy AHP helped to removes the vagueness and uncertainty in decision-making.

As per Liu (2020), following steps should be followed for Fuzzy AHP process, First, one need to structure the problem like AHP. Then establish Fuzzy pair wise comparison matrix. In third step, fix and calculate fuzzy weights for the criteria. In the next step, DeFuzzify the Fuzzy weights. In the final step, ascertain the ranks of the criteria.

For our study both AHP and FAHP were used to check whether both the cases we are getting same results or not. Similar data can be used for both the cases hence no extra effort is needed for the analysis. It ensures there is no uncertainty, vagueness, biasness in the data. After changing the weightage also if there are no changes observed then it proved that there is no biasness in the data. Since the data is based on opinion biasness may observe and to find the area of biasness FAHP is used and compared with AHP.

3.5.2 Fuzzy TOPSIS

Out of many MCDM technique, distance priority method is followed by Fuzzy TOPSIS approach. It is one of the most applicable methods which helps to prioritize the selective attributes and optimize from multiple responses. Hwang and Yoon invented TOPSIS model in 1981 and same Fuzzy logic was used by Chen and Hwang in 1992. The principle behind TOPSIS is the alternatives which are selected should be as close to the ideal one and negative ideal solution should be kept in distant. Based on estimated closeness coefficient values of the different solutions, final ranking is evaluated.

To execute Fuzzy TOPSIS approach step wise details as follows –

Step 1 – For the alternatives calculate the aggregated fuzzy rating along with the aggregated fuzzy weights for the input criteria received from the experts. Mean value will be used for data input and then nine-point scale will be used in a decision-matrix format.

Step 2 – determination of fuzzy number is happening in this stage. Conversion of decision matrix to its normalized format is done by converting the crisp values into triangular fuzzy numbers. To ascertain the level of importance for the solution each constraint are converted either to benefits or to cost. For the criteria related to benefits, maximum of the upper value is considered of the TFN (1, m, u). The 1, m, u values of each cell of that criterion is divided by the maximum value. Similarly for the non-beneficial/ cost criteria the minimum of the lower value is taken into consideration for TFN (1, m, u). This minimum value is divided by the values of 1, m, u values of each cell of that criterion.

Step 3 – in this step matrix is calculated in normalised fuzzy decision matrix through the calculation of product values. Assigning weightages to criteria is another important part.

Step 4 – in this step for each criteria the maximum TFN and minimum TFN are considered. Here fuzzy positive ideal solution (FPIS) and Fuzzy negative ideal solution (FNIS) computed and distance between each alternative to the FPIS and FNIS is taken into consideration. Post that, based on gap from maximum TFN, FPIS is determined and based on gap from minimum TFN, FNIS is determined. Post that for each solution di* (FPIS) and di- (FNIS) are determined.

Step 5 – in this step for each alternative, closeness coefficient to the ideal solution is determined.

Step 6 – In this last step alternatives was ranked based on order of preference. Highest closeness value will be top on the list and lowest closeness value will be at the bottom of the list.

3.5.3 DEMATEL

To assess the barriers in different sectors DEMATEL is chosen as one of the widely used effective method. In 1971 Decision Making and Trial Evaluation Laboratory (DEMATEL) was first projected by Bastille National Laboratory. Among the issues the causal relationship is assessed by using DEMATEL approach. This method is used to analysed complex causal relationship with a help of visual structural model. As per Wu and Lee (2007), DEMATEL method is depending on diagraphs, where factors are divided into separate group of cause and effects. Diagraph shows the direct relationship between the sub system. Kaushik And Somvir (2015) shared step by step DEMATEL method –

1. Creation of direct Relation Matrix
2. Calculation of direct Relation Matrix
3. Normalize direct relation Matrix
4. Calculation of total relation Matrix
5. To get diagraph setting the threshold value

6. Set cause and effect group based on (ri -cj)
7. Create interrelationship map based on (ri + cj) (ri -cj)

DEMATEL helped to identify the causal relationship between the identified constraints. It is a complete method which is helping to identify the causal relationship between the identified constraints. 5-point scale is used by the expert to share their opinion on the influence of one constraint over another, which is shared in Table number 3.3 -

Scale	0	1	2	3	4
Level of Influence	No influence	Low influence	Medium influence	High influence	Very High influence

Table 3.3 – 5 point scale used for DEMATEL

3.5.4 Sensitivity Analysis

For checking reliability, consistency of defined framework sensitivity analysis is performed. After making changes in weight for specific criteria, variation can be identified in the final ranking of the alternatives. Nine iterations done to reach that level. The solution with maximum weight is substituted with other solutions and the weight remain unchanged. Aim of sensitivity analysis is how the ranking of the alternatives are changing with changes in criteria weight. Chen (2010) confirmed that by this way through statistical techniques ranking in obtained and alternative selection is happened. Conducting sensitivity analysis gives many benefits to the decision markers. It will act as an in depth study and analysis for all the existing variables. In depth study helped to predict with more reliability. It also helps the decision makers to identify the area for improvement in future.

3.5.5 Chapter Summary

This chapter shared the details of the methodologies that are used of to accomplish the research objective. The technique is used to get the data for analysis and various methods used to assess the collected data was explained. Detailed discussion shared on various methods like Fuzzy AHP, Fuzzy TOPSIS, DEMATEL which were deployed for analysing the constraints, strategies to overcome the constraints.

Chapter 4

Identification and evaluation of constraints of Vehicle Fill Rate in Road Freight Transport of FMCG sector

Overview

Chapter 4 helped to understand vehicle fill rate (or VFR) in Road freight transport for FMCG sector in depth and explains the constraints related to vehicle fill rate in India. This chapter also describe the evaluation of various constraints that impacting the vehicle fill rate. Categories and subcategories of constraints are described in details. AHP/ Fuzzy Analytic Hierarchy Process (FAHP) method is adopted and demonstrated for identifying final ranking of the constraints.

4.1 Introduction

Vehicle Fill Rate (VFR) as a concept is gaining attention in India due to pressure of cost at FMCG sector, quality of Finish goods delivery, targeting reduction carbon emissions. To become competitive at global market Government of India taking aggressive steps, which we have already shared in Chapter 2. They have identified some of the constraints and working to eliminate the same. To have the alignment of the goal all the stake holders (including Government) should have knowledge of constraints, so that not only their business the whole country get benefit from the same. Through primary and secondary research, the categories and subcategories of constraints are determined. In the next steps for all the stake holders would be, to recognise the level of criticality for each category and their subcategory. This chapter is based on the first objective, which is stated below -

Objective 1: To understand the nature and status of the constraints affecting the Vehicle Fill Rate in Road freight transport of FMCG sector in India.

To identify the constraints, in vehicle fill rate extensive literature review was conducted. The constraints were identified which are impacting the vehicle fill rate from existing literature and relevant feedback from the subject matter experts from industry and academics. Those constraints were categorised and sub-categories according to the nature of the constraints. If the types of the constraints are similar then it kept under one category. For an example if constraints are related to physical structure of the truck then it grouped under structural constraints. Similarly if constraints are related weight of a box or volume of box then these constraints are clubbed together under one category. Categorisation is done based on similarity for the constraints. In above two examples, truck is one sub-category and box is another sub-category. During literature review similar type of constraints was observed which was clubbed and discussed under one head but categorisation was not observed since they have not ranked the categories and sub-categories. To rank the constraints categorisation is important. It will help to analyse the constraints and it will also help to get better results while solution or strategies will be used to overcome the constraints. For an example, if one providing solution to box related constraints he will cover all the constraints related to box – weight and volume both. Holistic approach towards this category of constraints will help to rank the constraints as well as to identify the solution for the whole constraints. Sub-categories within the category will be well covered. Through this process eight categories were identified and twenty-eight sub-categories were ascertained.

Post identification of constraints setting ranking of constraints is very important since number of constraints are high, and ranking will help to focus on the constraints which are impacting most in vehicle fill rate. In decision making where diversified conflicting criteria is there Multi Criteria Decision Making (MCDM) or Multi Criteria Decision Analysis (MCDA) plays vital role. For ranking of the constraints Fuzzy Analytics Hierarchy Process (FAHP) was deployed, which falls under MCDM/ MCDA which is part of operation research. Fuzzy AHP method was chosen since it gives reliability and fuzziness while taking any decision based on the constraints. For any practical application it is more appropriate. Pairwise comparison between the constraints helps to fulfil the decision for quantitative and qualitative characteristics.

4.2. Proposed Framework

Proposed framework for identification and evaluation of constraints shared below –

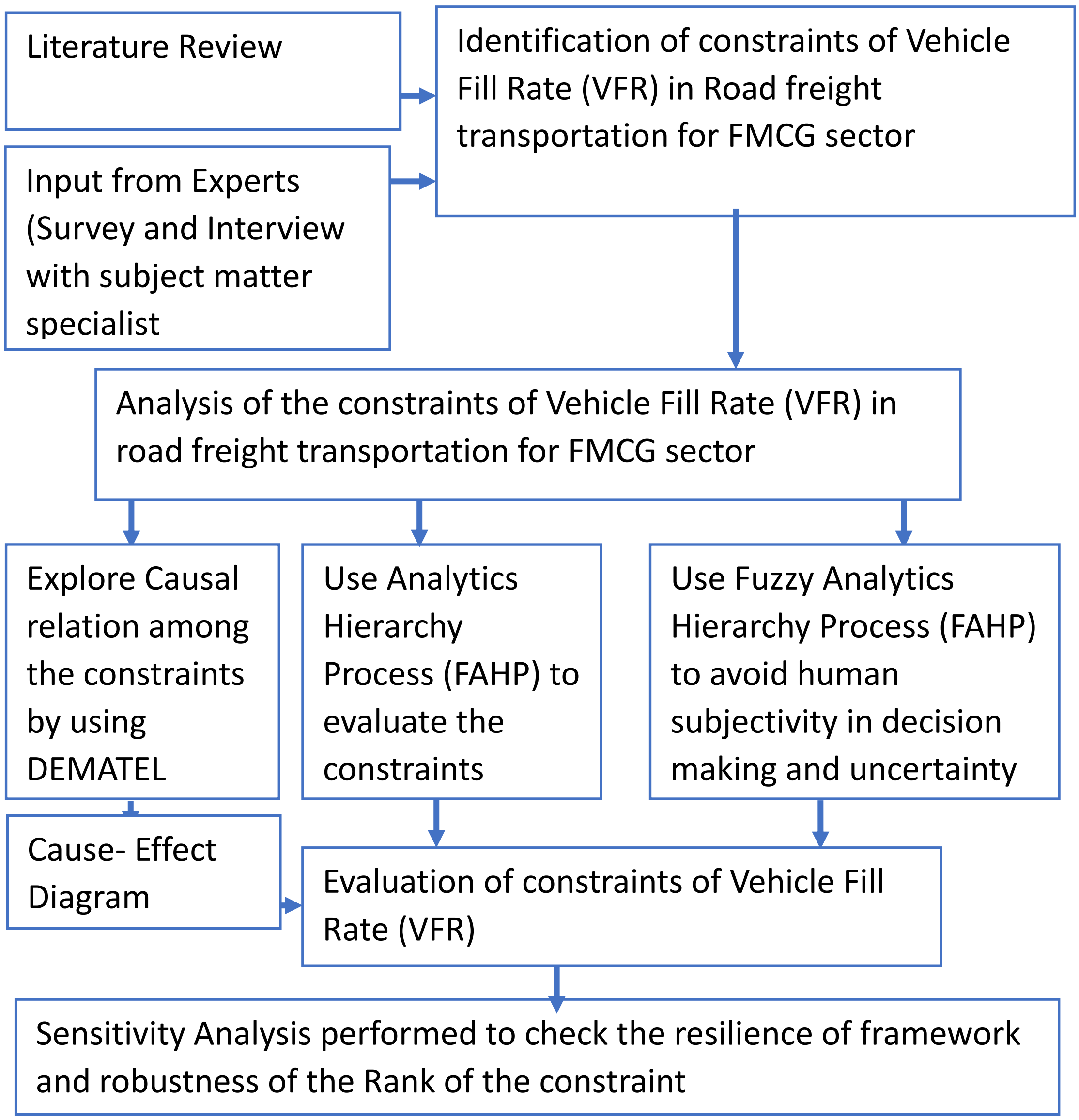


Figure 4.1 – Proposed Framework for Objective 1

Source – Author's Composition

Figure 4.1 describes the framework to achieve first objective. Putting the right framework is important for achieving the objective. Literature review and inputs from expert helped to identify the constraints related to vehicle fill rate. DEMATEL, AHP, FAHP helped to analyse and evaluate the constraints. Sensitivity analysis will help to check the resilience and robustness of the ranking for the identified constraints.

4.3. Sampling

To accomplish the objectives, very important to have suitable samples from the population. Samples are subset of the total population, which represents the population. Choosing right sample is very important for any sampling activity for the survey. For exploratory research non-probability solution will be practical approach to establish the problem which is not having any existence in current scenario. For this type of study non-probability sampling will play a vital role since to answer the question need good practical experience in logistics sector along with knowledge in logistics, general population will not serve the purpose. Probability sampling unable to serve the purpose, it may defeat the purpose of the survey. It is a sector specific study, for this study respondent are selected based on their experience in road freight transportation. Players related to road freight transportation acted as respondent for this sample. Since the respondent having practical or theoretical knowledge, they can identify the constraints and problems. For this study, respondents mostly selected from operational level executive, middle level and senior level management working in the several sectors in logistics focusing upon warehouse and road freight transportation in India and academician with relevant experience in logistics.

For the current research, the targeted **population** shared below –

Elements are Operational personnel, mid and senior level management related to logistics function, academician from SCM

Sampling units are Players and stakeholders in Road freight transportation

Time Span is July’2022 to Oct’2022

Location covered for sampling is PAN India

Professional and academician chosen for this research work having high experience in this relevant field with a vast knowledge. 302 number of professionals responded to this survey. It is important to know the experience and knowledge of the respondents in Vehicle Fill Rate at Road freight transportation.

While choosing the respondents certain criteria were fixed like – total experience in logistics industry, their experience specifically to vehicle fill rate in road freight transportation, preference given to specialist from FMCG industry, their current role or previous role in industry, their educational qualifications, their current position in their organization etc.

While choosing the sample fixing the types of actors related to Vehicle Fill Rate is important. Table 4.1 gives information on the type of actors contacted to acquire the feedback to achieve the objective through this survey –

Type of Actors	Number of Unique organizations	Questionnaire Shared with	Response Received	% Of Response
Manufacturing Organizations (shipper)	72	200	180	90%
Transporters	30	90	80	89%
Truck Manufacturing Organizations	6	6	6	100%
Warehouse Service providers	12	22	18	82%
Consulting Organization	11	15	13	87%
Academicians	5	6	5	83%
Total	136	339	302	

Table 4.1: Types and number of actors contacted and responded

Source – Authors composition

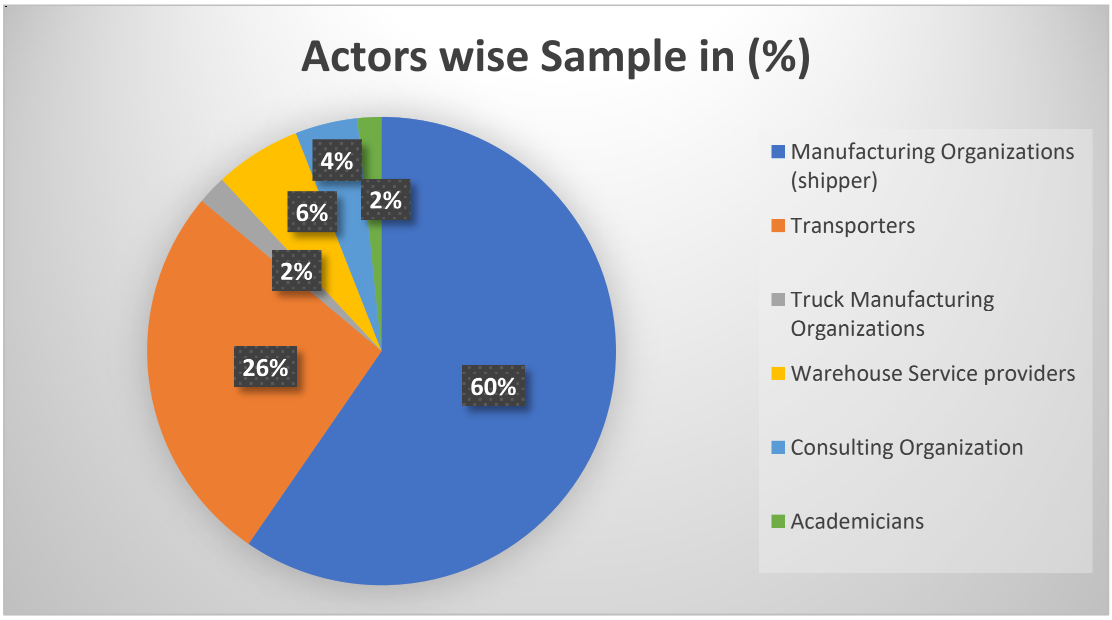


Figure 4.2: This figure described the percentage of Actors interviewed

Source: Author's composition

While choosing the sample not only sector, but position or profile also plays a vital role. Sample taken from higher management, middle level management and operational level executives. Operational level and middle level having knowledge and experience since they are handling the material loading and unloading day to day basis. From senior management quality feedback is expected. Category wise profile shared through Table Number 4.2.

Position	Number of Respondents	Respondents in terms of %
VP SCM/ Head SCM	14	5%
GM/ DGM/ AGM/ Head of Logistics	26	9%
Head of Transport	38	13%
Regional Logistics Manager	61	20%
Logistics Strategy maker/ Transformation	12	4%
Analyst and consultants	23	8%
Professor/ Associate Prof/Asst. Prof	5	2%
Truck and WSP owners	45	15%
Operational executive	78	26%
Total	302	100%

Table 4.2: Respondents profile

Source – Author’s composition

To get proper responses from the survey relevant experience plays an important role. It is essential to get right response from the professional who are having vast experience in vehicle fill rate in road freight transportation, focusing on Indian FMCG sector. Experience in India plays a vital role compared to global experience. Table 4.3 shows the level of experience the respondent is having -

Experience in Years	Number of Respondent	in Percentage
3 to 5 years	45	15%
5 to 10 years	82	27%
10 to 15 years	125	41%
16 to 20 years	36	12%
Above 20 years	14	5%
Total	302	100%

Table 4.3: Experience of the respondents

Source: Author’s composition

4.3.1 Sampling Adequacy Analysis

To have holistic view and analysis based on statistical techniques sample size was chosen very carefully. As suggested by Kline (2005, 2015), sample size 100 is treated as small, sample size between 100 and 200 is medium, 300 and above is good sample size for analysis. Suhr (2006) in his study suggested that sample should not have lesser than 5:1 ratio compares to the item (independent variables). For this study we are having 28number of variables. Hence the sample size should be 28 multiplied by 5; 200. But for this study we have collected 302 number of samples, which is fulfilling both the criteria mentioned above. Hence the sample size is good and adequate for statistical analysis.

To determine sampling adequacy two measures taken into consideration – the Kaiser-Meyer-Olkin (KMO) measure and the Bartlett's test of sphericity. KMO test check ensures the correlation is zero. Bartlett's test compared the partial correlations and observed the correlation between the variables taken for the test. KMO value <0.5 is not acceptable. KMO value between 0.6 to 0.7 is taken into consideration but with caution. If the KMO value is lying between 0.8 to 1 then it will be considered as sampling is adequate. In case of Bartlett's test of Sphericity if p value is less than 0.05 then it is considered as significant.

For our study, the test result for Kaiser-Meyer-Olkin measure of sampling Adequacy is .903. Hence as per above criteria it is proven the sampling is adequate.

In this study Bartlett's test of sphericity significance came to .000. Hence it is proved it is significant. Plz find the details below -

KMO and Bartlett's Test

Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		.903
Bartlett's Test of Sphericity	Approx. Chi-Square	16317.180
	df	378
	Sig.	.000

Figure 4.3: Result of KMO and Bartlett's Test

Source – IBM SPSS Version 22.0

4.3.2 Examining Reliability of Instrument

Questionnaire design ensures the success of the survey-based research work. Hence reliability test for questionnaire is necessary so that this data can be used for further analysis. Reliability ensures the consistency, how much the data is consistent for a research work. To decide the reliability of the construct of vehicle fill rate in road freight transportation for FMCG industry, dependability of the data is analysed. Two most common and prominent reliability statistics are standard error of measurement and reliability of coefficient – Cronbach alpha. Cronbach alpha is a reliability coefficient, that gives a method to measure the internal consistency for tests and measures. It indicates how well the variables in a set are positively correlated to each other. Reliability is used to ensure the degree of consistency, accuracy and stability of the data collected for this study. As per Ercan (2007), for 3-point or 5-pointer Likert scale Cronbach alpha is suitable for measuring the reliability. Value of Cronbach alpha lying between 0.7 to 0.9 is a indicating towards reliability. For our study the value of Cronbach alpha is 0.744. Hence, we can consider it as a reliable for our constraints related to the Vehicle Fill rate in road freight transport of FMCG industry. Table 4.4 shows the reliability of our study -

No. Of items	KMO Value	Bartlett's test of Sphericity	Reliability (Cronbach alpha)
28	0.903	0.000	0.744

Table 4.4 – Sampling Adequacy Results

Source – IBM SPSS Version 22.0

4.4. Identification of constraints of Vehicle Fill Rate in Road Freight Transport for FMCG sector

Based on Existing literature and input from subject matter experts the constraints are identified, which are impacting the vehicle fill rate in road freight transportation of FMCG sector. Based on the nature of the constraints, constraints are categorised, and sub categorised. The categories and sub-categories constraints are illustrated in the table number 4.5. The constraints are categorised in eight number of categories; Structural Constraints of Truck (SCT), Vehicle Related Constraints (VRC), Box Related Constraints (BRC), Cargo Related Constraints (CRC), Load Related Constraints (LRC), Order Related constraints (ORC), Packaging Related Constraints (PRC) and Inter/Intra Coordination and collaboration Constraints (ICC) –

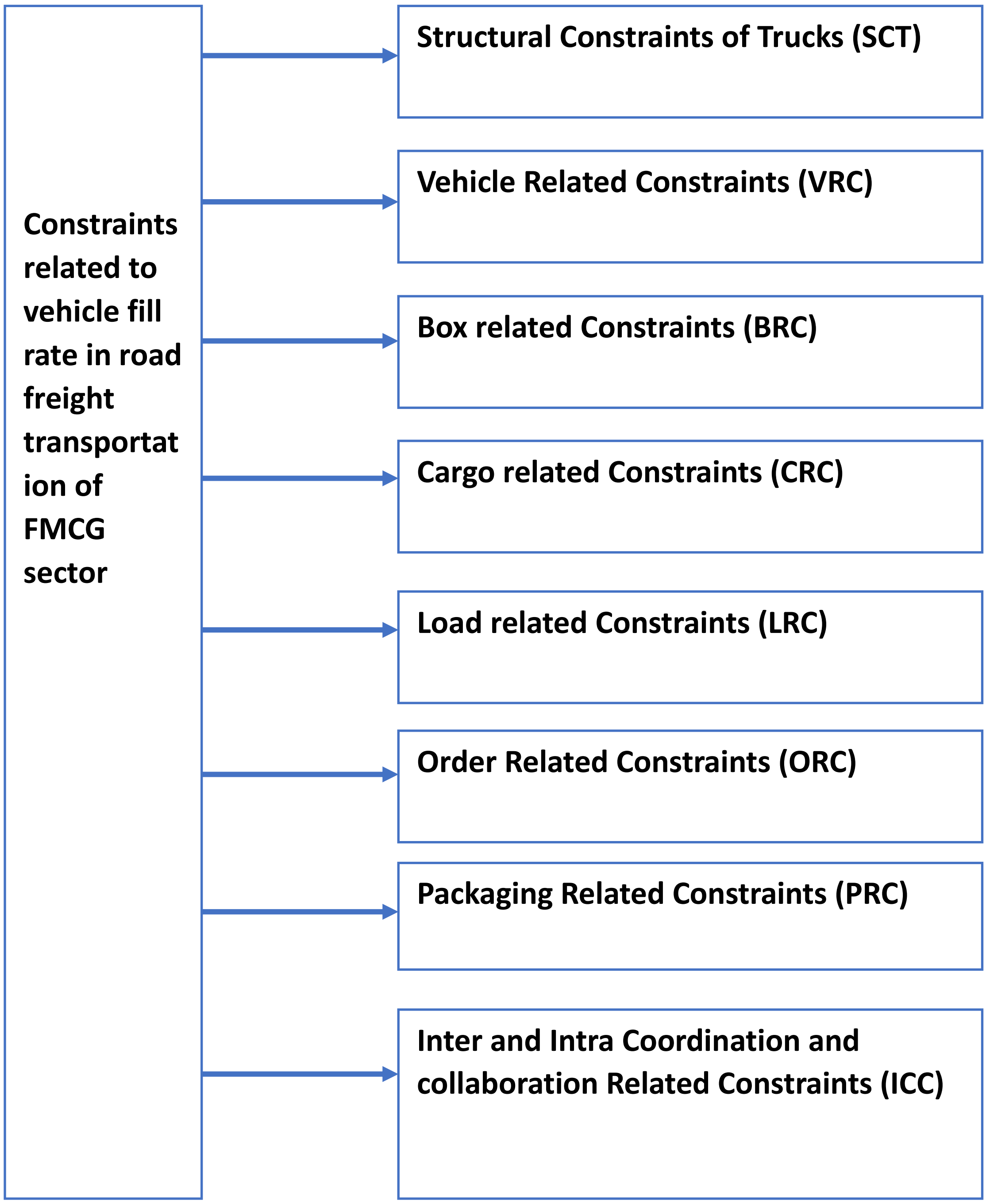


Figure 4.4: Constraints related to vehicle fill rate in road freight transportation of FMCG sector

Source – Author's composition

All these above-mentioned constraints are having sub constraints, which will be described below –

4.4.1 Structural Constraints of Trucks (SCT)

From the response of the industry experts, it was evident that structural issue of the trucks plays a vital role in vehicle fill rate in India for FMCG sector. But in the existing literature it is very much silent since developed country is not facing this issue. Developed countries having standard size of vehicle along with standard carrying capacity. But unfortunately, in India truck size, truck carrying capacity is not standardized. Eidhammer and Anderson, (2014), shared the similar concern for several Norwegian cities. Under this category three sub-categories are there: variability in truck size (SVTS), variability in truck carrying capacity (SVTC), usage of angle, nut-bolt inside truck (SUAT). In developed countries size of container is standardized and using palletized load to secure the cargo and maximize the load-ability. But in India unfortunately size of the truck is not standardized except export container. In India the usage of container is less compared to open body trucks. Chassis of trucks are purchased by the transporters from the manufacturer and building the structure or container as per their wish with the help of fabricators. Hence it was observed that for same container type container size is varying along with that carrying capacity is also varying due to usage of material in trucks. Since nonstandard process is followed in vehicle body making, the volumetric capacity and weight carrying capacity of the trucks both are varying. Along with this some other structural issues are also there in Indian trucks which are impacting the vehicle material carrying capacity –

Type 1- Fixed horizontal Angles in a truck creating issue while loading the top layer. It reduces the material carrying capacity of the vehicles.

Type 2- Fixed vertical bar in a truck creating issue while loading the top layer. It reduces the material carrying capacity of the vehicles.

Type 3 - Angle on face wall with extrusion on floor in a truck creating issue while loading the 1st layer. It reduces the vehicle fill rate. Impacting top to bottom all the row in 1st layer towards cabin of the truck

Type 4 - Wide angles with extrusion on floor of a truck creating issue while loading the 1^{st} layer. It reduces the vehicle fill rate. Impacting top to bottom all the row in 1^{st} layer towards cabin of the truck

Apart for that few more types of structural issue were found in a truck which are used by FMCG organizations.

These are the few infrastructural constraints which are impacting the vehicle fill rate and these constraints are exclusive in India for FMCG sector since very limited literature is available regarding this.

4.4.2 Vehicle Related Constraints (VRC)

From the existing literature and comment from experts it is evident that vehicle itself worked as a constraint. Under this constraint three sub-categories are there - weight limits (VWLT), weight distribution constraints (VWDC) and Load limit by volume (VLLV). In the literature review below mentioned authors identified this as one of the constraints in vehicle Fill rate. Hameed and Prathap (2018), Alonso et.al. (2017), Alonso et. al.(2019), Krebs and Ehmke (2021), Bortfeldt and Wäscher (2013), Che et al. (2011; Tian et al. (2016); Respen and Zufferey, (2017); Kumar and Kansara, (2018), Dereli and Das, (2010); Liu and Chen, (1981); Gehring and Bortfeld, (1997); Terno et al., (2000); Chan et al., (2006); Egeblad et al. (2010); Liu et al. (2011), McKinnon (2010), McKinnon (2015), Santén (2015), Fugate et al. (2009), Nascimento et al., (2021).

For any vehicle weight carrying capacity (VWLT) is acting as a constraint. Compared to other developed countries the truck carrying capacity was lesser. It is not only depending upon government who is fixing the weight carrying capacity of the vehicle, but also upon infrastructure of the country. Truck manufacturing organizations are also party to it. Government of India revised the truck load carrying capacity in 2018. As per that revision same truck can carry more than 25% load compared to earlier. But FMCG organizations are unable to fetch full benefits from this since FMCG products are more voluminous compared to weight-based product. Hence another important sub criteria is volume wise carrying capacity of the truck (VLLV). FMCG products are packed in boxes and not very heavy by nature hence volume of the boxes plays a vital role in vehicle fill rate. Volumetric carrying capacity of truck is depending upon the height, length, and width and of the truck. In India state wise truck dimensions are different hence volumetric capacity of the truck is also different. During primary data collection it was found that Andhra Pradesh registered truck is having higher length but lesser side support. Similarly Punjab registered truck is having higher side support compared to length. Hence it is clear volumetric capacity of trucks are different and it acted as once of the constraint for fill rate of FMCG products.

Another important constraint in this category is weight distribution constraints (VWDC). Axle of the vehicles plays an important role in vehicle fill rate. Depending upon the axle carrying capacity of the vehicle is determined. Many authors focused upon this weight distribution constraints. Depending upon axle placement of the material is happened and vehicle fill rate is impacted due to that. Depending upon density of the material, cargo was placed inside the truck. Not only vehicle fill rate quality of material delivery is also depending upon load distribution in a truck. Scientific methods should get followed while filling the truck depending upon axle load. For safety reasons also it is important.

4.4.3 Box related Constraints (BRC)

Most of the cases FMCG products are using corrugated boxes as an outer packaging to carry the material. Hence rectangular or square shaped box plays a significant role in vehicle fill rate. We have very enriched literature to identify Box related constraints (BRC) as one of the constraints for vehicle fill rate. Experts opinion also having the same view regarding the boxes. George and Robinson in 1980, Bischoff and Marriott in 1990, Moura and Oliveira, 2005, Portmann in 1990, Bischoff et al. in 1995, Bortfeldt and Gehring in 1997, Lim et. Al. 2013, Patil and Patil, 2016, Layeb et al. 2017, 2013, Pino et al. in 2013, Bortfeldt and Wäscher in 2013, Ngoi et al. in 1994, Santén in 2015, Nascimento et al. in 2021. Four important sun categories are there, under this category of constraints. Those are - Loading Priorities (BLPR), Orientation Constraints (BORC), Stacking Constraints (BSTC), Positioning Constraints (BPOC).

Loading priorities (BLPR) are depending upon nature of the product. If any lighter material is kept under a heavy material, then obviously the lighter material will be damage. Similarly, FMCG products are having many types of packaging, like pet jar should not kept at lower level while sending the mix load to avoid damages to the outer packaging material. Liquid material should not keep in the lower stack compared to solid product, since there is chances of seepages and natural pilferage. Loading priorities will be set based upon the nature of the material or nature of the packaging material. Boxes not only ensure the quality of the delivery, it is also acted as one of the constraints in vehicle fill rate. Certain priorities or rules are set based upon these parameters to ensure quality of delivery and reduces damages to the material, hence loading priorities acting as a constraint for vehicle fill rate in road freight transport for FMCG sector.

Orientation constrain (BORC) is another important constraint which is impacting the vehicle fill rate. Rectangular boxes having this orientation problem. In general, six types of orientations are possible in a rectangular share box. But all of them is not fit for movement of the boxes. More orientation is allowed to fit in a vehicle more combination is expected and expecting more gaps inside the stack, which will result lesser vehicle fill rate, and which is more prone to damages. Two types of orientation are preferred according to packaging team since in a corrugated box strength are there in the edges. Hence it is also acting as one of the constraints for vehicle fill rate.

Stacking Constraints (BSTC) is one of the constraints which is related to corrugated box. Each corrugated box having certain capacity to carry the weight. Beyond that bulging or buckling issue observed in a stack. Hence stack height is determined by packaging team. Strength of the corrugated box is depending upon number of plies is used to make the corrugated box. Paper strength decided how many stacks will be there in a vehicle. Static load and dynamic load are different in case of stacking. Higher number of plies resulting a greater number of stacks but also attract higher spent. Hence spent vs stack height is important decision to make and it is also impacting the vehicle fill rate. More number of stacks helped to fill the truck.

Positioning Constraints (BPOC) is another important factor in box loading. What will be the position of the box while loading the material is another important question to ask. Many types of algorithms are acting as a solution to decide the same but which one to choose and why it is also important to finalise the solution. Positioning the boxes inside the truck in an efficient manner helps in good vehicle fill rate, hence it is also identified as a constraint for vehicle fill rate in road freight transport for FMCG sector.

4.4.4 Cargo related Constraints (CRC)

From the existing literature and opinion of experts it was evident that cargo related constraints is one of the constraints which is impacting the vehicle fill rate. Under this category of constraint four sub constraints are available - Complete Shipment Constraints (CCSC), Allocation Constraints (CALC), Multi Drop Operation (CMDO), Service Requirements (CSRM). Following authors discussed about the constraints in their studies - Schöneberg et al. (2011), Bortfeldt and Wäscher (2013),Santén and Rogerson (2014), Treitl et al. (2014), Islam et al. (2019), Nascimento et al. (2021). Hence it is evident that it is one the constraints which is impacting the vehicle fill rate in road freight transportation.

Complete Shipment Constraints (CCSC) is described by Nascimento et al. (2021) in their studies. For this constrain truck size or truck carrying capacity is not important, sending full consignment in one truck or container is important. In a container all the items should get loaded hence it is acting as a constraint. If it is possible to ship out this material with other product it might give good vehicle fill rate compared to complete shipment in a truck. Hence it is treated as constraint.

Allocation constraint (CALC) is described by Bortfeldt and Wäscher (2013) in their study. It is similar to complete shipment constraints. Only difference is it is applicable for multi container loading problem. Here allocated SKU should go together to the customer irrespective of number of containers. One allocated material should reach together in one consignment which may causes lesser fill rate.

Multi Drop Operation (CMDO) is described by many authors in their studies. Whenever in any shipment multi drops are there, it is impacting vehicle fill rate. For multi drop shipment goods should be kept according to drop points, hence taking extra space while arranging the goods and for FMCG products delivery, multi point delivery is a very common feature. Multi point delivery in one side helped to optimize form loads for the vehicle, on other hand multipoint delivery acting as a constraint for vehicle fill rate.

Service Requirements (CSRM) is one the constraints for vehicle fill rate in road freight transport in FMCG sector. Sometimes customer required some special service while taking the delivery. It is also impacting the fill rate, but it is depending upon the service required by the customer while taking the delivery.

4.4.5 Load related Constraints (LRC)

Depending upon the existing literature and opinion of the expert on vehicle fill rate another major constraint is identified. Load related constraints is one of the most popular constraints on which many researchers worked. Researchers like Alonso et. al.(2019),Bortfeldt and Wäscher (2013), Landschützer, et al. (2015), Ramos et al. (2014), Bischoff (1991); Eley (2002); Pisinger (2002); de Castro et al. (2003); Moura and Oliveira (2005); Parreño et al. (2008); Egeblad et al. (2010); Junqueira et al. (2012), Abdou and Elmasry (1999), Carpenter and Dowsland (1985), Christensen and Rousoe (2009), Gendreau et al. (2006), Fuellerer et al. (2010), Gehring and Bortfeldt (1997), Mack et al. (2004) worked on load related constraints. Under these category four constraints are identified: Stability Constraints (LSTC), Complexity Constraints (LCOC), Product Mix (LPRM), Land Orthogonal placement and no overlap (LOPO). This constraint is related to loading activity of the material.

Stability Constraints (LSTC) is one of the constraints comes under load related constraints. Stacking stability is one of the major concerns while sending the material through trucks. Arrangement of material inside the trucks are depending upon stability of the stack. Static stability and dynamic stability of the stack is different. In static stability one can go up to 10 or 11 high depending upon stacking norms but for dynamic stability of the stack height might come lesser than the static one. During motion of the truck goods are also moving along with the truck. While trucks are using the breaks materials are moving towards the front of the vehicle or in bumper materials are moving straight. Hence dynamic stability is important while planning the stack height norms inside the trucks. This norm is also acted as a constraint in vehicle fill rate. Since FMCG products are transported in a box, stability constraints play an important role in vehicle fill rate.

Complexity Constraints (LCOC) is described by Bortfeldt and Wäscher (2013), which is practical by nature and supported by other experts of industry. In most of the research solutions are produced by algorithm supported by software or other ERP system but loading in that pattern without supporting of computer is complex for any human being. Every loading pattern is unique hence to load the material in a truck loader are taking time. Though this loading pattern creating more space to load the material optimally in a truck, but it is time consuming activity compared to regular loading. Hence complexity constraint considered as a constraint to fill the vehicle.

Product Mix (LPRM) is one of important factor for any FMCG product despatches. In general, most of the FMCG products are moving with high product mix. Product mix is depending upon the ordering pattern of the customer. Most of the cases FMCG goods despatches are happening with a mix of SKU. All FMCG SKUs (Stock keeping unit) are not having the same dimension or same weight, hence if the number of mixes is increasing the complexity for vehicle fill rate is also increasing. Different dimension with different weight is creating hindrance to optimize the vehicle fill rate. Since FMCG products are despatched in mix the despatches are always suboptimal by nature and product mix acted as a constraint.

Orthogonal placement and No overlap (LOPO) are also one of the constraints for vehicle fill rate. As mentioned above FMCG products are despatched in corrugated boxes. Hence six types of placements are possible for any boxes but due to nature of the product upside right policy is preferred, which is only possible for Orthogonal placement. Orthogonal placement of the boxes reduces the possibility of best fitment inside the truck. Since the dimensions of the boxes are different no overlap of the boxes also creates the constrain in filling the trucks.

4.4.6 Order Related Constraints (ORC)

One of the major constraints in vehicle fill rate is order related constraint. Order related constraint is related to order which is received from the customer. Customer plays a vital role in order management and in vehicle fill rate. Vehicle fill rate optimization process starts with order management. Experts from industry hence indicating the same as one of the constraints. Existing literature also indicates the same as one of the constraints. Following authors indicates order related constraints in their paper - Krebs and Ehmke (2021), Islam et al. (2019), Santén and Rogerson (2014), Schöneberg et al. (2011), Treitl et al. (2014). If orders are coming as per available vehicle type, then it is win-win condition for both the manufacturer and customer. Since it is not happening as per expectations it is acted as order management constraint. Under this order management constraints four sub constraints are merged - variability of order size (OVOS), Routing of deliveries (ORDC), JIT/frequency of deliveries (OJIT), Unloading Priorities (OULP). All these constraints will be discussed in brief –

Variability of order size (OVOS) is one of the important constraints comes under order related constraint. Customer gives the order as per their need. Hence quantity of the order or SKUs are not uniform for all the orders. Variability of order size makes the plan difficult of transport planner. Transport planner can plan better if the order is uniform. They can deploy the truck as per need and optimization is possible since order is coming with uniformity. If fixed days of invoice is possible it helped to plan the truck in a better manner as per the order size. Since customer is not selling the product with a uniformity, they are also not giving the order uniformly. Hence variability of the order size creates difficulty in vehicle fill rate.

Routing of deliveries (ORDC) helps to fill the truck in a better manner. But route planning is one of the difficult activities in vehicle fill rate. To have better vehicle fill rate route planning helped a lot. Multiple customers in same route are clubbed in a truck and delivered in a particular agreed day. Since the order quantity is not uniform multi drop along with proper route planning helped to fill the truck. But routing of the deliveries is also depending upon many factors like agreement with the customer on fixed days of invoicing in a week, weekly closure of the customer, credit control or cash management, vehicle availability and many more. Building all these above-mentioned constraints in an algorithm is a difficult task. Hence Routing of deliveries treated as one of the constraints in vehicle fill rate for FMCG sector in India.

JIT/frequency of deliveries (OJIT) is another important identified constraint for vehicle fill rate. Working capital management is one of the critical activities for any customer or distributors. Frequent delivery helped in working capital management for the distributor. Fixed days of invoicing and just in time delivery (JIT) helped in better fill rate but the truck size is reduced which has a reverse impact on transportation cost. To avoid higher freight cost clubbing is better option hence fixing the frequency of delivery/ JIT is important, which is acting as a constraint for vehicle fill rate in road freight transportation. For FMCG sector it is very much relevant.

Unloading Priorities (OULP) is another important constraint for vehicle fill rate. To have better vehicle fill rate multipoint delivery is planned. But for that one need to load the vehicle in a sequence of unloading point and for that proper route planning is required. But unloading priorities acted as constraints. If there is any unloading priority for any customer, then route planning will not work as per plan, and it is also impacting the fill rate since same material is to be loaded in a separate place in a truck to deliver the material separately. This segregation of material leads to less fill rate in a truck.

4.4.7 Packaging Related Constraints (PRC)

Quality delivery to the end customer is not only depending upon fill rate of the truck, but also upon Packaging of the material. Good packaging ensures the quality of the material along with good vehicle fill rate. For that not necessary the best quality packaging is required. Planned packaging also helped to deliver better fill rate. But it was evident that quality packaging ensures better fill rate of trucks since stacking height is dependent on the quality of the packaging material. Authors like Layeb et al. (2017), Moura and Oliveira (2005), Santén and Rogerson (2014), Lin et al., (2014) mentioned packaging while sharing facts related to vehicle fill rate. Experts from the industry also having the same opinion about packaging. space-In efficient packaging (PSIP), use of shelf-ready packaging (PUSR), product design - LBH of Boxes (PDPC) are the three constraints grouped under the Packaging related constraint (PRC).

Space-In efficient packaging (PSIP) is acted like a constraint for vehicle fill rate. FMCG products are mostly packed into boxes, hence packaging plays a crucial role to transport material. Stacking the box is dependent on packaging of the material. Without stacking the material in a truck optimized delivery is not possible. To put the material inside the boxes space is required. Robotic hand required more space in a box compared to manual packing, but both the cases space is required to pack the material. More space leads to high buckling issues in a stack since air unable to hold the box in a tight manner. Lesser space in a box helped to stack it properly inside the vehicle, also lesser movement inside the box ensures the quality of material. Hence space inside the boxes acted like a constraint in vehicle fill rate. Efficient space management through packaging leads to better fill rate of truck. Unnecessary space or inefficient packaging leads to lower vehicle fill rate.

Shelf-ready packaging (PUSR) is new form of packaging which used by some of the organization in India. In this particular case of packaging product is ready to go to shelf in an immediate basis and the shelf-ready packaging is collapsible by nature and it needs reverse logistics. But what will be the dimension of this packaging is important since product mix is very high and dimension of these FMCG products are varying a lot along with their weight. Hence shelf-ready packaging (PUSR) is acting as a constraint for vehicle fill rate. Moreover, it is impacting the fill rate in return load also as reverse logistics is required to bring back that shelf ready packaging to factories or warehouse.

Design of products - LBH of Boxes (PDPC) is very important aspect for vehicle fill rate. Volumetric vehicle fill rate is calculated based upon length, breadth, height (LBH) of the vehicle in comparison to length, breadth, height (LBH) of the material kept inside the truck. Hence it is eminent to design the LBH of the product to have good fill rate. Uniform LBH helps to achieve good fill rate, but uniform dimension is not always possible since dimension of the boxes is dependent upon many factors. Hence designing of the packing boxes plays a very significant role in vehicle fill rate. How many items to keep in a box to achieve high vehicle fill rate is also comes under product designing. Hence Design of product is acting like a constraint for vehicle fill rate.

4.4.8 Inter and Intra Coordination and collaboration Related Constraints (ICCC)

Not only vehicle fill rate coordination plays a very important role to achieve any target or Key performance indicator. (KPI). Without coordination job it is difficult to achieve any target since many inter dependencies are there in a process of logistics. Existing literature also having same view along with industry experts. Landschützer, et al. (2015), Rogerson and Sallnas (2017) shared their view on coordination for vehicle fill rate. Within the organization, outside the organization, functional coordination all of them acted as a constraint unless proper coordination is there. Inter-functional coordination within organization (IFCW), inter-Organization coordination (IIOC), within functional coordination within organization (IWFC) all these constraints come under inter and intra coordination and collaboration related constraints (ICC) as sub constraints.

Inter-functional coordination within organization (IFCW) is one of the major constraints for vehicle fill rate. For better fill rate coordination is required between various function within the organization. Vehicle fill rate is not only beneficial for supply chain team it is beneficial for other function as well. Without cooperation of sales team Supply chain will not be able to achieve good fill rate since sales team is custodian for sales and they only can influence the customer or distributor for better fill rate through optimized order. Similarly, some other functions are there who are influencing the fill rate. If sales team is not giving orders as per vehicle to optimize the vehicle fill rate and supply chain team is not coordinating with the sales team to get further order, there will be no orders and vehicle fill rate will be impacted. Hence inter functional coordination within organization will act like a constraint for vehicle fill rate in road transportation for FMCG product. Since the value of the FMCG products are not much coordination part takes care the credit or cash control part which is also a very important parameter for optimizing the fill rate.

Inter-Organization coordination (IIOC) will also act as a constraint for vehicle fill rate. Sharing of vehicle, back freighting of the vehicle between the organization plays a significant role in vehicle fill rate. But to ensure the load optimization through vehicle sharing or back loading needs lot of coordination between the organization. Hence inter-organization coordination acting like a constrain for vehicle fill rate.

To have good vehicle fill rate within supply chain function many functions are working together. For an example planning team is responsible to ensure stock planning and stock availability at right time, order management team is responsible for capturing right order from the customer, production team produces the material as per need and logistics team ensures the delivery with a good fill rate. Hence from the above-mentioned example it is very much evident that without proper coordination within the function in an organization good vehicle fill rate is not possible. Hence within functional coordination within organization (IWFC) is acting like a constraint for VFR.

4.5 Categories and sub-categories of Constraints of Vehicle Fill rate in Road Freight Transport

Below table depicts the categories and subcategories of constraints along with relevant references from the literature

Category	Category Code	Sub-Category	References
Structural Constraints of Truck (SCT)	SVTS	Variability in Truck Size	Eidhammer and Anderson (2014), Fugate et al. (2009)
	SVTC	Variability in Truck Carrying Capacity	
	SUAT	Usage of Angle, nut-bolt inside Truck	
Vehicle Related Constraints (VRC)	VWLT	Weight Limits	Hameed and Prathap (2018), Alonso et.al. (2017), Alonso et. al.(2019), Krebs and Ehmke (2021), Bortfeldt and Wäscher (2013), Che et al. (2011); Tian et al. (2016); Respen and Zufferey (2017); Kumar and Kansara (2018), Dereli and Das (2010); Liu and Chen (1981); Gehring and Bortfeld (1997); Terno et al. (2000); Chan et al. (2006); Egeblad et al. (2010); Liu et al. (2011), McKinnon (2010), Santén (2015), Fugate et al. (2009)
	VWDC	Weight Distribution Constraints	
	VLLV	Load limit by volume	

Box Related Constraints (BRC)	BLPR BORC BSTC BPOC	Loading Priorities Orientation Constraints Stacking Constraints Positioning Constraints	George and Robinson (1980), Bischoff and Marriott (1990), Moura and Oliveira (2005), Portmann (1990), Bischoff et al. (1995), Bortfeldt and Gehring (1997), Lim et. Al. (2013), Patil and Patil (2016) ,Layeb et al. (2017), Pino et al. (2013), Bortfeldt and Wäscher (2013), Ngoi et al. (1994), Santén (2015)
Cargo Related Constraints (CRC)	CCSC CALC CMDO CSRM	Complete Shipment Constraints Allocation Constraints Multi Drop Operation Service Requirements	Bortfeldt and Wäscher (2013), Islam et al. (2019) ,Santén and Rogerson (2014), Schöneberg et al. (2011), Treitl et al. (2014)

Category	Category Code	Sub-Category	References
Load Related Constraints (LRC)	LSTC LCOC LPRM LOPO	Stability Constraints Complexity Constraints Product Mix Orthogonal placement and No overlap	Alonso et. al.,(2019),Bortfeldt and Wäscher (2013), Landschützer, et al. (2015), Ramos et al. (2014), Bischoff (1991); Eley (2002); Pisinger (2002); de Castro et al. (2003); Moura and Oliveira (2005); Parreño et al. (2008); Egeblad et al. (2010); Junqueira et al. (2012), Abdou and Elmasry (1999), Carpenter and

			Dowsland (1985), Christensen and Rousoe (2009), Gendreau et al. (2006), Fuellerer et al. (2010), Gehring and Bortfeldt (1997), and Mack et al. (2004)
Order Related constraints (ORC)	OVOS ORDC OJIT OULP	variability of order size Routing of deliveries JIT/frequency of deliveries Unloading Priorities	Krebs and Ehmke (2021), Islam et al. (2019), Santén and Rogerson (2014), Schöneberg et al. (2011), Treitl et al. (2014)
Packaging Related Constraints (PRC)	PSIP PUSR PDPC	space-In efficient packaging use of shelf-ready packaging Design of products (LBH of Boxes)	Layeb et al. (2017), Moura and Oliveira (2005), Santén and Rogerson (2014), Lin et al. (2014),
Inter and Intra Coordination and collaboration Related Constraints (ICC)	IFCW IIOC IWFC	inter-functional coordination within organization inter-Organization coordination within functional coordination within organization	Landschützer, et al. (2015), Rogerson and Sallnas (2017),

Table 4.5: Categories and sub-categories of constraints related to vehicle fill rate

Source: Composition of author

4.5.1 Application of DEMATEL, AHP and Fuzzy AHP

In this section data analysis is discussed in depth for the constraints impacting the vehicle fill rate in road freight transport for FMCG sector. Collected data has been analysed by using SPSS 22.0 and MS-excel. To analysing the data different statistical tool and techniques are deployed. The analysis is started with DEMATEL, which helped to understand the influencing and influenced issue – the cause-and-effect relationship. For identify the ranking of the constraints and sub-categories of sub constraints AHP and FAHP is used.

In the present study to fulfil objective 1 - to understand the nature and status of the constraints affecting the Vehicle Fill Rate in road freight transport of FMCG sector in India, three analysis technique have been applied. To have a comprehensive analysis of the identified constraints mentioned above DEMATEL, AHP and FAHP are applied. DEMATEL, AHP and FAHP helped to assess the issues impacting the Vehicle Fill Rate in road freight transport of FMCG sector in India. These methods are chosen over other MCDM method since these methods are proven method and frequently used in the study of supply chain. In this study the objective is to identify the ranking of the constraints for vehicle fill rate. Hence direct comparison between constraints is important. Other MCDM method like Best-Worst Method (BWM) is not used here, since it is working depending upon certain criteria. For our study no such criteria were fixed hence for our study BWM method will not be applicable. For our study direct comparison between the constraints will give better ranking. As per Razaei (2020), FAHP gives better consistency compared to other MCDM techniques where pair wise comparison is important. Since method is based on full pairwise comparison and data is available FAHP gives better consistent result compared to others.

DEMATEL was applied first, to categorise the constraints as influencing constraints and influenced constraints. For identifying the cause-and-effect relation between the constraints this MCDM technique DEMATEL is applied. Post that, AHP and FAHP are applied to finalise the ranking of the constraints and their sub-categories of constraints. For DEMATEL method 5-point scale was used and for AHP and FAHP 7-point scale was used.

4.6 Analysis of constraints by using DEMATEL

5-point scale is used by the expert to share their opinion on the influence of one constraint over another, which is mentioned in table 4.6.

Scale	0	1	2	3	4
Level of Influence	No influence	Low influence	Medium influence	High influence	Very High influence

Table 4.6: Comparison Scale for DEMATEL method

Table 4.7 presents the responses that were reached by averaging and an underlying direct relation framework (D).

	SIT	VRC	BRC	CRC	LRC	ORC	PRC	ICCC	D
SIT	0.14	0.25	0.31	0.18	0.35	0.20	0.35	0.23	**2.00**
VRC	0.11	0.06	0.15	0.09	0.20	0.10	0.16	0.10	**0.95**
BRC	0.13	0.10	0.08	0.08	0.12	0.13	0.12	0.10	**0.85**
CRC	0.10	0.10	0.15	0.04	0.15	0.09	0.15	0.09	**0.88**
LRC	0.17	0.10	0.12	0.09	0.09	0.10	0.13	0.10	**0.89**
ORC	0.12	0.12	0.21	0.10	0.21	0.07	0.21	0.15	**1.20**
PRC	0.14	0.19	0.13	0.09	0.14	0.10	0.09	0.14	**1.02**
ICC	0.13	0.17	0.22	0.14	0.19	0.20	0.23	0.08	**1.36**
R	**1.03**	**1.08**	**1.36**	**0.81**	**1.45**	**0.98**	**1.44**	**0.99**	

Table 4.7: Total relation matrix

Source – DEMATEL Analysis

Post that the normalised direct-relation matrix, Y build and transformed to total-relation matrix. This total relation matrix is shared in table 4.7 where the row sums are represented by Di and column sums by Ri. Di depicts the total effects of constraint i to the other constraints and Rj depicts net influence received by j issue from other constraints. The prominence (Pi), the net effect (Ei) is calculated after D and R have been determined for each row and column.

code	D	R	D+R	D-R	Identify	Rank
SIT	2.001	1.034	3.034	0.967	Cause	1
VRC	0.951	1.083	2.035	-0.132	Effect	7
BRC	0.854	1.363	2.217	-0.509	Effect	5
CRC	0.876	0.807	1.683	0.069	Cause	8

LRC	0.886	1.448	2.334	-0.562	Effect	4
ORC	1.201	0.980	2.181	0.220	Cause	6
PRC	1.016	1.444	2.460	-0.428	Effect	2
ICC	1.360	0.985	2.345	0.375	Cause	3

Table 4.8: Exhibits the cause-and-effect relation of eight key criteria.

Source – DEMATEL Analysis

The effect of each constraint are determined by the value of Ei=D-R. If value of Ei is positive, then that constraints treated as cause / reason and negative value treated as effect or impact. The cause and effect has been shared through above table number 4.8.

4.7 Analysis of constraints and fixing the rank of the constraints by using AHP and FAHP

In decision making where multiple criteria is there, MCDM is preferred technique. Out of many MCDM technique AHP considered both qualitative and quantitative aspect. AHP having some complication since measurement scale is not balanced, impreciseness and subjectivity is there. The impreciseness and subjectivity are addressed through Fuzzy methodology. Fuzzy triangular numerals (TFN) are used recurrently and shared below in table 4.9.

Preference rating	**TFNs**
Equal Importance	(1,1,1)
Low Importance	(1,3,5)
Average Importance	(3,5,7)
High Importance	(5,7,9)
Extremely High Importance	(7,9,9)

Table 4.9: shares the TFNs (Triangular Fuzzy Numbers) used to evaluate the criteria under the AHP and Fuzzy AHP methods.

4.7.1 Measure of consistency and Ranking of constraints by using AHP

For 8 main categories of constraints pair wise comparison was done by the experts by using the Saaty scale for AHP. Table 4.10 presented the normalised pair wise comparison matrix for the eight categories of constraints. The normalized weights of the main criteria were calculated and appropriately exhibited in table 4.10. That table also presents the rank for each criterion. For the key criteria, λ max was estimated to be 8.416, Consistency Index (CI) is 0.059, Consistency Ratio (CR) was calculated to be 0.042. As the value of CR is less than 0.10, the suitability of data is indicated.

	SIT	VRC	BRC	CRC	LRC	ORC	PRC	ICCC
SIT	0.488	0.605	0.300	0.438	0.346	0.441	0.292	0.586
VRC	0.098	0.121	0.167	0.188	0.192	0.189	0.208	0.117
BRC	0.054	0.024	0.033	0.021	0.038	0.013	0.042	0.023
CRC	0.070	0.040	0.100	0.063	0.115	0.063	0.125	0.039
LRC	0.054	0.024	0.033	0.021	0.038	0.021	0.042	0.039
ORC	0.070	0.040	0.167	0.063	0.115	0.063	0.125	0.039
PRC	0.070	0.024	0.033	0.021	0.038	0.021	0.042	0.039
ICC	0.098	0.121	0.167	0.188	0.115	0.189	0.125	0.117

Table 4.10: Normalized Weights of the key criteria (AHP)

Source – AHP analysis

The coefficient vector for criteria weights for the constraints is determined and presented in below table number 4.11.

Main Criteria	Criteria Weight	Rank
SIT	8.95	1
VRC	8.62	3
BRC	8.12	7
CRC	8.17	6
LRC	8.28	4
ORC	8.10	8
PRC	8.22	5
ICC	8.86	2

Table 4.11: Criteria Weights and corresponding Ranks

Source – AHP analysis

From the above table 4.11 the final ranking of main eight constraints are determined with an application of FAHP - SIT>ICC>VRC>LRC>PRC>CRC>BRC>ORC.

4.7.2 Ranking of constraints by using Fuzzy AHP

The steps we mentioned in previous chapter is followed here to estimate the weighted score of the constraints for Fuzzy AHP.

Criteria	w_l	w_m	w_u	M_i	N_i	Rank
SIT	0.236	0.443	0.799	0.493	0.417	1
VRC	0.071	0.162	0.336	0.190	0.161	2
BRC	0.018	0.030	0.065	0.038	0.032	8
CRC	0.031	0.074	0.186	0.097	0.082	5
LRC	0.020	0.034	0.085	0.046	0.039	7
ORC	0.035	0.079	0.194	0.103	0.087	4
PRC	0.020	0.035	0.089	0.048	0.040	6
ICC	0.054	0.143	0.309	0.169	0.143	3

Table 4.12: Fuzzy Weights of Geometric Means - w_l, w_m and w_u

Source: FAHP analysis

Based on the analysis using FAHP method presented in table 4.12, final ranks are SIT>VRC>ICC>ORC>CRC>PRC>LRC>BRC.

4.7.3 Rank Comparison obtained by using AHP and Fuzzy AHP approaches

Ranking of the constraints related to vehicle fill rate in road freight transportation for FMCG sector is determined by using AHP/FAHP approaches. Table 4.13 presents a comparison of ranks obtained through both AHP and FAHP methods

Criteria	For AHP Method	For FAHP Method
SIT	1	1
VRC	3	2
BRC	7	8
CRC	6	5
LRC	4	7
ORC	8	4
PRC	5	6
ICC	2	3

Table 4.13: Criteria Weight Ranks for AHP and FAHP (comparison)

Source: AHP and FAHP analysis

Sharing the potential sequences of main categories of constraints below

RANKS	CRITERIA
1	SIT
3,2	VRC
7,8	BRC
6,5	CRC
4,7	LRC
8,4	ORC
5,6	PRC
2,3	ICC

Table **4.14:** the Potential Constraints in Sequence

Source: AHP and FAHP analysis

From this comparison it is clear in AHP some biasness is there among the respondent but which was eliminated by FAHP and since the deviation in ranking is not much it proved that degree of biasness is not high. Opinion is giving more or less same ranking for both the analysis.

4.7.4 Ranking of Sub-categories of the constraints

The ranking of sub-categories of the constraints has been done. In table 4.15 the ranking of sub-categories are shared

Criteria	w_l	w_m	w_u	M_i	N_i	Rank
			SIT			
SVTS	0.429	0.731	1.217	0.792	0.714	**1**
SVTC	0.049	0.081	0.179	0.103	0.093	**3**
SUAT	0.091	0.188	0.363	0.214	0.193	**2**
			VRC			
VWLT	0.268	0.649	1.268	0.729	0.589	**1**
VWDC	0.039	0.072	0.322	0.144	0.117	**3**
VLLV	0.132	0.279	0.682	0.364	0.295	**2**
			BRC			
BLPR	0.25	0.583	1.227	0.686	0.552	1
BORC	0.049	0.085	0.195	0.11	0.088	4
BSTC	0.085	0.24	0.651	0.325	0.262	2
BPOC	0.052	0.093	0.221	0.122	0.098	3
			CRC			
CCSC	0.162	0.513	1.344	0.673	0.465	1
CALC	0.082	0.261	0.826	0.39	0.27	2
CMDO	0.034	0.076	0.281	0.13	0.09	4
CSRM	0.055	0.15	0.552	0.253	0.175	3
			LRC			
LSTC	0.237	0.564	1.205	0.669	0.529	1
LCOC	0.029	0.055	0.145	0.076	0.06	4

LPRM	0.05	0.118	0.325	0.164	0.13	3
LOPO	0.106	0.263	0.696	0.355	0.281	2
ORC						
OVOS	0.237	0.564	1.205	0.669	0.529	1
ORDC	0.029	0.055	0.145	0.076	0.06	4
OJIT	0.05	0.118	0.325	0.164	0.13	3
OULP	0.106	0.263	0.696	0.355	0.281	2
PRC						
PSIP	0.429	0.731	1.217	0.792	0.714	1
PUSR	0.091	0.188	0.363	0.214	0.193	2
PDPC	0.049	0.081	0.179	0.103	0.093	3
ICC						
IFCW	0.254	0.637	1.402	0.764	0.597	1
IIOC	0.054	0.105	0.297	0.152	0.119	3
IWFC	0.103	0.258	0.733	0.365	0.285	2

Table 4.15 - Fuzzy Weights of Geometric Means - w_l, w_m and w_u for sub-criteria

4.8 Result analysis and discussion

Results of this study are derived by using the DEMATEL, AHP and Fuzzy AHP method. The final outcomes are discussed below:

4.8.1 Discussion of Results of DEMATEL approach

After getting the full information about the constraints it is become very much evident that vehicle fill rate for FMCG sector in road transportation is a big challenge for India. As per results of DEMATEL analysis, most influential constraint is “Structural Constraints of Truck (SCT)” and the least influential constraint is “Cargo Related Constraints (CRC)”. Based on the values received through “D+R”, the impact sequence of the constraints is arranged. The impact sequence will be SIT>PRC>ICC>LRC>BRC>ORC> VRC> CRC. Based on the value of “D-R” these identified constraints have categorised in to two groups – “influencing group” and “Influenced group”. Four constraints, namely SIT, CRC, ORC and ICC are coming under “influencing group” and rest 4 constraints, namely VRC, BRC, LRC, PRC comes under “Influenced group”.

Influencing Constraints

Through this DEMATEL method it is evident that most influencing constraints is the 'Structural Constraints of Truck (SCT)'. Without having improvement or standardization of structural issue of truck, improvement of vehicle fill rate is not possible. Truck size variability, carrying capacity variability of truck and usage of angle, nut bolt inside the truck need standardization for improving the vehicle fill rate. Next Influential constraints is 'Inter and Intra Coordination and collaboration Related Constraints (ICC)'. It is very much clear that without coordination and collaboration Vehicle fill rate improvement is not possible. Coordination activity is not only confined to the same organization. Outside the organization also coordination and collaboration activity is required to improve the vehicle fill rate. Within organization also coordination is required, within function and between the function if coordination and cooperation activity is not there then it will act as a constraint for vehicle fill rate. Very next influential constraint is 'Order related constraint (ORC)'. It is acting as a cause of less vehicle fill rate. variability of order size, routing of deliveries, JIT/ frequency of deliveries, unloading priorities acted as influencing issues for vehicle fill rate. For improving the vehicle fill rate the above-mentioned constraints need solution. Last Influential issue as per DEMATEL analysis is 'Cargo related constraints (CRC)'. Complete shipment, Allocation of shipment, multi drop constraint and service requirement is impacting the vehicle fill rate in road freight transport and all this are constraints for FMCG sector.

Influenced Constraints

Influenced constraints are those constraints which are influenced by other constraints and acting as a constraint. As per the order 'Packaging related constraints (PRC)' are acting like an influenced constraints and creating impact on vehicle fill rate. This 'Packaging related constraints (PRC)' is influenced by the structural issue of the truck, Order related issues and coordination and collaboration related constraints. Design of the product (LBH), space in efficient packing and shelf ready packaging are acting like a constraint for vehicle fill rate. Next influenced constraint is Load Related Constraints (LRC). It is influence by Cargo related constraints, Structural constraint of truck and order related constraint. Stability constraints of stack inside the truck, complexity constraints, product mix, orthogonal placement and no overlap are acting like constraints for vehicle fill rate in road freight transport for FMCG sector. Next influence constraint is 'Box Related Constraints (BRC)'. It is influenced by order related constraint and structural constraint of truck. Priorities of loading, box orientation constraints, stacking constraints and positioning acting like constraints for vehicle fill rate. Last influenced constraint is 'Vehicle Related Constraints (VRC)' and it is highly influence by structural issue of vehicle. Weight limit and distribution of weight limit acting as constraints for vehicle fill rate along with vehicle load limit by volume. Below figure represents the calculated results of sum and differences of D and R. It is plotted in a graph which shows cause-and-effect relation among the constraints to enhance the fill rate of vehicle in road freight transport for FMCG sector.

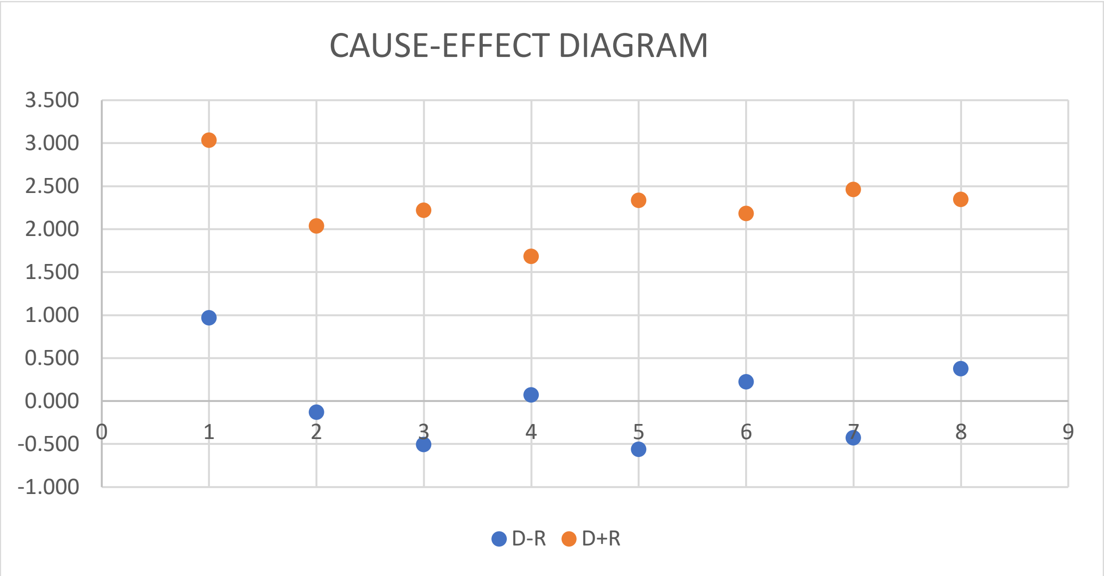


Figure 4.5: Cause and effect diagram of the constraints

Source - DEMATEL analysis

The above mentioned eight constraints is not standalone constraints. Some of the constraints are influencing the other constraints also which are impacting the vehicle fill rate.

4.8.2 Discussion of results received through deployment AHP and Fuzzy AHP

By using AHP and Fuzzy AHP the results of this study are derived. It helps to rank the constraints and sub-categories of constraints related to vehicle fill rate. Table 4.16 shows the ranking of constraints and sub constraints. The final outcome helps to build the below arguments –

Ranking of Constraints

In this section, the various constraints are discussed in terms of their ranking and the ranking of sub constraints.

Structural Constraints of Truck (SCT)

Structural constraint of truck is ranked highest as per analysis done by AHP/ FAHP. This is a typical constraint which exist exclusively in India and supported by most of the domain expert. Due it's exclusivity there is very minimum literature support received from the existing literature. As per literature only Norwegian cities has this similar problem. Eidhammer and Andersen in 2014, shared the similar constraints for Norwegian cities. Similar problem may exist in other developing countries and acting as a constraint. As per fuzzy AHP results within these structural constraints of truck 'Variability in truck size' ranked first among the other two constraints. As per result reflected in Table number 4.16 sub constraints SVTS> SUAT> SVTC. Variability of truck size influence the vehicle fill rate most compares to usage of angle, nut-bolt inside the truck and variability of truck carrying capacity. Variation of truck size impacting the volume base loadability of the truck. It is very much applicable for FMCG product since more than the weight of the product volume is important for FMCG product. It is also reflected in sub constraints ranking through FAHP method.

According to DEMATEL approach also, the constraints of 'Structural constraint of truck' has influence on all the other constraints. It is having Causal relationship with the other constraints related the vehicle fill rate. 'Structural constraint of truck' got the first rank in both AHP and FAHP method hence it is clear that it is having very high importance in vehicle fill rate for road freight transport in FMCG sector.

Criteria	w_l	w_m	w_u	M_i	N_i	Rank
SIT						
SVTS	0.429	0.731	1.217	0.792	0.714	**1**
SVTC	0.049	0.081	0.179	0.103	0.093	**3**
SUAT	0.091	0.188	0.363	0.214	0.193	**2**

Table 4.16: Structural constraints' Ranking

Vehicle related constraints

According to the ranking of FAHP vehicle related constraints is coming as second constraint which is impacting the vehicle fill rate most after structural constraints of truck. By using FAHP sub-categories of constraints also ranked. From that ranking it is evident in table 4.17 - VWLT>VLLV>VWDC.

Criteria	w_l	w_m	w_u	M_i	N_i	Rank
VRC						
VWLT	0.268	0.649	1.268	0.729	0.589	**1**
VWDC	0.039	0.072	0.322	0.144	0.117	**3**
VLLV	0.132	0.279	0.682	0.364	0.295	**2**

Table 4.17: Vehicle Related Constraints' Ranking

In the sub-categories of constraints Weight limit (VWLT) having the highest rank followed by Load limit by volume (VLLV) and Weight distribution constraints (VWDC). In India weight carrying capacity of trucks plays a role of constraint due to the limitation of carrying capacity. Compared to that weight carrying capacity of other developed country is much higher. Same truck type in other developed country can carry more material compared to India. Prior to 2018 it was even worse. Government of India made changes in GVW so that same truck can carry more load compared to earlier. Hence unless we improve weight carrying capacity the vehicle fill rate will not improve. Load limit by volume of the truck (VLLV) is the next constraints which impact most to vehicle fill rate after VWLT. Volumetric constraints of truck impacting the vehicle fill rate of FMCG product in road freight transport. Since most of the FMCG products are volumetric by nature hence volumetric capacity of truck is important for VFR. Product volume and truck volume both are helping each other to fill the volumetric utilization. Weight distribution constraints (VWDC) constraints is the last constraint in this category as per result of FAHP method. Load distribution within the truck is important from the centre of gravity point of view. Depending upon axle load of a truck load distribution should get planned. Since in India under FMCG products both volumetric and weight-based products are available hence distribution of load (weight) plays an important role in vehicle fill rate. Based on distribution of load acted inside the truck vehicle fill rate is varying.

The ‘vehicle related constraints’ has a rank 3rd and 2nd respectively in AHP and FAHP methods, indicating the significance of the constraints in vehicle fill road for FMCG products in road freight transportation. This constraint is influenced constraint and influenced by structural constraints of trucks.

Inter and Intra Coordination and collaboration Related Constraints (ICC)

According to the ranking of FAHP ‘Inter and Intra Coordination and Collaboration Related Constraints (ICC)’ is coming as third constraint which is impacting the vehicle fill rate most after structural constraints of truck and vehicle related constraint. By using FAHP sub-categories of constraints also ranked. From that ranking as per result reflected in Table number 4.18 it is evident that IFCW>IWFC> IIOC.

Criteria	w_l	w_m	w_u	M_i	N_i	Rank
IFCW	0.254	0.637	1.402	0.764	0.597	1
IIOC	0.054	0.105	0.297	0.152	0.119	3
IWFC	0.103	0.258	0.733	0.365	0.285	2

Table 4.18: Inter and Intra Coordination and Collaboration Related Constraints’ Ranking

If coordination and collaboration is not there the improvement of vehicle fill rate is not possible. Hence it is ranked in third position among the constraints of vehicle fill rate. In this constraint within organization collaboration, outside organization collaboration, within function coordination and outside function coordination plays a significant role. Out of these constraints related to coordination and collaboration inter-functional coordination within organization (IFCW) ranked 1st followed by within functional coordination within organization (IWFC) and inter-Organization coordination (IIOC). From the ranking of the constraints, it is very much evident that within organization coordination and collaboration is more important compared to outside organization coordination and collaboration. Within organization also between the function coordination is treated like an important constraint since for VFR cross functional coordination plays a significant role. Sales, Supply chain, Packaging development, Quality control, production and many more function is working together to have better vehicle fill rate. Unless coordination between the function worked well it will act as a constraint for vehicle fill rate.

Within functional coordination within organization (IWFC) is the 2nd constraints in this category which is more impactful compared to inter-Organization coordination (IIOC) for Indian FMCG sector. Within supply chain many functions are working together like demand-supply planning, order management, logistics. If between them coordination and collaboration is not happening, then it will act as a constraints for vehicle fill rate. Last in this category is inter-Organization coordination (IIOC). Between the organizations collaboration sometimes trying to solve vehicle fill rate issues. But for that collaboration and coordination is required between the organizations but in India this type of collaboration between the organizations is very minimum.

According to DEMATEL approach also, the constraints of ‘Inter and Intra Coordination and Collaboration Related Constraints (ICC) ’ has influence on all the other constraints . It is having Causal relationship with the other constraints related the vehicle fill rate. ‘Inter and Intra Coordination and Collaboration Related Constraints (ICC)’ got the 2nd and 3rd rank respectively through AHP and FAHP method. Hence it is clear that it is having very high significance in vehicle fill rate for road freight transport in FMCG sector. It is having Causal relationship with the other constraints related the vehicle fill rate.

Order Related constraints (ORC)

According to the ranking of FAHP ‘Order related constraints’ is coming as fourth constraint which is impacting the vehicle fill rate. By using FAHP sub-categories of constraints also ranked. As per result reflected in Table number 4.19, it is evident that OVOS>OULP>OJIT>ORDC.

Criteria	w_l	w_m	w_u	M_i	N_i	Rank
ORC						
OVOS	0.237	0.564	1.205	0.669	0.529	1
ORDC	0.029	0.055	0.145	0.076	0.06	4
OJIT	0.05	0.118	0.325	0.164	0.13	3
OULP	0.106	0.263	0.696	0.355	0.281	2

Table 4.19: Order related constraints' Ranking

In this category 4 number of sub constraints are there. As per result received via FAHP, variability of order size (OVOS) ranked first in the constraints list, followed by unloading priorities (OULP), JIT/frequency of deliveries (OJIT) and routing of deliveries (ORDC). Order is an important factor for fill rate. Hence constraint related order plays a significant role in filling the vehicle. Variation in order size impacting the vehicle planning issue. If the variation is high then it will impact the vehicle fill rate. Planning with this variability is acting as a constraint for vehicle fill rate. In Indian FMCG sector this variability observed very often hence it is one of the common constraints identified. Similarly Indian FMCG customers having certain preferences for unloading, which is impacting the vehicle fill rate. Preferences of unloading creating hindrances in product mix and leads to lower vehicle fill rate. In current scenario Indian FMCG customer preferred to have frequent delivery for which smaller vehicle types are used, which is not cost effective by nature. Consolidation of load leads to economy of scale and better utilization of vehicle but JIT will create lesser possibility of multi drop and product mix hence it is acting like a constraint.

The 'order related constraints' has a rank 8^{th} and 4^{th} respectively in AHP and FAHP methods, indicating the significance of the constraints in vehicle fill road for FMCG products in road freight transportation. This constraint is influenced constraint. It is influence by Cargo related constraints, Structural constraint of truck and order related constraint. According to DEMATEL approach also, 'Order related constraints (ORC)' has influenced all the other constraints. It is having Causal relationship with the other constraints related the vehicle fill rate. Hence it is clear that it is having high significance in vehicle fill rate for road freight transport in FMCG sector.

Cargo Related Constraints (CRC)

According to the ranking combination of AHP/ FAHP 'Cargo related constraints' is coming as fifth constraint which is impacting the vehicle fill. By using FAHP sub-categories of constraints also ranked. From that ranking it is evident in table number 4.20 - CCSC>CALC> CSRM> CMDO.

Criteria	w_l	w_m	w_u	M_i	N_i	Rank
CRC						
CCSC	0.162	0.513	1.344	0.673	0.465	1
CALC	0.082	0.261	0.826	0.39	0.27	2
CMDO	0.034	0.076	0.281	0.13	0.09	4
CSRM	0.055	0.15	0.552	0.253	0.175	3

Table 4.20: Cargo related constraints' Ranking

In this category of constraints 4 sub-category of constraints are there. Out of those constraints through FAHP it was evident that Complete Shipment Constraints (CCSC) ranked first followed by Allocation Constraints (CALC), Service Requirements (CSRM) and Multi Drop Operation (CMDO). All these constraints are related to serviceability of the cargo. What should the cargo distribution strategy and what will be the impact of that strategy on fill rate of truck. Complete shipment constraints (CALC) is one of the cargo servicing strategy which we have already discussed in this chapter. In Indian FMCG context all these constraints are valid and making impact on vehicle fill rate of road freight transport in FMCG sector.

According to DEMATEL approach also, 'Cargo related constraints (CRC)' has influenced all the other constraints. It is having Causal relationship with the other constraints related the vehicle fill rate. 'Cargo related constraints (CRC)' got the 6th and 5th rank respectively through AHP and FAHP method. Hence it is clear that it is having very high significance in vehicle fill rate for road freight transport in FMCG sector. It is having Causal relationship with the other constraints related the vehicle fill rate.

Packaging Related Constraints (PRC)

According to the ranking of FAHP 'Packaging related constraints' is coming as sixth constraint which is impacting the vehicle fill rate. By using FAHP sub-categories of constraints also ranked. From that ranking it is evident in table number 4.21 - PSIP> PUSR> PDPC.

Criteria	w_l	w_m	w_u	M_i	N_i	Rank
PRC						
PSIP	0.429	0.731	1.217	0.792	0.714	1
PUSR	0.091	0.188	0.363	0.214	0.193	2
PDPC	0.049	0.081	0.179	0.103	0.093	3

Table 4.21: Packaging related constraints' Ranking

In this category 3 number of sub constraints are there. As per result received via FAHP, space-In efficient packaging (PSIP) ranked first in the constraints list, followed by use of shelf-ready packaging (PUSR) and product design -LBH of Boxes (PDPC). Packaging plays a very significant role to transport the material in full. Quality of packaging material decides how many stacks is possible in the truck. To decide right packaging material with respect to stacking possibility, cost benefit analysis (CBA) is required. Space efficient packaging leads to good vehicle fill rate but if this packaging is not efficient that leads to lower vehicle fill rate, which will act as a constraint for vehicle fill rate in road freight transport of FMCG sector.

The 'Packaging related constraints' has a rank 5th and 6th respectively in AHP and FAHP methods, indicating the significance of the constraints in vehicle fill road for FMCG products in road freight transportation. According to DEMATEL approach, this constraint is influenced constraint. It is influenced by the structural issue of the truck, Order related issues and coordination and collaboration related constraints.

<u>Load Related Constraints (LRC)</u>

According to the ranking of FAHP 'Load related constraints' is coming as seventh constraint which is impacting the vehicle fill rate. By using FAHP sub-categories of constraints also ranked. From that ranking it is evident at ranking it is evident in table number 4.22 that LSTC>LOPO>LPRM>LCOC.

Criteria	w_l	w_m	w_u	M_i	N_i	Rank
LRC						

LSTC	0.237	0.564	1.205	0.669	0.529	1
LCOC	0.029	0.055	0.145	0.076	0.06	4
LPRM	0.05	0.118	0.325	0.164	0.13	3
LOPO	0.106	0.263	0.696	0.355	0.281	2

Table 4.22: Load related constraints' Ranking

In this category 4 number of sub constraints are there. As per result received via FAHP, stability constraints (LSTC) came as topmost constraints in the list, followed by orthogonal placement and no overlap (LOPO), product mix (LPRM), Complexity Constraints. These all constraints are related loading activity inside the truck. Activity related to loading is one of the most important activities comes under logistics function for any organization. For FMCG products since number of product and SKU despatch combination is high compared other organization in India hence loading related constraints plays a significant role in vehicle fill rate. Stability constraints of stack makes a huge difference in fill rate of truck. If quality of shipper is good once can stack more cases one after another but if the stack is not stable, it will lead to bulging issue and followed by damages of the material. Hence stacking impacting the vehicle fill rate. How other constraints in this group, is impacting the vehicle fill rate we have already discussed.

The 'load related constraints' has a rank 4th and 7th respectively in AHP ans FAHP methods, indicating the significance of the constraints in vehicle fill road for FMCG products in road freight transportation. According to DEMATEL approach this constraint is influenced constraint. It is influence by Cargo related constraints, Structural constraint of truck and order related constraint.

Box Related Constraints (BRC)

According to the ranking of FAHP 'Box related constraints' is coming as last constraint which is impacting the vehicle fill rate. By using FAHP sub-categories of constraints also ranked. From that ranking it is evident in table number 4.23 that BLPR>BSTC> BPOC>BORC.

Criteria	w_l	w_m	w_u	M_i	N_i	Rank
BRC						
BLPR	0.25	0.583	1.227	0.686	0.552	1
BORC	0.049	0.085	0.195	0.11	0.088	4
BSTC	0.085	0.24	0.651	0.325	0.262	2
BPOC	0.052	0.093	0.221	0.122	0.098	3

Table 4.23: Box related constraints' Ranking

In this category 4 number of sub constraints are there. As per result received via FAHP, loading priorities (BLPR) come on top of the constraints list, followed by stacking constraints (BSTC), positioning constraints (BPOC) and orientation constraints (BORC). FMCG products mostly packed into corrugated boxes. Hence box loading plays a significant role in filling the trucks. Loading priorities plays most significant role in this category of constraint. Depending upon priority of load fill rate is varying. If there is no priority of load it will give better fill rate compared to with priority load. Number of stacks decides the fill rate. More number of box height more the vertical space usage for a truck lead to better fill rate. Variation of side wall of truck also decides the stack height apart from packaging capability. Box positioning inside the truck while loading and orientation of boxes plays an important role while filling the truck. Depending upon box positioning space utilization is happening inside the truck and orientation of box also creates the space inside the vehicle for better fill rate. Better planning and execution of box positioning and orientation helped to load more in a truck.

The 'box related constraints' has a rank 7th and 8th respectively in AHP and FAHP methods, indicating the least significance of the constraints in vehicle fill road for FMCG products in road freight transportation. According to DEMATEL approach this constraint is influenced constraint. It is influenced by order related constraint and structural constraint of truck.

4.9 Sensitivity Analysis

For checking the resilience of the given framework and robustness of the rank of the constraints, sensitivity analysis was performed. AHP and FAHP was used for the analysis of the identified constraints. For vehicle fill rate in road freight transportation of FMCG industry most important is Structural Constraints of Truck (SCT) and least important is Box related constraint. The ranking of constraints in descending order of importance is SIT>VRC>ICC>ORC>CRC>PRC>LRC>BRC.

This study considered eight key criteria and from these eight, highly prioritized criteria is 'Structural Issue of Truck' (SIT). Slight fluctuation in weightage of highly ranked category can affect the other categories (refer Table 4.24). To address the fluctuations among variables, this study used sensitivity analysis. Hence, highly prioritized category weightage will be changed from 0.417 (SIT) to 0.417*0.9, 0.417*0.8…. 0.417*0.1 with values taken up to three decimal places. Referring to Table 4.24 -

Constraints	Normalized SIT=.417	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9
SIT	1	1	1	1	1	1	1	1	1	1
VRC	2	2	2	2	2	2	2	2	2	2
BRC	3	3	3	3	3	3	3	3	3	3
CRC	4	4	4	4	4	4	4	4	4	4
LRC	5	5	5	5	5	5	5	5	5	5
ORC	6	6	6	6	6	6	6	6	6	7
PRC	7	7	7	7	7	7	7	7	7	6
ICC	8	8	8	8	8	8	8	8	8	8

Table 4.24: Sensitivity analysis of main criteria with "SIT" criteria weight changes from (0.417*0.9 ... 0.417*0.1)

Source: Sensitivity Analysis

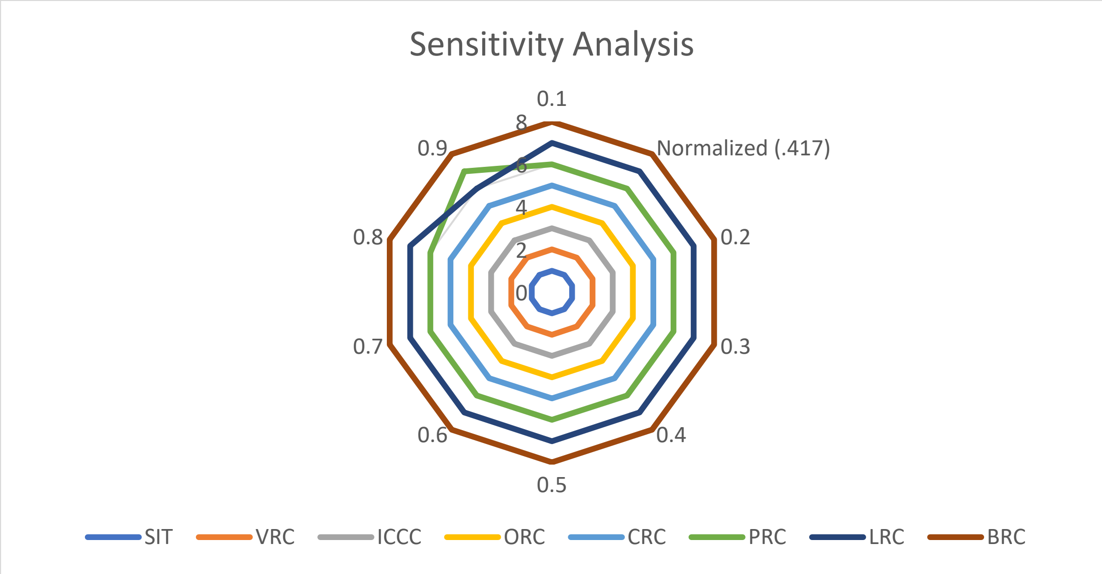


Figure 4.6: Results of sensitivity analysis for criteria

4.10 Chapter Summary

This chapter reflects the responses gathered from various respondents regarding the constraints related to vehicle fill rate in road freight transport for FMCG sector. Reliability of the information is checked along with the significance given to the various constraints by the respondents. This current chapter discussed the methodology and assessed the data gathered for categories and subcategories of constraints to vehicle fill rate in road freight transport for FMCG sector. To evaluate the constraints along with ranking methodology of the constraints DEMATEL and Fuzzy AHP technique was used. In each stage how the results are accomplished were illustrated clearly with details. Based on the criticality, the preference of weights and ranks are allocated to each category and sub-category of the constraints. Further analysis on the constraints shall be presented in the next chapter.

Chapter 5

Influence of topmost constraint on vehicle fill rate: Hypotheses testing and Model Development

Overview

In the previous chapter constraints were assessed by using DEMATEL, AHP and FAHP. All of them assessed 'Structural constraints of truck' as a topmost constraint. Hence assessing that constraint in detail is important. The 'Structural constraints of truck' are detected through conducting both primary and secondary research. In this part the analysis of data was presented and collected for the study and related findings also shared. It is analysed by using statistical software package SPSS 22.0. This analysis of the study is based on three sub-categories of constraints - variability in size of truck, variability in carrying capacity of truck and usage of angle, nut-bolt inside truck. The study evaluates the size variability of truck, variability in carrying capacity of truck, usage of angle, nut-bolt inside truck in respect to draw a relationship with vehicle fill rate. After collecting additional data related to these three particular constraints, coding of the data, all necessary parametric test is checked. Post that multivariate data analysis is conducted by using SPSS 22.0.

5.1 Introduction

Previous chapter we have identified the constraints related to vehicle fill rate in road freight transportation for FMCG sector. Post that we have analysed and ranked the constraints by using DEMATEL, AHP and FHAP analysis. From all the three methodology it was proven that for Indian FMCG sector to move the material through road freight transportation 'Structural constraints of truck' acting as topmost important constraint role in fill the truck. But unfortunately, very less research work is done in this context. In the existing literature only one research paper was found who discussed about this constraint. Similar issues were found at Norwegian cities. Hence going into depth of this constraint add value to existing literature. From the experts opinion it was clear that this unique constraints is available in India and it is impacting the vehicle fill rate of FMCG industry. We know that along with variation -

in truck dimension, truck carrying capacity and usage of angle, nut-bolt inside truck, fill rate varies but there is no certainty about the degree of changes due to this variation. This study helps to bring down the gap between academic knowledge and practical usage of vehicle fill rate in Indian context.

Post building the relationship we will run simulation to show the practical implication at FMCG Industry. It will help to derive the impact on certain parameter like cost and carbon emission due to variation in vehicle fill rate.

5.2 Linear Regression Modelling and Hypothesis Testing

In statistics, Linear regression helps to build the relation between a dependent variable (y) and one or more independent variables (x). Linear regression is used to forecast the value of dependent variable based on value of independent variable or variables. If single independent variable is there, then it is called simple regression. If more than one independent variable is there, then it is called Multiple Linear regression. We have chosen linear regression over SEM since we have single dependent variable i.e. vehicle fill rate. SEM mainly deals with multiple dependent variable. In case we have more than one dependent variable then linear regression model will not work and SEM will become the preferred model. Since the relation between dependents are linear we have used Linear regression over SEM. Here we want to test the prediction and want to test the hypotheses hence linear regression is preferred over SEM. For this study truck size (Length, breadth and height), truck carrying capacity, usage of angle, nut-bolt inside truck acted as independent variable and based on the variation of these variation we have to model the relationship with the dependent variable that is vehicle fill rate.

Sharing the basic assumptions to use the regression below –

All variables must be quantitative by nature. Variables should be free from multicollinearity. Multicollinearity increases the complexity due to interrelationship of variables.

Other parameters to check in regression analysis –

t statistics: For ‘t’ statistics the projected value of the parameter is divided by its standard error.

Proportion of Variance (R Square): The ‘proportion of variance’ shows how much reliable the function estimates the dependent variable compared to only mean value of the dependent variable.

Significance level: Result in statistics called as ‘Statistically significant’, so that it can prove that it is not happened by chance. For this research significant level has been taken at 5%.

Durbin-Watson test: As per McGurik and Spanos (2002), for Linear regression modelling one of the key assumptions is no autocorrelation between the variables. For good regression model, one of the assumptions is the data used for the regression model is free from autocorrelation. By looking the value of variables if one can predict the future value of other variables then it means that variable is having autocorrelation. Since we are using the regression analysis application, we need to check the suitability of the regression through research construct validity. Justifying the autocorrelation between the variables in the regression is an important factor. Auto correlation is a type of data characteristics which reflects the similarity between the values of the variables in a time interval. It is the predictability of the values in a series based on preceding values in the series. Positive, negative both type of autocorrelation is possible. Existence of autocorrelation leads to unsound model of regression. Hence for testing of autocorrelation between the variables, considered in the regression through Durbin – Watson (DW) test.

5.3 Data collection

Quantitative data was collected to further develop the body of knowledge on Structural constraints of truck. Multiple sources are used to get the data to have a holistic view and to improve research validity. Primary data played an important role here since readymade data is not available on size of truck, carrying capacity of truck. Primary data was collected from identified FMCG manufacturing sites. Since the research is confined to FMCG sector, primary data was collected from FMCG manufacturing units only. To bring synergy across India, manufacturing sites are chosen from all four parts of India. From northern India, a multinational organization plant was selected located at Rudrapur, Uttarakhand. From eastern parts of India, an Indian FMCG plant was selected located at Kolkata, West Bengal. From western parts of India, another plant was selected from a multinational organization, located at Pune, Maharashtra. From southern part of India, an Indian FMCG plant was selected which is located at Krishnapatnam, Tamilnadu. In the survey, we covered big FMCG company of India as well as FMCG MNCs located at India. Indian company as well as MNCs are chosen to cover all type of FMCG organization of India. We selected those organizations whose yearly turnover is more than twelve thousand crore and logistics spend is equally high. We have chosen the big organization over small since big organizations having the volume and data point will be higher compared to small one. We have collected the data at specific area like security gates and loading/unloading docks. We have Intentionally chosen Logistics executives/managers located at plants, dispatch executives/managers based at plants and security team based at plant gate. These three teams are involved in loading or unloading activity at plant day in day out, hence they have hands on experience in this field. Total ninety-two number of resources were identified to collect the primary quantitative data across India. This data covers all the parts of India, mostly in the primary distribution. Hence seven and half ton and above trucks are covered which are usually used in primary distribution for FMCG organization, in India. Secondary distribution is not covered in this study; hence smaller truck type (less than seven and half ton) is not explored here.

To get variation in truck size, one need to measure physical dimension of the vehicle. For that we used the following format –

Vehicle Measurement Sheet							
Location		Vehicle Number		Type of Truck		Make	
Length(ft)		Width(ft)		Height(ft)			
Tare Weight(ton)		Total Weight (ton)		No. Of Wheel			
Total Case Despatched		Date		Name			

Table 5.1: Truck Measurement Format (Source – Prepared by the author)

Secondary data also collected from the website of truck manufacturers. Since most of the manufacturers are making the chassis of the truck only and transporter making the trucks through their own fabricator that theoretical data will only help to build a data base of tuck type for all the truck manufacturing organizations. Not suitable for linear regression modelling.

5.4 Data Analysis with respect to Variability in Truck Size

Based on collected data of length, width and height data wise analysed with respect to volumetric capacity of truck and vehicle fill rate.

5.4.1 Initial Data Analysis for Variability in Truck Size

As per FAHP Variability in truck size is the topmost constraint which is impacting the VFR most in road freight transportation for FMCG sector. For this research work high number of data point was touched. Seven hundred and seventy trucks were measured by using above format. Through this primary data it is visible that there is high variation in truck size, which is reflected in Table No. 5.2.

	7.5 Ton			9 Ton			16 Ton			21 Ton			25 Ton		
Particulars	L	W	H	L	W	H	L	W	H	L	W	H	L	W	H
Mean	18.3	7.1	5.6	17.7	7.0	5.7	23.0	7.4	5.7	24.5	7.4	5.6	27.5	7.4	5.9
Mode	19.0	7.2	5.1	18.6	7.4	5.4	22.6	7.4	5.2	24.6	7.4	5.5	28.7	7.4	6.1
Median	19.0	7.2	5.6	18.0	7.2	5.7	22.7	7.4	5.6	24.5	7.4	5.6	28.1	7.4	6.1
SD	2.4	0.6	0.7	2.9	0.6	0.7	1.6	0.5	0.9	1.8	0.3	0.7	1.7	0.2	0.7
Maximum	29.2	10.0	7.5	31.2	7.8	7.7	34.9	9.1	10.0	40.4	8.5	7.6	28.9	8.2	7.3
Minimum	9.2	5.1	3.8	7.4	4.0	4.0	21.3	4.6	4.1	12.9	5.1	3.0	22.6	6.9	4.1

Table 5.2: – Summary of sample Truck size variation

Here L = Length, W = Width, H = Height and unit of measurement - feet

Source – Authors' Findings

For primary dispatches five types of trucks are considered. These are common truck types of Indian FMCG organization which are used on a regular basis to dispatch material from Factory to customer or warehouses. Based on carrying capacity we have categorized the truck types. Those type are – 7.5 Ton carrying capacity Truck, 9

Ton carrying capacity Truck, 16 Ton carrying capacity Truck, 21 Ton carrying capacity Truck and 25 Ton carrying capacity Truck.

It is considered mostly common case size of cargo which are generally used in FMCG organization for any volumetric cargo. Outer dimension of the of the cargo - length 335mm, width 255mm and height 287mm. Gross weight of the cargo is 0.0115 ton.

Based on data of truck size variation and cargo size we have simulated the data of vehicle fill rate. Total 770 number of sample size were picked up to draw conclusion on Hypothesis.

We have used SPSS to validate the hypothesis against each Truck Type and used both - Total Volumetric capacity (L*W*H) and individual Length, width and height were used to validate the same.

5.4.2 Hypotheses development related to truck size variation with vehicle fill rate

As per Yüceer and Özakça (2010) primary constraint is enforced by the container's capacity, either by volume or by vehicle dimensions (Che *et al*. 2011; Respen and Zufferey, 2017; Romão *et al*. 2012; Tian *et al*. 2016). In table 5.2, it was also evident that high variability is there in truck dimension. In this part we will present the variability along with Vehicle Fill Rate. Here we will share the analysis of data collected for this particular study and their findings. We analysed this data by using statistical software package SPSS. The evaluation of the study is based on Truck size. The study evaluates the truck size variability, draw relation between Truck size variability and Vehicle Fill Rate. In order to identify the high Vehicle Fill Rate we need to identify the relationship between truck size and vehicle fill rate, keeping case size as a constant. Here the independent variables are univariate by nature. These are length, width and height of truck, volumetric capacity of trucks. Dependent variable is vehicle fill rate. To build the relationship we have created a hypothesis.

Hypothesis - Truck dimension variability has a positive relationship with vehicle fill rate.

For hypothesis, Dimension Variability: To find the relation between vehicle fill rate and Dimensions (Length*Width*Height) of the vehicle, Multiple Linear Regression analysis can be used as Vehicle fill rate is dependent on 3 parameters of dimensions (independent Variable).

Y = A*L + B*W + C*H + D

Here regressors are denoted as L = Length, W = Width, H =Height

Here volumetric capacity of trucks means Length x Width x Height.

Dependent Variable is denoted as Y = Vehicle fill Rate.

Based on Volumetric capacity of truck (L*B*H) of 7.5 Ton capacity

In this hypothesis we are testing the vehicle size variance having an impact on Vehicle Fill Rate. To test the hypothesis H1, the variable which is dependent in nature (Y) was regressed on variable which we can predict - Volumetric truck carrying capacity. Truck size variability (L x W x H) significantly predicted Vehicle Fill rate(Y), F = 135.75, p<0.001, which indicates that Volumetric truck carrying capacity (L x W x H) can play a substantial role of determining Y (B 0.748, p < 0.001). From the outcome, it is clearly visible that the Volumetric truck carrying capacity having positive impact. Moreover, the R Square= 0.559 shows that this model explains 55.9 % of variance in vehicle Fill Rate. Hence H1 was supported. Table 5.3 we are sharing summary of our findings –

Hypothesis	Truck Type	Regressors	R	R Square	Beta Coefficient	t Statistics	Statistical Significance	F Statistics	Statistical Significance	Hypothesis Supported
H1	7.5	LXWXH	0.8	0.559	0.748	11.651	<.001	135.75	<.001	Yes

Table 5.3: – The regression relationship between volumetric capacity and Vehicle Fill Rate for 7.5 Ton vehicle (Source – Authors' Calculation)

Calculation based on Length, Width and Height of 7.5 Ton capacity vehicle

The hypothesis tests if vehicle size variance having an impact on Vehicle Fill Rate. To test the hypothesis H1, the variable which is dependent in nature was regressed on variable which we can predict Length, Width and Height (L, W, H). Truck size variability (L, W, H) significantly predicted Vehicle Fill rate(Y), F (3) =78.140, p<0.001, which indicates that Truck size variability (L, W, H) can play a significant role shaping Y (B for L is .540, W is .315, H is .424, p<0.001). From this result, it is clearly visible that the truck sizes having the positive impact. Moreover, the R Square= 0.691 shows that this model explains the model explains 69.1 % of variance in vehicle Fill Rate. Hence H1 was supported. In table 5.4 we are sharing summary of our findings –

Hypothesis	Truck Type	Regressors	R	R Square	Beta Coefficient	t Statistic	Statistical Significance	VIF Statistics	F Statistics	Statistical Significance	Hypothesis Supported
H1	7.5		0.8	0.691					78.14	<.001	Yes
H1	7.5	Constant				-3.327	0.001				
H1	7.5	L			0.54	9.616	<.001	1.072			
H1	7.5	W			0.315	5.763	<.001	1.015			
H1	7.5	H			0.424	7.558	<.001	1.069			

Table 5.4: The regression relationship between Length, width, Height of truck and Vehicle Fill Rate of 7.5Ton Truck (Source – Authors' Calculation)

As per standardized coefficients beta (.54) and significance value (<.001) Length of the vehicle (L) and is having positive and significant impact on Vehicle Fill Rate (Y). For this 7.5 Ton vehicle length of the vehicle is having is highest impact on Vehicle Fille rate over width and height of the vehicle as the beta value of length (.540) is highest over width (.315) and height (.424) of the vehicle.

Since the value of VIF is near to 1 only for all the independent variables (less than 10), we can say that there is no multi collinearity in the model and estimated results are accurate and unbiased.

Based on Volumetric capacity of truck (L*B*H) of 9 Ton capacity

In this hypothesis we are testing the vehicle size variance having an impact on Vehicle Fill Rate. To test the hypothesis H1, the variable which is dependent in nature (Y) was regressed on variable which we can predict - Volumetric truck carrying capacity. Truck size variability (L x W x H) significantly predicted Vehicle Fill rate(Y), F = 154.508, p<0.001 which indicates that Volumetric truck carrying capacity (L x W x H) can play a substantial role of determining Y (B 0.782, p <0.001). From the outcome, it is clearly visible that the truck sizes having the positive impact. Moreover, R Square = 0.612 depicts that the model explains 61.2 % of variance in vehicle Fill Rate. Hence H1 was supported. In table 5.5 we are sharing summary of our findings -

Hypothesis	Truck Type	Regressors	R	R Square	Beta Coefficient	t Statistics	Statistical Significance	F Statistics	Statistical Significance	Hypothesis Supported	Hypothesis
H1	9	LXWXH	0.782	0.612	0.782	12.43	<.001	154.058	<.001	Yes	yes

Table 5.5: The regression relationship between volumetric capacity and Vehicle Fill Rate for 9 Ton vehicle (Source – Authors' Calculation)

Based on Length, Width and Height of the vehicle 9 Ton capacity

The hypothesis tests if vehicle size variance having an impact on Vehicle Fill Rate. To test the hypothesis H1, the variable which is dependent in nature was regressed on variable which we can predict Length, Width and Height (L, W, H). Truck size variability (L, W, H) significantly predicted Vehicle Fill rate(Y), F (3) = 98.634, p<0.001, which indicates that Truck size variability (L, W, H) can play a significant role shaping Y (B for L is .457, W is .413, H is .462, p <0.001). These results clearly direct the positive affect of truck sizes. Moreover, the R Square= 0.755 shows that this model explains the model explains 75.5 % of variance in vehicle Fill Rate. Hence H1 was supported. In table 5.6 we are sharing summary of our findings.

Hypothesis	Truck Type	Regressors	R	R Square	Beta Coefficient	t Statistic	Statistical Significance	VIF Statistics	F Statistics	Statistical Significance	Hypothesis Supported
H1	9		0.869	0.755			<.001		98.634	<.001	Yes
H1	9	Constant				-8.011	<.001				
H1	9	L			0.457	8.543	<.001	1.121			
H1	9	W			0.413	8.025	<.001	1.039			
H1	9	H			0.462	8.753	<.001	1.091			

Table 5.6: The regression relationship between Length, width, Height of truck and Vehicle Fill Rate of 9Ton Truck (Source – Authors' Calculation)

As per standardized coefficients beta (.462) and significance value (<.001) Height of the vehicle (H) and is having positive and significant impact on Vehicle Fill Rate (Y). For this 9 Ton vehicle length (.457) and height (.462) of the vehicle is having almost same impact on vehicle fill rate. Width (.413) is having lesser impact compared length and height.

Since the value of VIF is near to 1 only for all the independent variables (less than 10), we can say that there is no multi collinearity in the model and estimated results are accurate and unbiased.

Based on Volumetric capacity of truck (L*B*H) of 16 Ton capacity

In this hypothesis we are testing the vehicle size variance having an impact on Vehicle Fill Rate. To test the hypothesis H1, the variable which is dependent in nature (Y) was regressed on variable which we can predict - Volumetric truck carrying capacity. Truck size variability (L x W x H) significantly predicted Vehicle Fill rate(Y), F = 361.964, p < 0.001, which indicates that Volumetric truck carrying capacity (L x W x H) can play a substantial role of determining Y (B 0.817, p<0.001). From the outcome, it is clearly visible that the Volumetric truck carrying capacity having positive impact. Moreover, the R Square= 0.668 shows that this model explains 66.8 % of variance in vehicle Fill Rate. Hence H1 was supported. In table 5.7 we are sharing summary of our findings -

Hypothesis	Truck Type	Regressors	R	R Square	Beta Coefficient	t Statistics	Statistical Significance	F Statistics	Statistical Significance	Hypothesis is Supported
H1	16	LXWXH	0.817	0.668	0.817	19.025	<.001	361.964	<.001	Yes

Table 5.7: The regression relationship between volumetric capacity and Vehicle Fill Rate for 16 Ton vehicle (Source – Authors' Calculation)

Based on Length, Width and Height of the vehicle 16 Ton capacity

The hypothesis tests if vehicle size variance having an impact on Vehicle Fill Rate. To test the hypothesis H1, the variable which is dependent in nature was regressed on variable which we can predict Length, Width and Height (L, W, H). Truck size variability (L, W, H) significantly predicted Vehicle Fill rate(Y), F (3) = 239.07, p<0.001, which indicates that Truck size variability (L, W, H) can play a significant role shaping Y (B for L is .540, W is .315, H is .424, p<0.001) Y (B for L is -0.116, W is .388, H is .821, p<0.001). From this result, it is clearly visible that the truck sizes having the positive impact. Moreover, the R Square= 0.801 shows that this model explains the model explains 80.1 % of variance in vehicle Fill Rate. Hence H1 was supported. In table 5.8 we are sharing summary of our findings –

Hypothesis	Truck Type	Regressors	R	R Square	Beta Coefficient	t Statistic	Statistical Significance	VIF Statistics	F Statistics	Statistical Significance	Hypothesis Supported
H1	16		0.895	0.801			<.001		239.07	<.001	Yes
H1	16	Constant				-6.747	<.001				
H1	16	L			-0.116	-2.01	0.046	2.989			
H1	16	W			0.388	9.724	<.001	1.423			
H1	16	H			0.821	15.989	<.001	2.359			

Table 5.8: The regression relationship between Length, width, Height of truck and Vehicle Fill Rate of 16Ton Truck (Source – Authors' Calculation)

As per standardized coefficients beta (.388) and significance value (<.001) width of the vehicle (W) and is having positive and significant impact on Vehicle Fill Rate (Y). For this 16 Ton vehicle height of the vehicle is having is highest impact on Vehicle Fille rate over length and width of the vehicle as the beta value of height (0.821) is highest over width (.388) and length (-.116) of the vehicle. Only Length is having negative impact over Vehicle Fill rate.

Since the value of VIF is ranging between 1.4 to 2.9 only for all the independent variables (less than 10), we can say that there is no multi collinearity in the model and estimated results are accurate and unbiased.

Based on Volumetric capacity of truck (L*B*H) 21 Ton capacity

In this hypothesis we are testing the vehicle size variance having an impact on Vehicle Fill Rate. To test the hypothesis H1, the variable which is dependent in nature (Y) was regressed on variable which we can predict - Volumetric truck carrying capacity. Truck size variability (L x W x H) significantly predicted Vehicle Fill rate(Y), $F = 2054.236$, $p < 0.001$, which indicates that Volumetric truck carrying capacity (L x W x H) can play a substantial role of determining Y (B 0.931, $p<0.001$). From the outcome, it is clearly visible that the Volumetric truck carrying capacity having positive impact. Moreover, the R Square= 0.866 shows that this model explains 86.6% of variance in vehicle Fill Rate. Hence H1 was supported. In table 5.9 we are sharing summary of our findings –

Hypothesis	Truck Type	Regressors	R	R Square	Beta Coefficient	t Statistics	Statistical Significance	F Statistics	Statistical Significance	Hypothesis Supported
H1	21	LXWXH	0.931	0.866	0.931	45.324	<.001	2054.236	<.001	Yes

Table 5.9: The regression relationship between volumetric capacity and Vehicle Fill Rate for 21 Ton vehicle (Source – Authors' Calculation)

Based on Length, Width and Height of the vehicle 21 Ton capacity

The hypothesis tests if vehicle size variance having an impact on Vehicle Fill Rate. To test the hypothesis H1, the variable which is dependent in nature was regressed on variable which we can predict Length, Width and Height (L, W, H). Truck size variability (L, W, H) significantly predicted Vehicle Fill rate(Y), $F(3) = 796.375$, $p<0.001$, which indicates that Truck size variability (L, W, H) can play a significant role shaping Y (B for L is .273, W is .388, H is .869, $p<0.001$). From this result, it is clearly visible that the truck sizes having the positive impact. Moreover, the R Square= 0.883 shows that this model explains the model explains 88.3% of variance in vehicle Fill Rate. Hence H1 was supported. In table 5.10 we are sharing summary of our findings –

Hypothesis	Truck Type	Regressors	R	R Square	Beta Coefficient	t Statistic	Statistical Significance	VIF Statistics	F Statistics	Statistical Significance	Hypothesis Supported
H1	21		0.94	0.883			<.001		796.375	<.001	Yes
H1	21	Constant				-24.798	<.001				
H1	21	L			0.273	13.407	<.001	1.121			
H1	21	W			0.388	18.297	<.001	1.213			
H1	21	H			0.869	42.608	<.001	1.124			

Table 5.10: The regression relationship between Length, width, Height of truck and Vehicle Fill Rate of 21Ton Truck (Source – Authors' Calculation)

As per standardized coefficients beta (.273) and significance value (<.001) Length of the vehicle (L) and is having positive and significant impact on Vehicle Fill Rate (Y). For this 21 Ton vehicle Height of the vehicle is having is highest impact on Vehicle Fill Rate over width and Length of the vehicle as the beta value of height (.869) is highest over width (.388) and length (.273) of the vehicle.

Since the value of VIF is near to 1 only for all the independent variables (less than 10), we can say that there is no multi collinearity in the model and estimated results are accurate and unbiased.

Based on Volumetric capacity of truck (L*B*H) 25 Ton capacity

In this hypothesis we are testing the vehicle size variance having an impact on Vehicle Fill Rate. To test the hypothesis H1, the variable which is dependent in nature (Y) was regressed on variable which we can predict - Volumetric truck carrying capacity. Truck size variability (L x W x H) significantly predicted Vehicle Fill rate(Y), $F = 462.851$, $p < 0.001$, which indicates that Volumetric truck carrying capacity (L x W x H) can play a substantial role of determining Y (B 0.95, $p<0.001$). From the outcome, it is clearly visible that the Volumetric truck carrying capacity having positive impact. Moreover, the R Square= 0.903 shows that this model explains 90.3% of variance in vehicle Fill Rate. Hence H1 was supported. In table 5.11 we are sharing summary of our findings -

Hypothesis	Truck Type	Regressors	R	R Square	Beta Coefficient	t Statistics	Statistical Significance	F Statistics	Statistical Significance	Hypothesis Supported
H1	25	LXWXH	0.95	0.903	0.95	21.514	<.001	462.851	<.001	Yes

Table 5.11: The regression relationship between volumetric capacity and Vehicle Fill Rate for 25 Ton vehicle (Source – Authors' Calculation)

Based on Length, Width and Height of the vehicle 25 Ton capacity

The hypothesis tests if vehicle size variance having an impact on Vehicle Fill Rate. To test the hypothesis H1, the variable which is dependent in nature was regressed on variable which we can predict Length, Width and Height (L, W, H). Truck size variability (L, W, H) significantly predicted Vehicle Fill rate(Y), F (3) = 168.708, p<0.001, which indicates that Truck size variability (L, W, H) can play a significant role shaping Y (B for L is .315, W is .238, H is .611, p<0.001). From this result, it is clearly visible that the truck sizes having the positive impact. Moreover, the R Square= 0.913 shows that this model explains the model explains 91.3 % of variance in vehicle Fill Rate. Hence H1 was supported. In table 5.12 we are sharing summary of our findings –

Hypothesis	Truck Type	Regressors	R	R Square	Beta Coefficient	t Statistic	Statistical Significance	VIF Statistics	F Statistics	Statistical Significance	Hypothesis Supported
H1	25		0.96	0.913			<.001		168.708	<.001	Yes
H1	25	Constant				-9.284	<.001				
H1	25	L			0.315	6.073	<.001	1.492			
H1	25	W			0.238	4.005	<.001	1.953			
H1	25	H			0.611	11.803	<.001	1.485			

Table 5.12: The regression relationship between Length, width, Height of truck and Vehicle Fill Rate of 25Ton Truck (Source – Authors' Calculation)

As per standardized coefficients beta (.611) and significance value (<.001) Height of the vehicle (H) and is having positive and significant impact on Vehicle Fill Rate (Y). For this 25 Ton vehicle height of the vehicle is having is highest impact on Vehicle Fill Rate over width and length of the vehicle as the beta value of height (.611) is highest over width (.238) and Length (.315) of the vehicle.

Since the value of VIF is near to 1 only for all the independent variables (less than 10), we can say that there is no multi collinearity in the model and estimated results are accurate and unbiased.

From the above-mentioned data of all the truck types it was proved that Hypothesis is valid i.e., truck size variability has significant positive impact on Vehicle fill rate, considering uniform case size.

5.4.3 Research construct validity

To test the autocorrelation between the variables, considered in the regression through Durbin – Watson (DW) test. Through DW test we have checked all the variables we have used in regression. DW test explains any autocorrelation between successive observation in the data. We have tested the through Durbin – Watson (DW) test with the help of SPSS. In SPSS if the Durbin – Watson values is lying between 1.5 and 2.5 then it means no auto correlation is there between the variables. If the DW value is less than 1.5 then positive auto correlation exist there between successive observation. When the DW value is more than 2.5, negative auto correlation exist between successive observation. DW value of Less than 1.5 and more than 2.5 is not desirable result to construct suitability of the regression analysis application.

In this case for all the truck types, Durbin – Watson (DW) tested in SPSS with all the variables. We have used Length (L), Width (W), Height (H) of the vehicles separately as three independent variables along with Vehicle fill rate as dependent variable. Also tested volumetric capacity of the vehicle (LXWXH) as independent variables with Vehicle fill rate as dependent variable. Results summary shared through Table number 5.13.

	L, W, H			L x W x H		
Truck Type	R	R Square	Durbin-Watson	R	R Square	Durbin-Watson
7.5	0.831	0.691	1.664	0.748	0.559	1.719
9	0.869	0.755	2.074	0.782	0.612	2.059
16	0.895	0.801	2.311	0.817	0.668	2.147
21	0.94	0.883	1.749	0.931	0.866	1.747
25	0.956	0.913	2.347	0.95	0.903	2.355

Table 5.13: Result of Durbin-Watson test for all the Truck Types

Source – Authors' Calculation

Durbin-Watson test score for all the truck types lying between 1.5 to 2.5, hence it was proved that there is no autocorrelation exist in the regression analysis application. It ensures the validity of research construct for the suitability of the regression analysis application for all the truck types.

5.4.4 Simulation building activity based on Variability in Truck Size

After building the relationship between truck size variability and vehicle fill rate, further to check the impact of non-standardized truck over Vehicle Fill and impact on logistics cost, we have done a live simulation test between two factories located at Kolkata. **Plant A** using standardized dedicated vehicle and **Plant B** using non standardized market-based vehicle. To do this simulation we have made certain assumptions and standardization –

a. **Plant A and B**, both are using 21 metric ton carrying capacity vehicle.
b. Both are sending material through carton boxes or cases.
c. Case size is also same for both. Carton Length is 33.5cm, width 25.5cm and height is 28.7cm.
d. Case or box weight is same for both. Gross weight of a box is 11.48Kg.
e. Stack height norms to keep the material inside the trucks is 9 high for both the plants.
f. 2 types of case/ box orientation are allowed.
g. Both are sending single SKU (Stock keeping Unit) in a vehicle. No mix of SKU.

h. Both are sending material from Kolkata to Delhi.

i. Per vehicle freight rate is same (INR 79800) from both the plants for 21MT vehicle, between Kolkata to Delhi.

j. Time frame for despatch is same for both the plans.

k. Both will send equal number of vehicles from their respective plants. 5 each from **Plant A and Plant B** respectively.

Plant A, 5 number of standard dedicated 21 metric ton carrying capacity vehicle will despatch from Kolkata to Delhi. Vehicle Dimension is 739cm length, 221cm width and 200.7cm height. At **plant A**, all the vehicle is having same vehicle dimension and carrying capacity and dedicatedly running for plant A only.

Plant B, 5 number of nonstandard market based 21 metric ton carrying capacity vehicle will despatch from Kolkata to Delhi in. Vehicle dimension is varying as per vehicles receipt at plant. Vehicle dimension details shared in Table 5.14.

Vehicle Type	Length (CM)	Width (CM)	Height (CM)
21 MT	736	221	200.7
21 MT	739.1	219	200.7
21 MT	739.1	217	200.7
21 MT	740	217	200.7
21 MT	732.4	217.3	200.7

Table 5.14: 21 MT Vehicle dimension at Plant B (Source – Prepared by Author)

Plant A

From Kolkata to Delhi at plant A, 5 number of 21MT standardized vehicles planned. In each vehicle they will load standard 1128 number of cases. Case dimension is Length is 33.5cm, width 25.5cm and height is 28.7cm and Gross weight is 11.48Kg. For this 5 vehicles volume utilization is 84.4% and weight utilization is 62% only.

For **Plant A** to Despatch 5640 cases from Kolkata to Delhi, they will have following freight spend

- Per vehicle freight multiply by number of vehicles despatched

= INR 79800 per vehicle x 5 number of vehicles

= INR 399000.

- Freight per case will be = Total Freight Spend divide by total number of cases despatch

= INR 399000/ 5600 cases

= INR 70.74/case

For all the vehicles per case cost will be same since all the vehicles carried same number of boxes/ cases.

Plant B

From Kolkata to Delhi **Plant B** planned 5 number of 21MT vehicles which are non-standardized vehicle sourced from market. Vehicle dimensions is varying for all the vehicles. Case dimension and case gross weight is same as **Plant A**. By this 5 vehicles **Plant B** will despatch 5532 cases.

For **Plant B** to despatch 5532 cases from Kolkata to Delhi, they will have following freight spend

- Per vehicle freight multiply by number of vehicles despatched

= INR 79800 per vehicle x 5 number of vehicles

= INR 399000.

- Freight per case will be = Total Freight Spend divide by total number of cases despatch

= INR 399000/ 5532 cases

= INR 72.13/case

For all the vehicles per case cost is not same since all the vehicles carried different case quantity.

Findings based on simulation

Due to non-standardized vehicle dimension Plant B send 108 boxes less (5640 cases minus 5532 cases) compared to Plant B standardized vehicle. This less fill rate having direct impact in per case transportation cost. Plant B spending INR 1.38 per case more (INR 72.13 minus INR 70.74) compared to plant A, which is reflected in Table No. 5.15.

	Total Freight Spend (INR)	Total Case Despatched (CS)	Per Case Transportation cost (INR)
Plant A	399000	5640	70.74
Plant B	399000	5532	72.13
Impact		- 108	1.38

Table 5.15: Transportation Cost Comparison between Plant A and Plant

In table 5.16 we have shown the comparison between **Plant A** and **Plant B**. **Plant A** send standardized truck and **Plant B** send nonstandard truck. For **Plant A** weight and volume utilization is same but for **Plant B** it is varying along with case quantity shipped.

Plant A							Plant B						
Vehicle Type	Length (CM)	Width (CM)	Height (CM)	Case loaded	Volume Utilization	Weight Utilization	Vehicle Type	Length (CM)	Width (CM)	Height (CM)	Case loaded	Volume Utilization	Weight Utilization
21 MT	739	228	200	1128	84.40%	61.66%	21 MT	736	221	200	1116	83.80%	61.01%
21 MT	739	228	200	1128	84.40%	61.66%	21 MT	739	219	200	1104	83.40%	60.35%
21 MT	739	228	200	1128	84.40%	61.66%	21 MT	739	217	200	1092	83.20%	59.70%
21 MT	739	228	200.	1128	84.40%	61.66%	21 MT	732	217.3	200	1080	83.10%	59.04%
21 MT	739	228	200	1128	84.40%	61.66%	21 MT	740	221	200	1140	85.20%	62.32%

Table 5.16: Comparison between Plant A and Plant B in terms of case shipped, volume utilization and weight utilization

Source – Authors' calculation

5.4.5 Practical Implication based on Simulation building activity based on Variability in Truck Size

Based on academic literature, industry practice and data analysis through SPSS we can draw few conclusion –

Primary data helped to prove that for volumetric capacity there is high variation in trucks. This type of variation creating dispatch-planning and execution related issue at factories or warehouse. Due to this variation in specification of trucks despatch standards are also varying.

From the above-mentioned analysis and interpretation it was clear that truck size variability in a truck have significant impact on Vehicle fill rate, considering uniform case size. SPSS was used for analysing the data set. To test the hypothesis Multivariate tools were used, to be specific simple linear regression analysis were performed. It is done to test Structural issue of truck and Vehicle Fill Rate (VFR) empirically. This discovery gives us deep insights about structural issues of India's truck industry and impact of vehicle fill rate particularly to FMCG sector of India. Hence standardization of truck size is very much required in India in the context of FMCG goods transportation.

Through the analysis, if we calculate Length, Width and Height of the vehicle separately instead of volumetric capacity of vehicle (Length * Width * Height) we are getting better result while doing the analysis.

From VIF score it is also clear that Length, Width and Height of the tuck is not having any multi collinearity.

We also found that, comparatively smaller truck (7.5Ton and 9 Ton) have more impact in Vehicle Fill rate due to Length of the vehicle over Width and height of the vehicle. In other words, due to variability of the length(L) in 7.5ton and 9ton truck, we will see more impact in Vehicle Fill rate, Width (W) and Height (H) have comparatively less impact. This interpretation leads to further analysis in smaller truck size (less than 7.5 ton), trucks which are generally used in secondary transportation for FMCG sector.

It was also found that, in comparatively bigger truck (more than 9 Ton) have more impact in Vehicle Fill rate due to Height(H) of the vehicle over Width(W) and Length (L) of the vehicle. In other words, due to variability of the Height (H) in more than 9ton trucks we have more impact in Vehicle Fill rate, Width (W) and Length (L) have comparatively less impact.

From above mentioned study it is evident that variance in truck size impact the Vehicle Fill rate of Indian FMCG organization, hence standardizing truck size is important for Indian economy. Utilization of full vehicle capacity will help to carry more material with same number of vehicles, which is beneficial for any economy. Through the simulation it was proven that standard truck size will carry more material compared to non-standardized truck and standard truck is cost effective compared to nonstandard one. We can simulate the same for each and every vehicle used in a

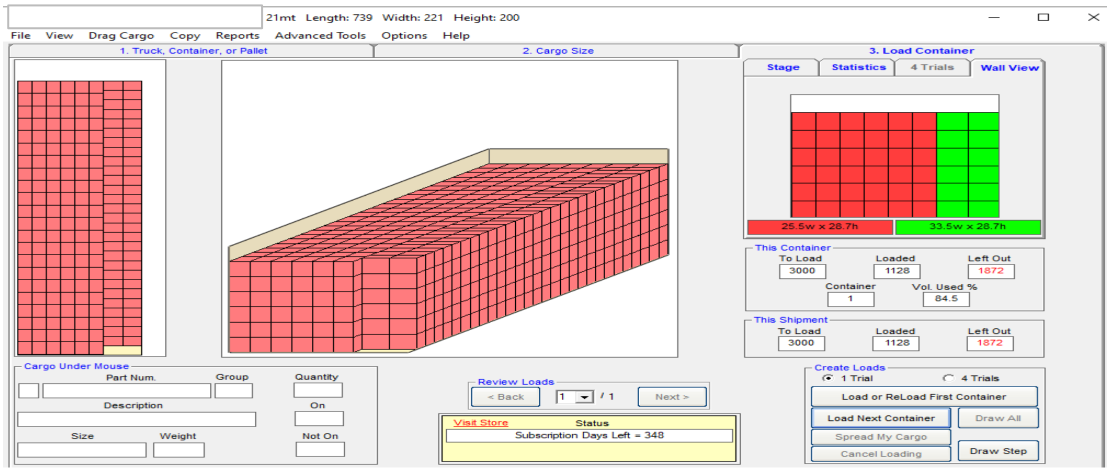
FMCG organization and can extrapolate the result, which will be in line with our small simulation result.

Not only cost, but it will also ensure lesser damages due to less space available for movement of the material in transit. But in this study, we have not covered that which will require further research in this area. Improved Vehicle Fill Rate (VFR) resulted lesser number of vehicles usage and it also reduces congestion and carbon emission.

5.4.6 Theoretical Implication based on Simulation building activity based on Variability in Truck Size

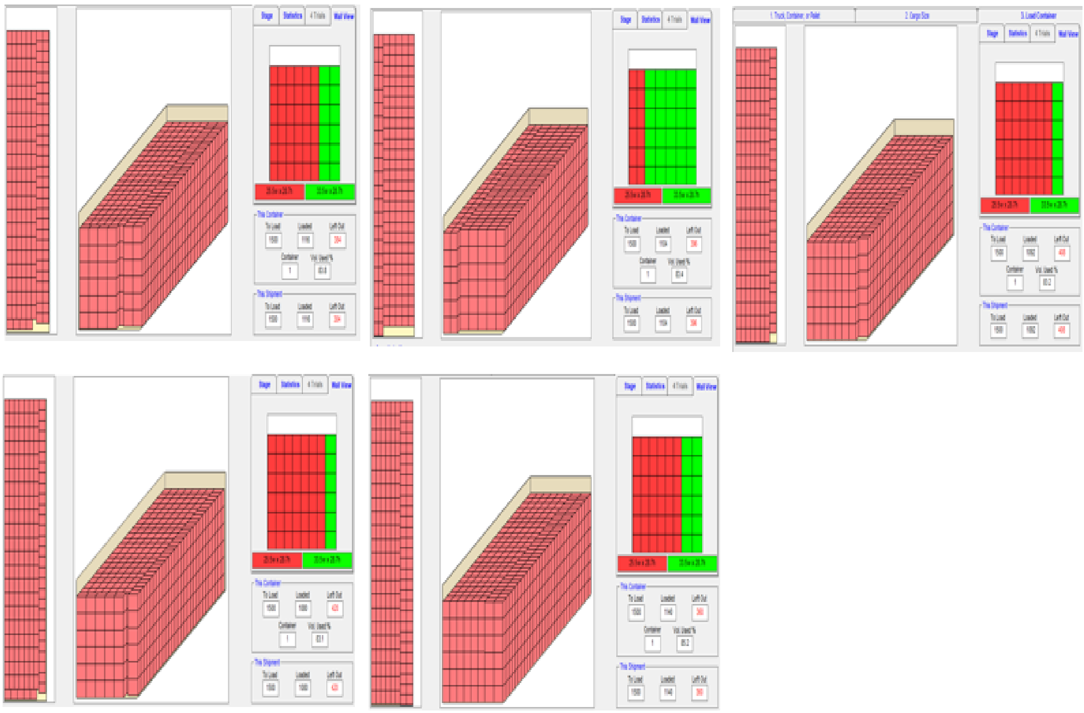
The current study intends to timely answer research question - What is the association between vehicle dimension and Vehicle Fill rate (VFR)? The study considered 770 samples from Indian Truck industry for testing the hypothesis. Drawing upon Resource Based View (RBV) theory, we established relation of dimensions of the vehicle and volumetric carrying capacity to Vehicle Fill Rate. Truck is a tangible resource and standardization of vehicle will bring competitive advantage to those firms who are having or using standardized vehicle. Those firms having their own or hired standardized trucks will get competitive advantage in terms of vehicle fill rate over their competitor who are using non standardized trucks. Through simulation it was proven that **Plant A** having competitive edge over **Plant B** since **Plant A** is having tangible resource like Standard vehicle. Strategic collaboration between shipper and carrier on usage of standardized vehicle will bring efficiency to bring down the logistics cost and improve the performance of the firm. Extension of RBV of the firm provides theoretical justification to find the vehicle dimension and the relationship between the resources (vehicle), vehicle fill rate and the resource expertise is developed which we can measure at operational level.

Intangible resource like knowledge of vehicle loading gained through regular practice and it is having interdependency on trucks (Tangible resource). Once trucks will have standard dimension, this intangible resource (knowledge) will have their base to bring competitive advantages through various algorithm. Hence standardization of truck dimension is prerequisite to improve Vehicle Fill Rate (VFR). Non-standard trucks are having separate loading pattern for each vehicle, which is a disadvantage from knowledge point of view. (Snap 5.2) Standard vehicle dimension will give always same loading pattern which will help the loading team to enhance their expertise and load the vehicle faster compared to non-standardized vehicle. (Snap 5.1). Standardized vehicle will always give better Truck Turn Around time (TAT) compared to non-standardized vehicle, which is another logistics efficiency parameter. Sharing the loading pattern below (Snap 5.1, Snap 5.2) to recognise the need of standardization of truck to have better knowledge to bring competitive edge –



Snap 5.1: Identical Loading Pattern for 5 number of Standard vehicles

Source - Prepared by the author (Cargo Wiz software demo version)



Snap 5.2: Different loading pattern for non-standardized vehicle

Source - Prepared by the author (Cargo Wiz software demo version)

From Snap 5.1, it is evident that the entire 5 vehicles for plant A is having same loading pattern and loader can load in a similar manner without using their mind. It will be repetitive job for them and any repetitive job brings the efficiency in the system. It will enhance the productivity of the loader. In plant A loader can load more vehicles compared to Plant B. It will help to enhance the productivity of their logistics team. But from Snap 5.2 it is evident that loading pattern at Plant B is different for loading the same material due to variation in truck size. Different loading pattern means loaders have to use their brains for filling the vehicles while loading. It will be non-repetitive by nature hence the productivity of the loader will be less. Within a stipulated time period the loader at plant B will load lesser number of vehicle since the loading time will be high at Plant B compared to Plant A. Hence standardization of vehicle is playing a vital role for filling the vehicle.

Aronsson, 2006 shared the similar view, that both Industry and government can help each other to increase standardization for transportation. To improve fill rate by structural means government should standardized the truck dimension.

5.5 Hypotheses development regarding truck carrying capacity variation with vehicle fill rate

For this research work, high number of data point was touched. Same seven hundred trucks carrying capacity were measured, which we have used in previous section. We have taken a most common case size, which are mostly used in FMCG organization for any weight centric cargo. Outer dimension of the cargo as follows, Length-370mm, Width - 205mm and Height - 198mm. Gross weight of the cargo is 0.112 ton. Volumetric cargo not taken into consideration since weight variation is notpossible to measure through volumetric material.

Based on data of truck carrying capacity and cargo size, weight we have simulated the data of vehicle fill rate. Total 700 number of sample size were picked up to draw conclusion on Hypothesis. We have used SPSS to validate the hypothesis.

In order to identify the high vehicle fill rate we need to identify the relationship between truck (open/ containerized) carrying capacity and vehicle fill rate, keeping case size and case weight as a constant. For that quantitative methodology is proposed. Here the independent variables are univariate by nature. Those are carrying capacity of the truck. Dependent variable is vehicle fill rate. Sharing the Hypothesis which we need to test –

Hypothesis (H2) - There is a significant impact of Variability in truck carrying capacity leadsto changes in vehicle fill rate (VFR)

For **H2**, to find the Relation between vehicle fill rate and Vehicle carrying capacity (Gross Vehicle Weight – Tare weight), Simple Linear Regression can be used as Vehicle fill rate is dependent on carrying capacity of vehicle.

Y (Vehicle fill Rate) = A*W + B

W= (Gross Vehicle Weight – Tare weight). Here regressors are denoted as W Dependent Variable is denoted as Y = Vehicle fill Rate. B is intercept for line Y.

Following the below mentioned loading constraint set while making the packing plan -

C1 – Items should get packed within the vehicle, without overlapping.

C2 – The items should be placed inside the vehicle orthogonally.

C3 – Permissible stacking norms should be followed while stacking the material inside the vehicle.

C4 - The sum of total items of a vehicle does not cross the maximum load carrying capacity of the vehicle.

C5 – Heavy material will be kept at the bed of the vehicle, light material will be kept on the heavy material

Based on data of truck carrying capacity variation and cargo size we have simulated the data of vehicle fill rate. Same 700 number of sample size were picked up to draw conclusion on Hypothesis. We have used SPSS to validate the hypothesis against each Truck Type and Truck carrying capacity.

The hypothesis tests if vehicle size variance carries a substantial impact on Vehicle Fill rate. Here Y is the dependent variable, regressed on predicting variable truck carrying capacity (weight) to test the hypothesis (H2). Truck carrying capacity variability (W) significantly predicted Vehicle Fill rate(Y), F = 6868.997, p = 0.000, which indicates that truck carrying capacity (weight) can play a substantial role shaping Y (B 0.949, p=0.000). From the result it is clearly evident that truck carrying capacity having direct positive affect. In this case R Square= 0.9 illustrate that this model explains 90% of variance of vehicle Fill Rate. Hence H2 was supported. In Table 5.17 we have shared the summary of our findings -

Hypothesis	Truck Type	Regressors	R	R Square	Beta Coefficient	t Statistics	Statistical Significance	F Statistics	Statistical Significance	Hypothesis Supported
H2	any	W	0.949	0.9	0.949	82.879	0.000	6868.997	0.000	Yes

Table 5.17: The regression relationship between weight wise capacity and Vehicle Fill Rate

While doing the calculation we have not taken more than standard weight into consideration since if we received higher capacity vehicle also, we are unable to use the same as there is no visibility of higher capacity vehicle at the time of transportation planning. Hence over carrying capacity vehicle assumed as 100% utilized. In case of under capacity vehicle as per vehicle Registration Certificate (RC) planned quantity reduced. Hence Hypothesis 2 is valid and not rejected.

VFR (Placed Capacity) %	VFR (GVW-Tare weight) %
100	98.1
99	97.2
98	96.3
97	95.4
96	94.5
95	93.6
94	92.6
93	91.7
92	90.8

Table 5.18: Comparison of VFR for standard carrying capacity vehicle with actual carrying capacity-based vehicle.

Source: Data gathered by researcher

From the above data and discussion, it is very much clear that variance in carrying capacity of truck impacted Vehicle Fill Rate (VFR). Structural issue having adverse impact on vehicle capacity, from Table No. 5.18 we can draw a conclusion better the load carrying capacity better the vehicle fill rate. Table 5.18 depicting that due to change in carrying capacity of the vehicle fill rate is varying. This table shows that in those cases where carrying capacity is full vehicle fill rate is also higher. Here Placed Capacity is considered as a full capacity of the vehicle. For an example if we called 21ton placed capacity then material carrying capacity is also 21ton. For this cases vehicle fill rate is high compared to those cases where vehicle is used based on actual carrying capacity as per document. In the right hand column we measured the vehicle fill rate based on actual carrying capacity which is GVW-Tare weight. For an example if actual carrying capacity of 21 ton vehicle is 20.5 ton then we are losing vehicle fill rate because of lower carrying capacity of the vehicle. The primary data we have gather for analysis giving this direct relation with vehicle fill rate. Hence it is evident standardization of truck is required to ensure better vehicle rate.

5.5.1 Simulation building activity based on Variability in Truck Carrying Capacity and Vehicle Fill Rate

After building the relationship between truck carrying capacity variability and vehicle fill rate, further to check the impact of non-standard truck over Vehicle Fill and impact on logistics cost, we have done a live simulation test between two factories located at Kolkata. **Plant ABC** using non standardized market-based vehicle and **Plant XYZ** using standardized dedicated vehicle. To do this simulation we have made certain assumptions and standardization –

A1. Plant ABC and XYZ, both are using 7.5 metric ton carrying capacity vehicle.

A2. Both are sending material through carton boxes or cases.

A3. Case size is also same for both. Carton Length is 30.0cm, width 20.5cm and height is 19.9cm.

A4. Case or box weight is same for both. Gross weight of a box is 9.3Kg.

A5. Stack height norms to keep the material inside the trucks is 8 high for both the plants.

A6. 2 types of case/ box orientation are allowed.

A7. Both are sending single SKU (Stock keeping Unit) in a vehicle. No mix of SKU.

A8. Both are sending material from Haldia to Kolkata.

A9. Per vehicle freight rate is same (INR 8870) from both the plants for 7.5MT vehicle, between Haldia to Kolkata.

A10. Time frame for despatch is same for both the plans.

A11. Considering vehicle dimension is same for both the plant.

Both plants will send 20000 cases from Haldia (120km away from Kolkata) to Kolkata- through 7.5 metric ton carrying capacity vehicle. Both the plant using same size of vehicle – Length 555.9cm, Breadth 216.1cm, height 178.3cm but actual carrying capacityof the vehicles are different due to other than OEM make vehicles.

Plant XYZ using standard vehicle type with standard carrying capacity to send these 20000 cases from Haldia to Kolkata and Plant ABC using same type of vehicle but carrying capacity is different.

Plant	**Vehicle Number**	**Length (mm)**	**Width (mm)**	**Height (mm)**	**GVW (in MT)**	Tare weight (in MT)	Loading capacity (in MT)	Standard Truck Capacity (MT)	Freight Haldia to Kolkata (INR)
ABC	**WB41B9974**	5559	2161	1783	14	6.83	7.17	7.5	8870
ABC	**WB31-0993**	5559	2161	1783	14	6.99	7.01	7.5	8870
ABC	**WB25E2608**	5559	2161	1783	13	5.95	7.05	7.5	8870
XYZ	**WB25J4171**	5559	2161	1783	13	5.5	7.5	7.5	8870

Table 5.19: Vehicle dimension and weight carrying capacity details along with Freight cost for ABC and XYZ company respectively

ABC company sends the same type of vehicle (7.5 MT) but their carrying capacity is 7.17 MT, 7.01 MT and 7.05MT respectively. ABC company also sends same 20000cases between Haldia to Kolkata. To send these 20000 cases with the above-mentioned vehicle configuration, company ABC will use 27 numbers of trucks. Here the standard truck type is 7.5 MT but due to local fabrication the carrying capacity is different. The capacity of the trucks in terms of cases is 770 cases, 753 cases and 742 cases respectively. Details shared in Table 5.19.

Vehicle fill rate varies according to vehicle carrying capacity. In the Table 5.20 vehicle utilization is reflecting –

Plant	**Vehicle Number**	**GVW (in MT)**	**Tare wt (in MT)**	**Loading capacity (in MT)**	**Actual Qty Despatch ed(MT)**	**Standard Truck Capacity (MT)**	**Despatch ed in a vehicle (No. of CS)**	**Despatch ed in a vehicle (KG)**	**Weight Utilization (in %)**	**Volume Utilizati on(in %)**
ABC	**WB41B997**	14	6.83	7.17	7.62	7.5	770	7161	95%	57.30

	4									%
ABC	**WB31-0993**	14	6.99	7.01	7.35	7.5	753	7003	93%	56.10 %
ABC	**WB25E2608**	13	5.95	7.05	7.69	7.5	742	6901	92%	60.00 %

Table 5.20: Vehicle carrying capacity, total despatch quantity, along with vehicle utilization for ABC company

For XYZ company we will send standard vehicle with 7.5 ton carrying capacity i.e., 4th vehicle from Table 5.21. Between Haldia to Kolkata with this vehicle to send 20000 cases company XYZ will take 25 number of vehicles. Since the carrying capacity is same, their vehicle utilization is also same. It will carry 806 number of cases in each trip between Haldia to Kolkata.

Plant	**Vehicle Number**	**GVW (in MT)**	**Tare wt (in MT)**	**Loading capacity (in MT)**	**Actual Qty Despatched(MT)**	**Standard Truck Capacity (MT)**	**Despatched in a vehicle (No. of CS)**	**Despatched in a vehicle (KG)**	**Weight Utilization (in %)**	**Volume Utilization (in %)**
XYZ	**WB25J4171**	13	5.5	7.5	7.38	7.5	806	7496	100%	56.40%

Table 5.21: Vehicle carrying capacity, total despatch quantity along with vehicle utilization for XYZ company

5.5.2 Findings based on simulation, related to vehicle fill rate and freight cost

This above-mentioned study proves that for ABC company due to variation in vehicle carrying capacity vehicle utilization is varying but major impact is reflecting on **cost**. Freight per case or freight per ton varies a lot, hence it is difficult for any organization to predict or budget the freight spends. Similarly, it is also difficult to predict how many vehicles or trips is required to despatch a certain quantity, since the despatch quantity is varying in each vehicle though the case size and case weight is same.

In this case ABC required 27number of vehicles to despatch 20000 cases.

Compared to that XYZ company required 25 number of vehicles to despatch same 20000 cases. As a result, company ABC used 2 additional vehicles compared to company XYZ, and as such, incurred further cost, amounting to **INR 17740** (INR 8870 x 2 number of vehicles).

The additional vehicles used by company ABC, magnifies the carbon emission emitted by the vehicles.

For XYZ company the vehicle carrying capacity is the same. Hence equal number of quantities are despatched in every vehicle. For all these despatched vehicles - Vehicle utilization, per case freight or per kg freight remain same XYZ company can predict estimated freight to despatch 20000cases.

Plant	Vehicle Number	GVW (in MT)	Tare wt (in MT)	Loading capacity (in MT)	Actual Qty Despatched(MT)	Standard Truck Capacity (MT)	Freight Haldia to Kol (INR)	Despatched in a vehicle (No. of CS)	Despatched in a vehicle (KG)	Freight per case (INR/Case)	Freight per KG (INR/KG)
ABC	WB41 B9974	14	6.83	7.17	7.62	7.5	8870	770	7161	11.52	1.24
ABC	WB31-0993	14	6.99	7.01	7.35	7.5	8870	753	7003	11.78	1.27
ABC	WB25 E2608	13	5.95	7.05	7.69	7.5	8870	742	6901	11.95	1.29
XYZ	WB25 J4171	13	5.5	7.5	7.38	7.5	8870	806	7496	11	1.18

Table 5.22: Comparison of freight per ton, freight per case between the vehicle used by ABC and XYZ company respectively.

From Table 5.22 it is evident that for ABC company per case freight cost varies between INR 11.52 per case to INR 11.95. Compared to that for XYZ company the freight cost is around INR 11 per case. Company XYZ has better predictability and visibility in terms of per unit freight cost, which helped them to create a better financial budget.

5.5.3 Findings based on simulation, related to vehicle fill rate and carbon emissions

To calculate the carbon emission for this simulation we will use the process described in India Specific Road Transport Emission Factors, 2015 issued by India GHG Program.

To calculate the carbon emissions, the below data was used –

a. Fuel type – For this simulation we have used Diesel for trucks as a fuel.
b. Vehicle Type – MDV. Since 7.5ton is more than 3.5ton but less than 12ton. As per the central motor vehicle rules, 1989 for this simulation vehicle category is N2, which lies between 3.5ton and 12ton.
c. Gross capacity of the vehicle is 7.5ton.
d. Mileage - Average Fuel burn per km (km/lit). In this case since all four vehicles are BSIV vehicle, mileage is 4 km/lit between haldia to Kolkata.
e. Emission factor of Diesel – 2.6444 Kg CO2/ lit. As per Intergovernmental Panel on Climate Change (IPCC).

For 7.5 Ton truck (MDVs), Emission factor (kg CO2/km) is equals to 2.6444 (kg CO2/ lit) divide by 4 (km/lit).

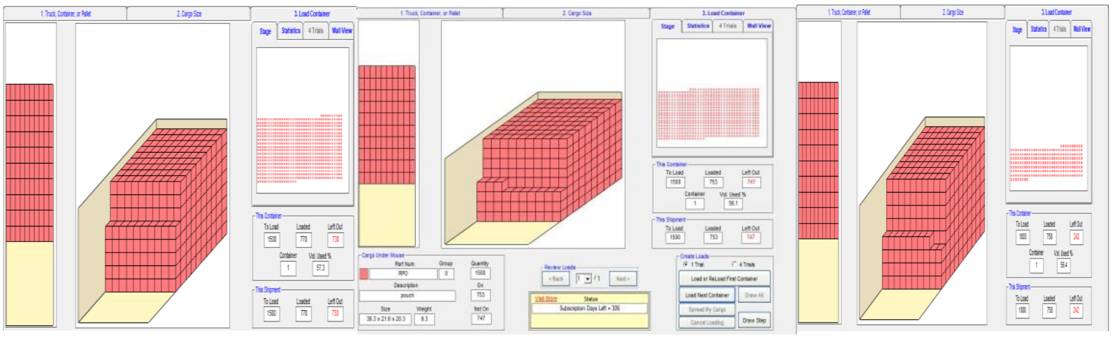
For this 7.5ton truck emission factor (kg CO2/km) is equals to 0.6611 kg CO2/km

In this simulation for both the company (ABC, XYZ) we will use emission factor by multiplying the km travelled between Haldia and Kolkata. For ABC total KM travelled will be 125km multiplied by 27 number of trucks i.e., 3375 km and for XYZ will be 125km multiplied by 25 number of trucks i.e., 3125.

Carbon emissions for ABC will be 0.6611kg multiplied by 3375km, equals to 2231.21 kg CO2. Compare to that for similar quantity despatches XYZ will have 2065.94 kg of CO2 emission. 165.28kg lesser CO2 emission compared to ABC company.

Findings based on simulation, related to vehicle fill rate and Truck Turn Around Time (TAT)

Since the number of cases despatched per vehicle varies it will create some confusion between the execution team, which leads to some error or delay in operation. In this case loading pattern will be same for all the vehicle type only case quantity will vary due to variation in vehicle carrying capacity. (Reference Snap 5.3)



Snap 5.3: Loading pattern of XYZ company

For XYZ company since equal number of quantities is despatched every time, it assists in faster execution (loading) while despatching the stock. It leads to better Truck Turn Around time (TAT) inside the plant for XYZ company compared to ABC company.

5.5.4 Practical Implication based on Simulation building activity based on Variability in Truck Carrying Capacity

Form above study it was eminent that truck carrying capacity is varying in India due to non- standardized vehicle. Most transporters within India, are taking the chassis of the vehicle from OEM. They are building the body of trucks by their own (through fabricator) according to their own specification. Hence truck wise carrying capacity varies for same type of trucks. It may give benefit to individual transporters for the time being but as a whole in long run organizations are losing and struggling to set the required specification of the vehicle. Unable to predict the freight spend and budget related to freight. Since most of the organizations are suffering due to this non standardization India economy also suffering despite of taking big steps of making changes in rules and regulation related to freight transport.

Since XYZ organization is having better visibility in terms of freight per unit they can have better product pricing strategy compared to ABC company. Here XYZ and ABC company is used for simulation purpose, but same thing is applicable to most of the organizations in India. Those who are using standard vehicle with standard carrying capacity will have better edge over their competitor since they can have better pricing strategy along with better profitability since they are having better visibility and predictability of per unit freight cost. For every organization fright cost plays a significant role in product pricing.

Truck turnaround time (TAT) is one of the important performance parameters for Logistics. Less TAT resulting better performance for any organization. TAT is impacted by many Factors. One of the influencers is vehicle loading time. Vehicle with same standard carrying capacity will give better TAT compared to nonstandard vehicle. Because every time executor has to give same number of cases in the vehicle. In this study it is evident for ABC and XYZ company. Same will be applicable for other industries in India.

As per NITI Aayog report published in June 2021, India wants to reduce energy consumption by 50 per cent between 2020 and 2050. For that they have identified three levers, optimizing truck use is one of them. If they can leverage the truck utilization and other two factors, (modal shift and efficient-alternative fuel technology) they can bring down the carbon emissions, improve the quality of air. India can save 2.8 Giga tones of CO_2 caused by freight transport by 2050. Singh et al. (2021), shared details of carbon emissions generated by on road vehicles with reference to year 2020. As per that Freight vehicles running with diesel have highest contribution of 104 Tera-gram carbon dioxide which is 38% of total estimated carbon dioxide emissions generated by on road vehicles. Reports of NITI Aayog published in June 2021 also supported the vision. As per this report better load factor will help to reduce carbon emission and our study help to build this better load factor. Better fill rate means lesser number of trucks required to dispatch same quantum of materials. Lesser number of trucks leads to lesser fuel usage and lesser carbon emissions. Hence our study will help to identify the need of standardizing the vehicle carrying capacity. From the above illustration we found XYZ company required 2 vehicles less compared to ABC company who is using non standardized vehicles. Lesser usage of vehicles will generate freight savings, also reduce the carbon emission of 165.28kg. From this small simulated of freight cost and carbon emission we are getting idea of savings one can generate by standardizing the vehicle carrying capacity.

Industry experts P. Mukherjee, R. Ghosh and A. Sanyal vouched the influence of the structural issue on vehicle fill rate based on their experience in FMCG sector. All of them confirmed that this structural issue having direct impact on vehicle fill rate and impacting the freight cost. Above mentioned persons having more than 20 years of industry experience and all are worked at very senior level in FMCG organization. They have share their personal opinions since they have not taken the consent from their current organisation we are unable to share their organization details in this study. But they have worked in many renowned FMCG companies in India and abroad. Practical results also shared in chapter 7 based on this study.

In this study we have focused on non-standard size of truck and their influence on truck fill rate. Efficiency in truck fill rate having direct impact on freight cost and carbon emission from the above illustration it is clear to meet the target taken by Government of India on reduction of carbon emission, standardization of vehicle will be one of the important levers which will help in better vehicle utilization, resulted reduction of number of vehicle usage.

5.5.5 Theoretical Implication based on Simulation building activity based on Variability in Truck Carrying Capacity

Resource Utilization is one of the important factors for any organization. As per Resource based view theory there are two types of resources available in every organization - Tangible resource and Intangible resource. In this particular study trucks are treated as tangible resources and knowledge of load building for truck and loading the vehicle is intangible resource. Those organization who are having standard vehicle with standard carrying capacity will get more return from this tangible resource compared to those who are using non-standardized truck. Load forming and execution of loading activity will be easier if trucks are having same carrying capacity. Regular practice or activity with standard carrying capacity will help to reap the benefit from this intangible resource and helped to get competitive advantage over the companies who are using non standardized vehicle. Those who are using vehicles with various carrying capacity either landed with under load since at last phase of loading load increase is not possible or they have to drop the load if vehicle is having lesser carrying capacity compared to standard carrying capacity of a truck. In India majority of the vehicle is non-standardized by nature hence compared to other developed country India is unable use their tangible resource properly to get the competitive advantages. Hence to get competitive they have modified the rules of carrying capacity in 2018 after 33 years and targeted the segment of increasing the load in each truck which is captured in Niti Aayog report published in June 2021.

5.6 Hypotheses development related to Usage of Angle, nut-bolt inside Truck with vehicle fill rate

To investigate how structural issue within the trucks (angel/nut-bolt inside trucks) leads to change in vehicle fill rate (VFR).

To find the Relation between vehicle fill rate without structural Issues and Vehicle Fill rate with structural issues, Simple Linear Regression can be used considering Vehicle fill rate without structural issues as dependent variable and vehicle fill Rate with structural issues as independent variable.

Y (Vehicle fill Rate W/O structural Issues) = A*W + B

W = (Vehicle fill Rate with structural Issues)

In structural issues, we have to calculate the Loadability Loss happened due to that issue.

Correlation between Loadability without loss and Loadability after loss = 0.9983

VFR Before Loss	VFR After Loss
100%	99.85%
99%	98.82%
98%	97.79%
97%	96.75%
96%	95.72%
95%	94.69%
94%	93.66%
93%	92.63%
92%	91.60%
91%	90.57%
90%	89.54%

Table 5.23: Relation between VFR before loss and after loss due to structural issue in a truck

Source: Primary data collected by the researcher for this study

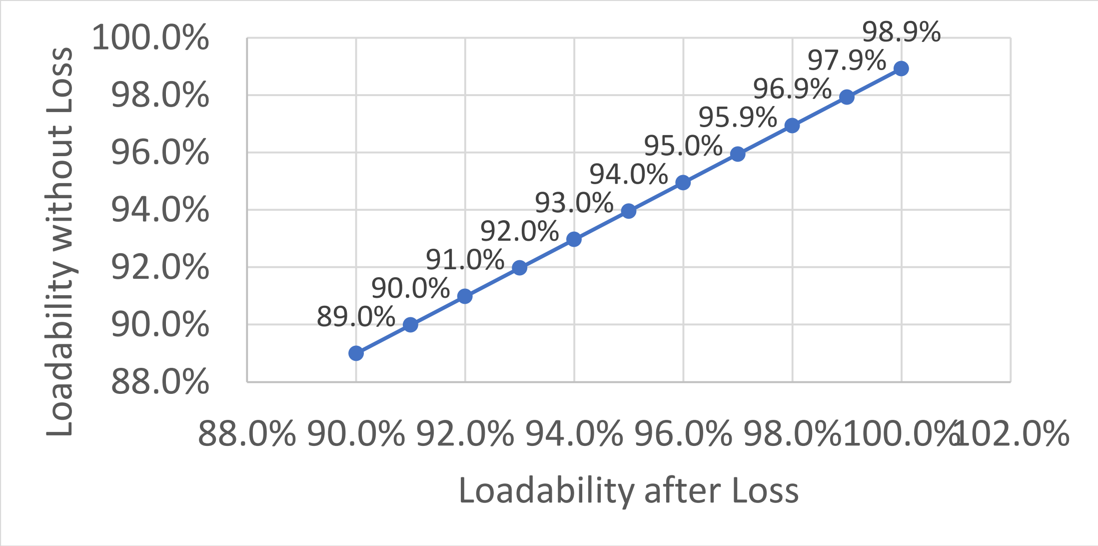


Figure 5.1 – Graphical presentation of VFR before loss and after loss due to structural issue in a truck

From the Table 5.23, Figure 5.1 and correlation, it was clear that this hypothesis is valid and structural issue within the trucks (angel/nut-bolt inside trucks) leads to change in vehicle fill rate (VFR).

To prepare Table number 5.23 primary data is collected by the researcher. Here comparison happened between those trucks where structural issue is present and where there is no structural issue in the trucks. From those data it is evident that in those trucks where structural issues are present - like presence of angle, nut bolts in a truck having lesser vehicle filling rate compared to no structural issue trucks. Because of those structural issues lesser number of cases loaded in those vehicles though the truck carrying capacity and truck dimensions are same. For an example, in a good truck (without structural issue) if we can load 100 cases then those trucks where structural issues are there we will be able to load 99 cases where truck carrying capacity and truck dimension is constant. It was proven with the collected data.

5.7 Chapter Summary

This chapter discussion is only focused on 'Structural constraints of truck' which was assessed as topmost constraint through DEMATEL, AHP and FAHP. Linear regression and hypotheses were tested for all the possible truck types which was used for FMCG organization in India mainly focusing on primary transportation. It is analysed by using statistical software package SPSS 22.0. Moreover, this chapter portrays the relationship of all the three constraints related to ‘structural issue of truck’ with vehicle fill rate. Here details of simulation activity were shared with respect to cost and carbon emissions. To ensures research construct validity the Durbin-Watson test was also used. In this chapter we also shared the score of DW test, and it was proven that there is no autocorrelation exist in the regression analysis application test score for all the truck types. In next chapter, we will discuss about the strategy and solutions related to vehicle fill rate.

Chapter 6

Assessment of Solution and Strategies to overcome the constraints of vehicle fill rate in road freight transport

Overview

This chapter cover the identification of strategies and solutions, prioritizing the solution to overcome the constraints of vehicle fill rate in road freight transport. Fuzzy TOPSIS method was applied to prioritize the solutions. Moreover, an integrated framework was identified and discussed in this chapter to overcome the constraints related to vehicle fill rate.

6.1 Introduction

Vehicle fill rate is relatively a new subject for developing country like India. In the world, the economy of India is one of the fastest growing economies and FMCG sector is one of the major sectors of the growing economy. One of the primary motives of the FMCG sector is to reduce the cost to become competitive in global market along with good quality of delivery. Reduction of carbon emissions is responsibility of everyone. However, the focus of vehicle fill rate is very minimum in most of the sector in India, including FMCG sector. Hence in extremely competitive market of FMCG where cost is the utmost priority trucks are not sending in full conditions. Constraints related to vehicle fill rate creates barriers to fill the trucks in full. Moreover, some unique constraints are there which are not covered in the literature on vehicle fill rate and for that only this current research holds great importance. ;Since these unique constraints are available in developing countries like India, same thing may exist in other developing countries. This study will help them also to fill the truck and become competitive in global markets. Identifying the constraints are not enough to contribute to vehicle fill rate. Along with that, identification of solutions and strategies, ranking the strategies are also equally important to overcome the constraints. Hence this current chapter is based on below mentioned two objective -

Research Objective 2: To identify the solution/ strategies to overcome the constraints of Vehicle Fill Rate in Road freight transport of FMCG sector in India.
Research Objective 3: To develop and test an integrated framework to overcome the constraints of Vehicle Fill Rate in Road freight transport of FMCG sector in India.

To achieve these two objectives an integrated framework (Figure 6.1) was drawn along with prioritization of solutions to overcome the constraints of Vehicle Fill Rate in Road freight transport of FMCG sector in India. Along with existing literature, subject matter experts also shared their opinion on the strategies to be identified to overcome the constraints. 32 number of strategies are identified and ranked based on the criticality and impact on the identified constraints. Subject matter experts are same who provided feedback on constraints. Details of experts already shared earlier in Chapter 4. To rank the strategies Fuzzy TOPSIS method was used. This is also a method comes under multi criteria decision making (MCDM) like Fuzzy AHP.

6.2 Proposed Framework

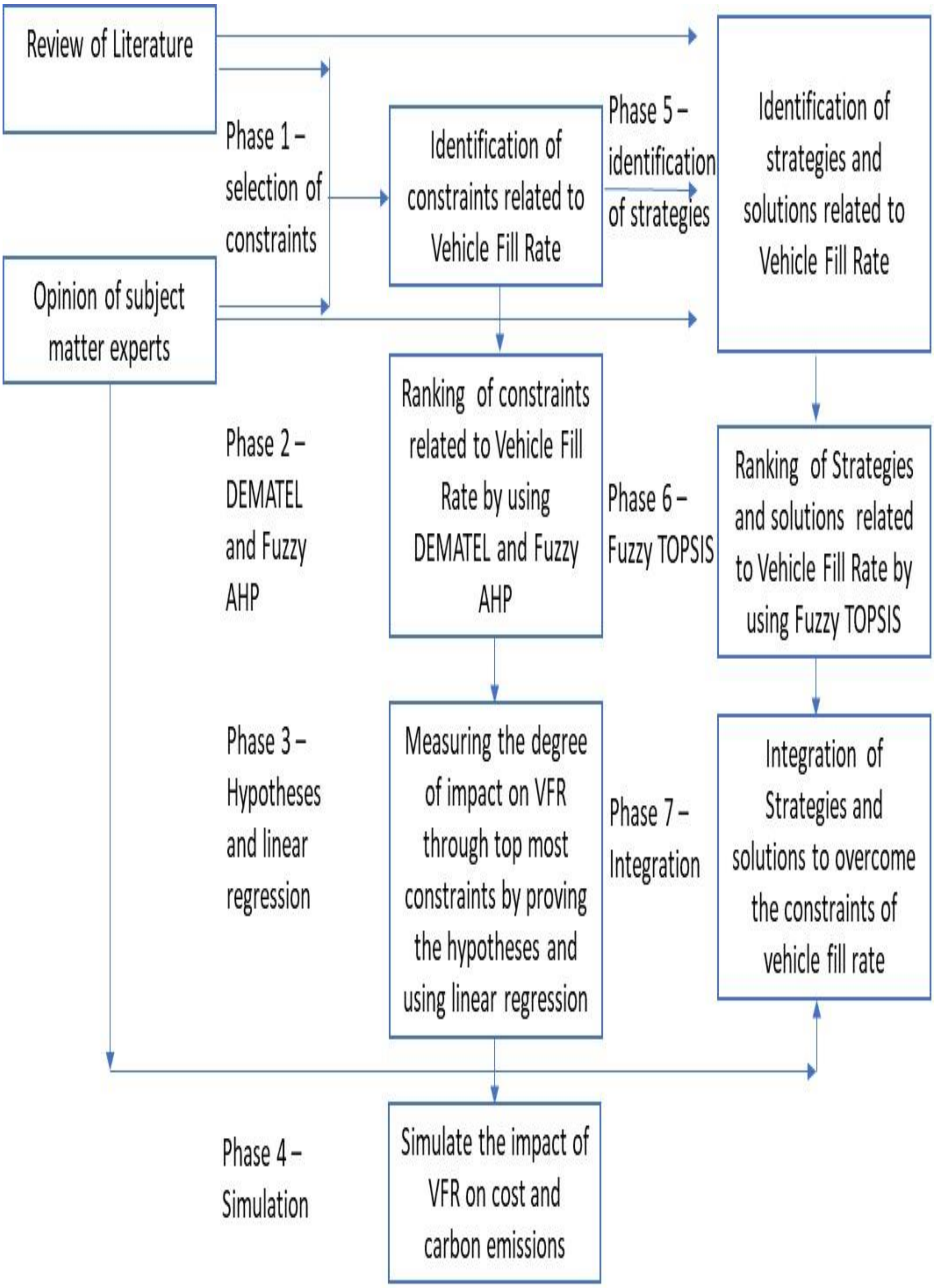


Figure 6.1 – Recommended Framework for this research thesis

Source – Author's Composition

6.3 Identified strategies and solutions to overcome the constraints in vehicle fill rate for FMCG sector

Based on review of literature and opinion of subject matter experts solutions and strategies are identified to overcome constraints in vehicle fill rate for FMCG sector.

Categories of Strategies and Solutions	Strategies and Solutions sub-categories	Code	Source
Government Support - Law enforcement regarding harmonization of truck size and carrying capacity (GSL)	Regulatory directives and Transportation legislation regarding harmonization of truck size (GHS)	GHS	Biswas and Anand (2022), Ortega et al. (2014), Ramos et al. (2017),Eidhammer and Andersen (2014), Ortega et al. (2014),Transport et al. (2011); Aronsson and Brodin(2006).
	Regulatory directives and Transportation legislation regarding harmonization truck carrying capacity (GHC)	GHC	
	Increase in Carrying capacity (GCC)	GCC	
Choosing Right Truck Type (RTT)	Double stack/ Double Deck vehicle (RDD)	RDD	Ramos et al. (2017),Knight et al. (2008),Hosseini and Shirani (2011), McKinnon (2010), Slob (2013),Morabito et al. (2000),Gadde and Håkansson (2001), Aronsson and Brodin(2006),McKinnon (2000), Santén and Rogerson(2014)
	High Cube truck (RHC)	RHC	
	Selecting Right size truck (RRS)	RRS	
	Usage of Longer and Heavier vehicle (RLH)	RLH	
Physical loading Activity (LAP)	Reorganizing the way in which the cargo is boxed/packed (LRC)	LRC	Knight et al. (2008), Slob (2013), McKinnon (2010), Morabito et al. (2000),Jordan (2011),Hosseini and Shirani (2011), A.T. Kearney Management Consultants (1997),Cruijssen (2012), McKinnon(2000)
	Choosing an appropriate loading method (LAL)	LAL	
	Increasing stacking height (LSH)	LSH	
	On top loading (LOT)	LOT	
	Training on loading activity (LTL)	LTL	
Product and packaging design (PPD)	Redesigning dimensions and shape of packaging (PRD)	PRD	McKinnon et al. (2003),Jordan (2011), Wu and Dunn (1995), McKinnon (2000), Gustafsson et al. (2004), Gustafsson et al. (2004); Pålsson et al. (2013)
	Packing more efficiently on each loading unit (PEL)	PEL	
	Choosing appropriate packaging system (PCA)	PCA	
Coordination and Consolidation Activity (CAA)	Within function and outside function coordination (CFO)	CFO	Hosseini and Shirani (2011), Rogerson and Sallnäs (2016), McKinnon (2010),Kohn and Brodin(2008), Cruijssen(2012),McKinnon(2000),Ljungberg and Gebresenbet(2004), Santén and Rogerson (2014),Islam et al. (2019)
	Consolidation by freight forwarder in terms of sharing vehicle capacity (CSV)	CSV	
	Back loading Activity (CBA)	CBA	
Ordering pattern (OPP)	Multi drop delivery (OMD)	OMD	McKinnon et al. (2003), Baumgartner et al. (2008),McKinnon (2010b), Jordan (2011), Hosseini and Shirani (2011),
	Route planning (ORP)	ORP	
	Postponement of delivery (OPD)	OPD	
	load Consolidation and collaboration (OLC)	OLC	

	Nominated day delivery system (OND) Reducing the variation of order size (ORV)	OND ORV	Piecyk and McKinnon (2010),Kohn and Brodin(2008); Santén and Rogerson (2014);Islam et al. (2019)
warehousing Related Changes (WRC)	Increasing size of warehouses (WIS) Reducing the number of Warehouses (WRN) Relocating warehouses (WRW)	WIS WRN WRW	Hosseini and Shirani (2011), Aronsson and Brodin(2006)

Categories of Strategies and Solutions	Strategies and Solutions sub-categories	Code	Source
Implementation of IT (IOI)	Usage of two-phase optimizer tool (ITP) Implementation of Transport Management System (ITM) load planning and 3D load building through ERP (ILL) Excel based solver for load building (IEC) Computerized vehicle routing and scheduling and vehicle telematics (ICR)	ITP ITM ILL IES ICR	Lim. A.,Ma H., Qiu C., Zhu W (2013), Bortfeldt and Wäscher (2012), Jose. T., Sijo. T.M., Praveen, (2013), Sitompul. C.,Horas, M. C., (20121), Zhu, W. & Lim, A., (2012), Landschu¨ tzer, C., Ehrentraut, F., Jodin, D., (2015), Patil and Patil (2016),Gürbüz. Z.M., Akyokuş. S., Emiroğlu. I., Güran. A., (2009), Olsson et al. (2019), Saraiva et al. (2019),Tian et al. (2015),Bischoff and Ratcliff(1995),Ramos et al. (2017), Nascimento et al. (2020), Chen et al. (1995), Oliveira et al. (2020),Li et al. (2022), Padberg (2000), Moura & Oliveira (2009), Chen et al. (1995), Erbayrak et al(2021), Hakim & Abbas (2019), Sawik (2018), Junqueira et al. (2012), Junqueira et al. (2012), Martello et al. (2000), Boef et al.(2005), Hifi (2004), Fekete et al. (2007), Li & Cheng (1990, 1992), Miyazawa & Wakabayashi (1997, 1999, 2007 und 2009), Jansen & Solis-Oba (2006), Bansal et al. (2006), Terno et al. (2001), Mack et al. (2004), de Araujo & Armentano (2007), Parreño et al. (2010b), Fanslau & Bortfeldt (2010), Goncalvez & Resende (2012), Bischoff & Ratcliff (1995), Davies & Bischoff (1998), Gehring & Bortfeldt (2002), Moura & Oliveira (2005), Parreño et al. (2010b), Fanslau & Bortfeldt (2010), Goncalvez & Resende (2012), Ivancic et al. (1989), Eley (2003), Che et al. (2011), Martello et al. (2002), Martello et al.

			(2000), Lodi et al. (2002); Faroe et al. (2003), Crainic et al. (2009), Parreño et al. (2010), Bortfeldt & Gehring (1999), Bortfeldt & Mack (2007), Allen et al. (2011), Bortfeldt & Mack (2007), Bortfeldt & Mack (2007), Allen et al. (2011), Ramos et al. (2014), Gürbüz et al. (2009), Baumgartner et al. (2008), Vega-Mejía et al. (2017), Gajda et al. (2020);Santén and Rogerson (2014); Kilincci & Medinoglu (2021), Nishiyama et al. (2021)Lin et al.(2014),Kanniga et al.(2014).

Table 6.1: 32 strategies to overcome the constraints of vehicle fill rate in Road freight transport along with source of the literature

Source – Authors composition

Category of Constraints	Sub-Category of Constraints
Structural Constraints of Truck (SCT)	Variability in Truck Size (SVTS)
	Variability in Truck Carrying Capacity (SVTC)
	Usage of Angle, nut-bolt inside Truck (SUAT)
Vehicle Related Constraints (VRC)	Weight Limits (VWLT)
	Weight Distribution Constraints (VWDC)
	Load limit by volume (VLLV)
Box Related Constraints (BRC)	Loading Priorities (BLPR)
	Orientation Constraints (BORC)

Categories of Strategies and Solutions	Strategies and Solutions sub-categories
Government Support - Law enforcement regarding harmonization of truck size and carrying capacity (GSL)	Regulatory directives and Transportation legislation regarding harmonization of truck size (GHS)
	Regulatory directives and Transportation legislation regarding harmonization truck carrying capacity (GHC)
	Increase in Carrying capacity (GCC)
Choosing Right Truck Type (RTT)	Double stack/ Double Deck vehicle (RDD)
	High Cube truck (RHC)
	Selecting Right size truck (RRS)
	Usage of Longer and Heavier vehicle (RLH)
Physical loading Activity (LAP)	Reorganizing the way in which the cargo is boxed/packed (LRC)

	Stacking Constraints (BSTC)
	Positioning Constraints (BPOC)
Cargo Related Constraints (CRC)	Complete Shipment Constraints (CCSC)
	Allocation Constraints (CALC)
	Multi Drop Operation (CMDO)
	Service Requirements (CSRM)
Load Related Constraints (LRC)	Stability Constraints (LSTC)
	Complexity Constraints (LCOC)
	Product Mix (LPRM)
	Orthogonal placement and No overlap (LOPO)

	Choosing an appropriate loading method (LAL)
	Increasing stacking height (LSH)
	On top loading (LOT)
	Training on loading activity (LTL)
Product and packaging design (PPD)	Redesigning dimensions and shape of packaging (PRD)
	Packing more efficiently on each loading unit (PEL)
	Choosing appropriate packaging system (PCA)
Coordination and Consolidation Activity (CAA)	Within function and outside function coordination (CFO)
	Consolidation by freight forwarder in terms of sharing vehicle capacity (CSV)
	Backloading Activity (CBA)

Continuation of the table

Category of Constraints	Sub-Category of Constraints
Order Related constraints (ORC)	variability of order size (OVOS)
	Routing of deliveries (ORDC)
	JIT/frequency of deliveries (OJIT)
	Unloading Priorities (OULP)
Packaging Related Constraints (PRC)	space-In efficient packaging (PSIP)
	use of shelf-ready packaging (PUSR)
	Design of products -LBH of Boxes (PDPC)
Inter and Intra Coordination and collaboration Related Constraints (ICC)	inter-functional coordination within organization (IFCW)
	inter-Organization coordination (IIOC)
	within functional coordination within organization (IWFC)

Categories of Strategies and Solutions	Strategies and Solutions sub-categories
Ordering pattern (OPP)	Multi drop delivery (OMD)
	Route planning (ORP)
	Postponement of delivery (OPD)
	load Consolidation and collaboration (OLC)
	Nominated day delivery system (OND)
	Reducing the variation of order size (ORV)
warehousing Related Changes (WRC)	Increasing size of warehouses (WIS)
	Reducing the number of Warehouses (WRN)
	Relocating warehouses (WRW)
Implementation of IT (IOI)	Usage of two-phase optimizer tool (ITP)
	Implementation of Transport Management System (ITM)
	load planning and 3D load building through ERP (ILL)

	Excel based solver for load building (IEC)
	Computerized vehicle routing and scheduling and vehicle telematics (ICR)

Table 6.2: Constraints, sub-categories of constraints, category of solution and sub-categories of solution for vehicle fill rate in road freight transport

Table 6.2 is the summary for all the constraints and all the probable solutions to overcome those constraints related to vehicle fill rate.

6.4 Prioritization of the strategies and solutions to overcome the constraints related to vehicle fill rate in road freight transport for FMCG sector

Like constraints ranking, prioritization of solution ranking is equally important since implementation of all the solutions with equal importance within a stipulated timeline is not possible. Those constraints were categorised and sub-categories according to the nature of the solutions for the constraints. If the types of the solutions are similar then it kept under one category. For an example if solutions are related to information technology or computer, then it grouped under 'implementation of IT Based Soultion'. Similarly if constraints are related to law enforcement, law modifications then these constraints are clubbed together under one category. Any legal changes is depending upon Government only, hence the category will be 'Government Support through Law enforcement regarding harmonization of truck size and carrying capacity'. Categorisation is done based on similarity of the solutions. In above two examples, information technology is one sub-category and legal is another sub-category. During literature review similar type of solutions were observed which was clubbed and discussed under one head but categorisation was not observed since they have not ranked the categories and sub-categories of solutions. To rank the solutions categorisation is important. It will help to analyse the solutions and it will also help to get better results while solution or strategies will be used. Holistic approach towards this category of solutions will help to rank the solutions as well as to identify the solution for the whole constraints. Sub-categories within the category will be well covered. Through this process eight categories were identified and thirty two sub-categories were ascertained.

In the solutions, both qualitative and quantitative aspects are available; hence usage of MCDM is appropriate for this study. Out of many MCDM techniques Fuzzy TOPSIS was selected. Fuzzy TOPSIS is based on distance priority matrix, it helped to prioritize the solutions to overcome the constraints. 32 solutions are identified to overcome the constraints. Based on the nature of the solutions these 32 strategies are grouped in to 8 categories of solutions. Based on closeness coefficient value final ranking is determined. Fuzzy TOPSIS technique is discussed below –

6.4.1 Fuzzy TOPSIS

The prioritization of the solution and strategies to overcome the constraints in vehicle fill rate in road freight transport for FMCG sector is conducted by applying FTOPSIS method. Table No. 6.3 to Table No. 6.11 shares the calculation to derive the ranking of the strategies and solutions through Fuzzy TOPSIS. Table 6.4 presents the scores matrix for the solution. The fuzzy scores determined for the solution are displayed in Table 6.5. The normal fuzzy matrix for the solutions is illustrated in Table number 6.6. The weighted decision matrix after application of normalised fuzzy logic is illustrated in Table number 6.7. Post that, ideal solution is finalised by using fuzzy positive and negative vector and determining the distance of every arrangement from both the positive and negative vectors to show up the nearness coefficient value. Details are exhibited in Table number 6.8, 6.9 and 6.10. The rank for the solution is determined based on the nearness coefficient value in Table number 6.11. The higher the nearness coefficient value the higher will be the rank for the proposed solutions.

To get a matrix for the strategies score is given to each category

Linguistics	Specific TFNs	Score
VERY LOW	(1,1,3)	1
LOW	(1,3,5)	3
AVERAGE	(3,5,7)	5
HIGH	(5,7,9)	7
VERY HIGH	(7,9,9)	9

Table 6.3: Score of linguistics variable

	SCT	VRC	BRC	CRC	LRC	ORC	PRC	ICCC
GSL	9	9	7	1	1	3	3	7
RTT	9	7	7	1	3	3	3	7
LAP	7	5	5	9	7	9	7	5
PPD	1	3	7	3	7	7	9	1
CAA	3	1	5	1	7	9	3	9
OPP	1	5	1	5	7	9	5	3
WRC	1	1	3	9	9	7	9	1
IOI	9	9	7	1	1	3	1	9

Table 6.4: Score matrix for the solutions

	SCT	VRC	BRC	CRC	LRC	ORC	PRC	ICCC
GSL	(7,9,9)	(7,9,9)	(5,7,9)	(1,1,3)	(1,1,3)	(1,3,5)	(1,3,5)	(5,7,9)
RTT	(7,9,9)	(5,7,9)	(5,7,9)	(1,1,3)	(1,3,5)	(1,3,5)	(1,3,5)	(5,7,9)
LAP	(5,7,9)	(3,5,7)	(3,5,7)	(7,9,9)	(5,7,9)	(7,9,9)	(5,7,9)	(3,5,7)
PPD	(1,1,3)	(1,3,5)	(5,7,9)	(1,3,5)	(5,7,9)	(5,7,9)	(7,9,9)	(1,1,3)
CAA	(1,3,5)	(1,1,3)	(3,5,7)	(1,1,3)	(5,7,9)	(7,9,9)	(1,3,5)	(7,9,9)
OPP	(1,1,3)	(3,5,7)	(1,1,3)	(3,5,7)	(5,7,9)	(7,9,9)	(3,5,7)	(1,3,5)
WRC	(1,1,3)	(1,1,3)	(1,3,5)	(7,9,9)	(7,9,9)	(5,7,9)	(7,9,9)	(1,1,3)
IOI	(7,9,9)	(7,9,9)	(5,7,9)	(1,1,3)	(1,1,3)	(1,3,5)	(1,1,3)	(7,9,9)

Table 6.5: Fuzzy score matrix for the solution

	SCT	VRC	BRC	CRC	LRC	ORC	PRC	ICCC
GSL	(7/9,9/9,9/9)	(7/9,9/9,9/9)	(5/9,7/9,9/9)	(1/3,1,1)	(1/3,1,1)	(1/5,1/3,1)	(1/5,1/3,1)	(5/9,7/9,9/9)
RTT	(7/9,9/9,9/9)	(5/9,7/9,9/9)	(5/9,7/9,9/9)	(1/3,1,1)	(1/5,1/3,1)	(1/5,1/3,1)	(1/5,1/3,1)	(5/9,7/9,9/9)
LAP	(5/9,7/9,9/9)	(3/9,5/9,7/9)	(3/9,5/9,7/9)	(1/9,1/9,1/7)	(1/9,1/7,1/5)	(1/9,1/9,1/7)	(1/9,1/7,1/5)	(3/9,5/9,7/9)
PPD	(1/9,1/9,3/9)	(1/9,3/9,5/9)	(5/9,7/9,9/9)	(1/5,1/3,1)	(1/9,1/7,1/5)	(1/9,1/7,1/5)	(1/9,1/9,1/7)	(1/9,1/9,3/9)
CAA	(1/9,3/9,5/9)	(1/9,1/9,3/9)	(3/9,5/9,7/9)	(1/3,1,1)	(1/9,1/7,1/5)	(1/9,1/9,1/7)	(1/5,1/3,1)	(7/9,9/9,9/9)
OPP	(1/9,1/9,3/9)	(3/9,5/9,7/9)	(1/9,1/9,3/9)	(1/7,1/5,1/3)	(1/9,1/7,1/5)	(1/9,1/9,1/7)	(1/7,1/5,1/3)	(1/9,3/9,5/9)
WRC	(1/9,1/9,3/9)	(1/9,1/9,3/9)	(1/9,3/9,5/9)	(1/9,1/9,1/7)	(1/9,1/9,1/7)	(1/9,1/7,1/5)	(1/9,1/9,1/7)	(1/9,1/9,3/9)
IOI	(7/9,9/9,9/9)	(7/9,9/9,9/9)	(5/9,7/9,9/9)	(1/3,1,1)	(1/3,1,1)	(1/5,1/3,1)	(1/3,1,1)	(7/9,9/9,9/9)

Table 6.6: Normal Fuzzy matrix for the solution

	SCT	VRC	BRC	CRC	LRC	ORC	PRC	ICCC
GSL	(7/9*7,9/9*9,9/9*9)	(7/9*6,9/9*7,9/9*9)	(5/9*2,7/9*3,9/9*4)	(1/3*3,1*4,1*5)	(1/3*5,1*6,1*7)	(1/5*1,1/3*2,1*3)	(1/5*4,1/3*5,1*6)	(5/9*7,7/9*8,9/9*9)
RTT	(7/9*7,9/9*9,9/9*9)	(5/9*6,7/9*7,9/9*9)	(5/9*2,7/9*3,9/9*4)	(1/3*3,1*4,1*5)	(1/5*5,1/3*6,1*7)	(1/5*1,1/3*2,1*3)	(1/5*4,1/3*5,1*6)	(5/9*7,7/9*8,9/9*9)
LAP	(5/9*7,7/9*9,9/9*9)	(3/9*6,5/9*7,7/9*9)	(3/9*2,5/9*3,7/9*4)	(1/9*3,1/9*4,1/7*5)	(1/9*5,1/7*6,1/5*7)	(1/9*1,1/9*2,1/7*3)	(1/9*4,1/7*5,1/5*6)	(3/9*7,5/9*8,7/9*9)
PPD	(1/9*7,1/9*9,3/9*9)	(1/9*6,3/9*7,5/9*9)	(5/9*2,7/9*3,9/9*4)	(1/5*3,1/3*4,1*5)	(1/9*5,1/7*6,1/5*7)	(1/9*1,1/7*2,1/5*3)	(1/9*4,1/9*5,1/7*6)	(1/9*7,1/9*8,3/9*9)
CAA	(1/9*7,3/9*9,5/9*9)	(1/9*6,1/9*7,3/9*9)	(3/9*2,5/9*3,7/9*4)	(1/3*3,1*4,1*5)	(1/9*5,1/7*6,1/5*7)	(1/9*1,1/9*2,1/7*3)	(1/5*4,1/3*5,1*6)	(7/9*7,9/9*8,9/9*9)
OPP	(1/9*7,1/9*9,3/9*9)	(3/9*6,5/9*7,7/9*9)	(1/9*2,1/9*3,3/9*4)	(1/7*3,1/5*4,1/3*5)	(1/9*5,1/7*6,1/5*7)	(1/9*1,1/9*2,1/7*3)	(1/7*4,1/5*5,1/3*6)	(1/9*7,3/9*8,5/9*9)
WRC	(1/9*7,1/9*9,3/9*9)	(1/9*6,1/9*7,3/9*9)	(1/9*2,3/9*3,5/9*4)	(1/9*3,1/9*4,1/7*5)	(1/9*5,1/9*6,1/7*7)	(1/9*1,1/7*2,1/5*3)	(1/9*4,1/9*5,1/7*6)	(1/9*7,1/9*8,3/9*9)
IOI	(7/9*7,9/9*9,9/9*9)	(7/9*6,9/9*7,9/9*9)	(5/9*2,7/9*3,9/9*4)	(1/3*3,1*4,1*5)	(1/3*5,1*6,1*7)	(1/5*1,1/3*2,1*3)	(1/3*4,1*5,1*6)	(7/9*7,9/9*8,9/9*9)

Table 6.7: Weighted Fuzzy matrix for the solutions

	SCT	VRC	BRC	CRC	LRC	ORC	PRC	ICCC
GSL	(5.44,9,9)	(4.66,7,9)	(1.11,2.33,4)	(.11,4,5)	(1.66,6,7)	(.2,.66,0.33)	(.8,1.66,6)	(3.88,6.22,9)
RTT	(5.44,9,9)	(3.33,4.66,9)	(1.11,2.33,4)	(.11,4,5)	(1,2,7)	(.2,.66,0.33)	(.8,1.66,6)	(3.88,6.22,9)
LAP	(3.88,7,9)	(2,3.88,7)	(.66,1.66,3.11)	(.33,.44,0.71)	(.55,.85,1.4)	(.11,.22,0.42)	(0.44,0.71,1.2)	(2.33,4.44,7)
PPD	(0.77,1,3)	(0.66,2.33,5)	(1.11,2.33,4)	(.6,1.33,5)	(.55,.85,1.4)	(.11,.28,0.6)	(.44,.55,.85)	(.77,.88,3)
CAA	(0.77,3,5)	(0.66,0.77,3)	(.66,1.66,3.11)	(.11,4,5)	(.55,.85,1.4)	(.11,.22,0.42)	(.8,1.66,6)	(5.44,8,9)
OPP	(0.77,1,3)	(2,3.88,7)	(.22,0.33,1.33)	(.42,.8,1.66)	(.55,.85,1.4)	(.11,.22,0.42)	(0.57,1,2)	(.77,2.66,5)
WRC	(0.77,1,3)	(0.66,0.77,3)	(.22,1,2.22)	(.33,.44,0.71)	(.55,.66,1)	(.11,.28,0.6)	(.44,.55,.85)	(.77,.88,3)
IOI	(5.44,9,9)	(4.66,7,9)	(1.11,2.33,4)	(.11,4,5)	(1.66,6,7)	(.2,.66,0.33)	(1.33,5,6)	(5.44,8,9)
A*	(5.44,9,9)	(4.66,7,9)	(1.11,2.33,4)	(.11,4,5)	(1.66,6,7)	(.11,.28,0.6)	(1.33,5,6)	(5.44,8,9)
A-	(0.77,1,3)	(0.66,0.77,3)	(.22,0.33,1.33)	(.33,.44,0.71)	(.55,.66,1)	(.11,.22,0.42)	(.44,.55,.85)	(.77,.88,3)

Table 6.8: Weighted Fuzzy matrix with FPIS and FNIS for the solutions

	SCT	VRC	BRC	CRC	LRC	ORC	PRC	ICCC	
A*	(5.44,9,9)	(4.66,7,9)	(1.11,2.33,4)	(.11,4,5)	(1.66,6,7)	(.11,.28,0.6)	(1.33,5,6)	(5.44,8,9)	di*
GSL	0	0	0	0	0	0	2	1	3.6
RTT	0	2	0	0	2	0	2	1	7.5
LAP	1	4	1	3	4	0	4	3	20.6
PPD	6	4	0	2	4	0	4	6	26.6
CAA	5	6	1	0	4	0	2	0	17.7
OPP	6	3	2	3	4	0	3	5	26.2
WRC	6	6	1	3	5	0	4	6	31.1
IOI	0	0	0	0	0	0	0	0	0.3

Table 6.9: Distance from FPIS for the solutions

	SCT	VRC	BRC	CRC	LRC	ORC	PRC	ICCC	
A-	(0.77,1,3)	(0.66,0.77,3)	(.22,0.33,1.33)	(.33,.44,0.71)	(.55,.66,1)	(.11,.22,0.42)	(.44,.55,.85)	(.77,.88,3)	di-
GSL	6	6	2	3	5	0	3	5	30.1
RTT	6	4	2	3	4	0	3	4	26.4
LAP	5	2	1	0	0	0	0	3	12.7
PPD	0	1	2	3	0	0	0	0	6.4
CAA	2	0	1	3	0	0	3	6	15.5
OPP	0	3	0	1	0	0	1	2	6.1
WRC	0	0	1	0	0	0	0	0	0.8
IOI	6	6	2	3	5	0	4	6	32.0

Table 6.10: Distance from FNIS for the solutions

Solution code	di*	di-	Nearness coefficient	rank
GSL	3.59	30.06	0.893	2
RTT	7.49	26.43	0.779	3
LAP	20.60	12.72	0.382	5
PPD	26.59	6.36	0.193	6
CAA	17.66	15.48	0.467	4
OPP	26.22	6.13	0.190	7
WRC	31.14	0.75	0.024	8
IOI	0.27	32.01	0.992	1

Table 6.11: Ranking for Solutions

6.5 Ranking of suggested solutions to overcome the constraints

To overcome the constraints of vehicle fill rate 32 numbers of strategies has been identified. But it is difficult to decide which strategy will have more impact to overcome the constraints. 32 strategy implementations at a time is difficult, hence prioritization of strategy is important. Integrated framework will help to make it systematic and structured to overcome the constraints one after another. Highest level of nearness coefficient value helped to rank the strategies. 'Implementation of IT based solutions' in vehicle fill rate scored highest and ranked first preferred strategy and 'warehousing related changes' received the least score and ranked 8th in the category of solutions. Ranking of the strategies are as follows – IOI>GSL>RTT>CAA>LAP>PPD>OPP>WRC. Based on the ranking, strategies are discussed below –

6.5.1 Implementation of IT based solutions (IOI)

From the existing literature and experts opinion it was evident that IT based solution is required to overcome the constraints related to vehicle fill rate. In table number 6.1 it was visible how many authors suggested solutions which are related to IT based models. Most of the literature related to vehicle fill rate is about the IT based model. Unfortunately during the survey with experts it was observed that very minimum usage of technology in vehicle fill rate in India. One of major reason is lack of focus on vehicle fill rate and non-standard truck size or non-standard carrying capacity. Non standardization always give sub optimal result with the usage of technology since dependency is high on manual intervention. However, usage of technology always gives better result compared to no usage of technology, which is confirmed by the subject matter experts. Treiblmaier et al., (2019), brings the concept of Physical Internet (PI) as an emerging logistics concept, which also covers the vehicle utilization. As per Mehrotra (2010) appropriate usage of technology helped to improved productivity of logistics. Vision of The National Logistics Policy 2022 is to develop technologically enabled logistics ecosystem to bring cost efficiency, resilience, sustainability and trust. It will help to accelerate the growth of the country. Same type of technology enablement is possible in the field of vehicle fill rate. Five sub-groups are identified under this solution. Those are – Implementation of Transport Management System (ITM), Load planning and 3D load building (ILL), Excel based solver for load building, Computerized vehicle routing, scheduling, and vehicle telematics (ICR) and usage of two-phase optimizer tool (ITP).

Implementation of Transport Management System (ITM)

Transport Management system (TMS) is much bigger term compared to vehicle fill rate. Vehicle fill rate is a part of Transport Management system (TMS), many more activities come under TMS. But load planning is acting like an engine for Transport Management system (TMS). Load building planning in TMS help to fill the truck in an optimized manner. Many organizations are giving many load building solutions to fill the trucks. Many types of formulation are working behind optimizer to form the load. In the existing literature we have found discussion on heuristic algorithms, dynamic programming, greedy heuristics, LAFF algorithm, two level metaheuristics, multi-population biased random-key genetic algorithm (BRKGA), integer linear programming (ILP), neighbourhood search heuristic algorithm, mixed-integer model, linear programming model, genetic algorithm, permutation block algorithm, integer nonlinear programming, randomized constructive heuristic, exact and approximation algorithms, two-level tree search algorithm, dynamic programming algorithm, branch-and bound algorithm. Li et al. (2022), suggested to use hybrid adaptive large neighbourhood search (HALNS) algorithm to solve large scale heterogeneous container loading problem. For multi container loading problem of a shoe manufacturer, Vieira and Carvalho (2022) suggested MILP and lexicographic optimization. ElWakil et al. (2021) suggested linearized quadratic model (LQM) technique for parallel stack loading problem. Gonçalves et al. (2020), also suggested MIP based model based on genetic algorithm for two- dimensional cutting problem which is very similar to Vehicle Fill rate. Nascimento et al. (2021), suggested integer linear model-based algorithm where they have considered practical constraints of container loading problem. For container loading problem Oliveira et al. (2021) also suggested integer linear model. Most of the literature are discussing about these basics behind the optimizer model. From this huge literature it is clear how much focus is there to optimize the load and fill the truck. Evaluation of these base of the optimizer is a strenuous task. In India system-based optimizer usage is very minimum hence system-based optimizer will always give good result compared to manual decision making on filling the truck.3D load building in TMS also helps the loader to load the vehicle in a sequence to fill the truck as per plan. Since in FMCG industry product and SKU mixing is very high compared to other industry load building through TMS is one of the most preferred solutions for filling the vehicle optimally.

Load planning and 3D load building through ERP (ILL)

Most of the big FMCG organizations are using Enterprise Resource Planning to run their day-to-day business efficiently. ERP is type of software that is helping the organizations to automate and manage business processes for optimal performance. Oracle, SAP is some of the examples of ERP. Small FMCG organizations unable to effort the ERP. Various models are there within ERP. ERP also helps to optimize the load planning along with load building. Majority of big FMCG organizations are using the ERP system to form a load. For an example in SAP Truck loading building (TLB) and Truck planning and vehicle scheduling (TPVS) is some optimizer which helped to optimize the truck filling. Hence it is one of the preferred solutions to overcome the constraints related to vehicle fill rate but difficult to effort for all the FMCG organizations.

Excel based solver for load building (IES)

During the survey with the subject matter experts it is evident that India many FMCG players are still using Excel based optimizer due to ease of use and cost is very minimum. This excel based optimizer is very easy to create, hence it is very popular in Indian FMCG organizations. This optimizer is very simple hence unable to overcome all the constraints. It will not give the visibility of sequence of loading. But it is always better than no usage of technology. Movement towards TMS or ERP based optimizer from excel based optimizer will help the FMCG organization to optimize the load.

Computerized vehicle routing and scheduling and vehicle telematics (ICR)

For FMCG organizations multipoint delivery is very important parameter in terms of load distribution. Vehicle routing along with scheduling helped to form a load better manner. It is part of TMS functionality only but separately called out in this study since route planning also helped in load building for multi points delivery and multi points delivery is very much evident for Indian FMCG sector. Based on vehicle telematics vehicle scheduling is possible and based on scheduling load formation is possible with the help of technology. Manually route planning, scheduling is not giving the optimal result hence Indian FMCG organizations who are not using IT unable to overcome the constraints related to vehicle fill rate.

Usage of two-phase optimizer tool (ITP)

Some of author suggested two phase optimizer tool to optimize the vehicle fill rate. Fekete et al. (2007) suggested two-level tree search algorithm. Tian et al. (2015) suggested optimizer which is based on two phase algorithms. Olsson et al. (2020), Saraiva et al. (2019) in their study also suggested two level container loading metaheuristics approach. Munien and Ezugwu (2021) also supported Metaheuristic algorithms for bin packing problem. From these literatures it is evident that researchers are thinking furthermore sophisticated optimizer for developed country where vehicle fill rate is reached up to certain level by using the IT based solution. From the experts opinion it is also evident that some of the FMCG organizations are in advance stage and looking for next level optimizer. Hence two- phase optimizer tool will act as one of the solutions to overcome vehicle fill rate.

From the literature review and expert opinion, it is obvious that usage of IT based technologies will help to overcome the constraints related the vehicle fill rate in road freight transport for FMCG sector. Since India is having a unique constraint like non-standard vehicle dimension, non-standard vehicle carrying capacity, IT based solution always gives suboptimal results unless some solution is implemented for these constraints. Hence next ranked solution is important in Indian context. As per National Logistics policy, 2022 aim of Comprehensive Logistics Action Plan (CLAP) is to standardized the physical assets in logistics. In logistics biggest physical asset is trucks. Standardization of truck will bring cost-efficient, sustainable and trusted logistics ecosystem for the country.

6.5.2 Government Support through Law enforcement regarding harmonization of truck size and carrying capacity

Through Fuzzy TOPSIS method this solution stood in second position in ranking of strategies. In experts opinion it was came out very clearly as a much needed solution for vehicle fill rate in FMCG sector in India. In chapter 5, detailed discussion was there regarding the variability of truck size. Primary data was collected from various factory site in India and secondary data was collected from websites of truck manufacturer. From this data it is very much evident that same truck type having high variation of truck size along with truck carrying capacity. High variation in truck size and carrying capacity leads to high number of variations in vehicle fill rate. Impact of that variation on transportation freight cost and on carbon emissions already discussed in chapter 5. To run the IT based optimizer efficiently standard size of truck and standard carrying capacity of truck is a prerequisite. IT based optimizer running based on certain parameters. Out of which one is vehicle dimension and another one is vehicle carrying capacity. Since it is not standardized one average vehicle dimension or average truck carrying capacity is used in the optimizer hence the optimizer also gives the sub optimal results. To get the full benefit of IT based optimizer standard size of truck and standard carrying capacity of truck is required, which is possible if only Government of India pass certain law regarding standardization of sizes of truck and carrying capacity of truck. But it is a long-term process, since in India truck life is 15 years. If government fill the need and enforced the law now also, it will take minimum 15 years to remove all the nonstandard trucks from the road. Hence it is a long journey but most needed one for the future of India to support Indian transportation sector and become cost competitive in global market. It will not only give the benefit to FMCG sector, but it will also give benefit to other sectors as well. Since this problem is unique by nature limited number of literature were found regarding this and they have also suggested to standardized the vehicle size and vehicle carrying capacity by enforcement of law by government. Biswas and Kumar (2022), Eidhammer and Andersen (2014) shared the same view in their respective studies. As per The National Logistics Policy 2022, under Service Improvement Framework standardization and regulatory improvement takes place. It will help to bring the efficiency in Indian logistics filed. In this category of solution three subcategory of solutions are there - Regulatory directives and Transportation legislation regarding harmonization of truck size (GHS), Regulatory directives and Transportation legislation regarding harmonization truck carrying capacity (GHC) and increase in truck carrying capacity (GCC).

Regulatory directives and Transportation legislation regarding harmonization of truck size (GHS)

Since the truck manufacturer are selling the chassis only, transporters are making the vehicle as per their wish and need through local fabricator. Since law related to this is not stringent enough individual transporter are gaining but as nation industry is losing. It is impacting the overall planning of load building and execution. In Motor vehicles law of India truck size specification regarding dimension is missing for all the truck types. Apart from that Truck manufacturer also produces many trucks with various sizes. It also needs some restriction for optimization through IT based software. Eidhammer and Andersen (2014) felt the same need for Norwegian cities and Biswas and Anand (2022) shared the same need for India.

Regulatory directives and Transportation legislation regarding harmonization truck carrying capacity (GHC)

Since body of the trucks are build by local fabricator the usage of material is varying a lot. Variation in usage of truck building materials leads to variation in truck carrying capacity. Some transporters are using lighter weight iron sheet to build the side body of the trucks. It will help to get more carrying capacity since truck body weight is lesser. But it varies transporter to transporter and this variation leads to variation in fill rate. Apart from vehicle fill rate it exposes the safety aspect which leads to high number of road accident in India. Most of the truck manufacturer only building the chassis of the truck, not even building the cabin of truck. To make the truck lighter, transporters are making wooden cabin instead of iron cabin. It will reduce empty weight of the truck and increase the truck carrying capacity, but it also exposes the safety of the truck driver during head on collision. Some truck manufacturing company like Bharat Benz selling the truck along with the cabin but all the truck manufacturers in India are not. Hence Government of India's intervention is required to make and enforce certain rules regarding truck building materials. It will not only help to standardize the truck carrying capacity, it will also ensure the safety and will reduce the accident in India in road transportation. Regulatory directives and transportation legislation regarding harmonization truck carrying capacity (GHC) will help to solve the issue related to vehicle fill rate in road freight transportation for FMCG sector in long run.

In August' 2018 Government of India tried to standardize the vehicle carrying capacity. Unfortunately, every state government is having the authority to overrule the motor vehicles act enacted by the central government. They can change or can continue the vehicle registration by with their own state rule. It is also impacting the vehicle load carrying capacity. Some states in northeast and States like west Bengal not accepted the above mentioned rules and continued for long with the old motor vehicles rule. Hence it is important to have single rule for motor vehicles across India. Biswas and Anand (2022), Biswas and Kumar (2022) shared the same view in their respective studies for India.

Increase in truck carrying capacity (GCC)

Companies are always looking for a competitive edge. Hence everyone is trying to maximize the vehicle utilization and aiming to minimize the number of trucks used. Moura and Oliveira, 2005 also shared the similar thought of achieving the highest efficiency of the available vehicle capacity. Truck carrying capacity is decided by government based on existing infrastructure and many other factors. Government of India understood the need of the industry and bought revision of safe axle weights for transport vehicles on 7th August 2018. After 33 years, Government of India made changes on gross vehicle weight (GVW) with different axle combination. Since vehicles are having the capacity and infrastructure is ready to support the vehicle carrying more load in same vehicle, due to this change in policy, it was expected that same vehicle will carry 25% more load compared to earlier. Government of India stopped overloading through stringent law enforcement and high rates penalties. On the other hand, legal authority is given to those trucks who are having more capacity to carry more loads. On 26th June 2020 Government of India has published a notice of amending Rule -93 which is connected to dimensions of motorized vehicles. Through these amendments' government of India moving towards standardization of vehicle, and it will follow the international standards and improve logistics efficiency of India by increasing the material load carrying capacity of the vehicle. More development in infrastructure will help to carry more load in same trucks in future. Hence government will play a vital role by increasing the carrying capacity of truck by enforcing the law. In India carrying capacity of trucks is quite lower compared to other developed countries. Hence this strategy will act as lever in future for vehicle fill rate.

From the above-mentioned discussion, it is very much evident that this strategy will play a significant role to improve the vehicle fill rate in road freight transport for FMCG sector, but impact will be observed in longer run, not an immediate basis.

6.5.3 Choosing Right Truck Type (RTT)

As per fuzzy TOPSIS ranking third best ranking solution category is 'choosing the right truck type' for vehicle fill rate. Existing literature and opinion of experts also suggesting that choosing the right type of truck is important. In TMS one of the very important parameters while doing the load planning is understand the load and choosing the right truck type. Voluminous cargo required specious truck compared to high weight carrying capacity. The material which are having higher weight compared to volume of the cargo need high load capacity truck compared to specious truck. Authors like Ramos et al., (2017), Hosseini and Shirani (2011), McKinnon (2010), Slob (2013), Morabito et al. (2000), Aronsson and Bordini (2006); McKinnon (2000); Santén and Rogerson (2014) suggested this solution category as one of the solutions to overcome the constraints of vehicle fill rate. As per existing literature and opinion of experts four sub-categories exists – usage of double deck or double stack vehicle (RDD), high cube containerized truck (RHC), selecting right size truck (RRS), usage of longer and heavier vehicle (RLH).

Double deck or double stack vehicle (RDD)

In developed countries most of the FMCG materials are transported through pallets and which are very much evident in existing literature. Every material or boxes having certain load bearing capacity. Based on which stacking of material is happening inside the truck. In many cases in existing literature, it was suggested to load double pallet to use the vertical height of the truck. Slob (2013), in his study on P&G suggested to double stack pallets to improve the fill rate of the vehicle. Samuelsson (2002) also proposed to use double deck vehicle to use the height of the vehicle. In India palletized movement within the truck is very minimum due to infrastructure issues at both the end. To use the vertical space of truck, increasing the shipper quality or number of plies for a carton will attract extra cost per box which is beneficial from cost and benefit point of view since it is a recurring cost. Hence it is suggested by the experts to use double deck vehicle. In India, few FMCG organizations already started using double deck vehicle to improve the vehicle fill rate. Extra deck will act a platform which will give support to the stack and reduce the pressure on the lowest stack, avoid damages. It also helped to increase the stack height and ensure good fill rate. It was a concept which was used for car carrier and motorcycle carrier. They are using motorized platform which is fixed by nature but for FMCG sector fixed platform will not help since this vehicle will be used for return load. Fixed platform will reduce the material load carrying capacity of the vehicle in return and also take away the ease of loading. Hence it recommended to use channel system with flexible platform facility. This recommendation was tested with one FMCG organization in India and got very much successful result. Vehicle fill rate in terms of volume and weight is almost hundred per cent and damages are almost nil. Both the organizations are generating savings in Crores. Few snaps are attached below



Snap 6.1: Tailor made double deck vehicle

Hence this solution will help to overcome the constraints related to vehicle fill rate.

High cube containerized truck (RHC)

From the opinion of experts, it was evident that majority of the organization is transported their product in containerized truck. In India, truck manufacturers are not producing any containerized truck, they are only manufacturing the chassis. Fabricators are creating the body. From the primary data it was evident that most of the container height is hovering near to 8 feet. But some of the organizations who are transporting lighter FMCG material using the high cube container whose height is around 10 feet. While collecting the primary data it was observed that the carrying capacity of this high cube container is much more compared to normal containerized vehicle. 2 feet extra height giving edge to this container compared to normal container. Hence it is recommended that to use a greater number of high cube container for transporting light FMCG material. It will help to overcome the constraints related to volume utilization of vehicle for FMCG industry.

Selecting right size truck (RRS)

In TMS, one of the major parameters is selecting right truck for transportation. Most of the cases the available truck types are not known to the shipper hence they are using the traditional truck type which they are using for long. In India, difficult part is truck manufacturers are manufacturing many varieties of truck in a year and it is not exclusively for FMCG industry. In many literatures it is evident that choosing right size of truck is very important to overcome the constraints related to vehicle fill rate. Lighter FMCG material should be transported in different types of vehicles compared to heavier one. Similarly, for longer distance different set of vehicles are required compared to shorter distance. Hence choosing right truck type based on availability at the market is important to overcome the constraints related to vehicle fill rate in road freight transport for FMCG sector.

Usage of longer and heavier vehicle (RLH)

Ortega et al. (2014) suggested this solution of usage of longer and heavier vehicle to have better vehicle fill rate. As per them longer vehicle will help to load more compared to smaller vehicle. Smaller size vehicle will attract extra cost compared to long vehicle since long vehicle can carry more load. In experts opinion also it came out very clearly that usage of long vehicle is preferred compared to small size vehicle. Heavier vehicle will ensure the safety compared to lighter vehicle.
Hence it is evident that right truck type (RTT) acted as one of the major solutions for the constraints of vehicle fill rate in road freight transport in FMCG sector.

6.5.4 Coordination and Consolidation Activity

During discussion on constraints also coordination and consolidation came up as one of the major constraints in vehicle fill rate. After doing fuzzy TOPSIS analysis also it came up as one of the important solutions to overcome the constraints. To have better fill rate coordination and cooperation is always needed, without that desired result will not come. Exiting literature and experts also shared the same view. Ljungberg and Gebresenbet (2004), Hosseini and Shirani (2011), Rogerson and Sallnäs (2016) described this as a solution to have better fill rate. Three sub- categories are there under this main category of solution - Within function and outside function coordination (CFO), Consolidation by freight forwarder by sharing the vehicle capacity (CSV), Back loading Activity (CBA).

Within function and outside function coordination (CFO)

Coordination will help to get the desired result in vehicle fill rate. To implement above solutions also coordination is required. This coordination sometimes happened within the supply chain function, like coordination between demand-supply planning team with logistics team. Sometimes it is in between the functions coordination like coordination between sales and supply chain or between packaging development and supply chain and many more.

Within supply chain many sub functions are there. Demand and supply planning ensures the material availability and logistics ensure the delivery of the material. Since there is variation in vehicle size and vehicle carrying capacity, it was often found there is space left in the vehicle after loading the material in the vehicle. Load plan building is difficult activity with such variability, hence coordination between the function is required to fill the truck.

Similarly, between sales and supply chain also coordination required. To get more load consent is required from sales team in case someone wants to send more item in a same vehicle. Unless logistics team coordinates with sales team getting more load is not possible. Packaging development team decides the stack ability inside the truck. Hence if vertical space is available in vehicle logistics team have to coordinate with packaging development team to change the shipper quality to ensure more stacks in same vehicle, which will help to fill more material in same vehicle. Similarly, coordination is also required between quality team and supply chain team to have more vehicle fill rate.

Consolidation by freight forwarder by sharing the vehicle capacity (CSV)

Not necessary all the time FMCG organizations having full truck load for a customer or distributor. At that point of time, they must wait for further load from the same customer to have optimal cost of delivery. It will delay the serviceability to the customer. Hence to avoid this delay load consolidation is a better option. Existing literature also suggested the same. Between the organization load consolidation required coordination between two or more organizations. In a same route if organizations are having lesser than full truck load, they can consolidate the load and can send a single truck together with a help of freight forwarder. For that coordination is required between the function and it will help to overcome the constraints related to low order resulting lesser vehicle fill rate.

Back loading Activity (CBA)

One of the major constraints for vehicle fill rate is one way load, which does not ensure the return load. For any transporter it is a major area of concern in India. Non-availability of return load transporters are building the freight cost for empty run of the vehicle, which is treated an extra cost for the FMCG organization. Hosseini and Shirani (2011), Santén and Rogerson (2014) have suggested to have backload to improve vehicle fill rate. To avoid empty run of the vehicle synergy between the organizations are important. Backload is possible when there is synergy of load between two or more organizations. To ensure the synergy coordination plays the most significant role. Flow of information along with coordination between two organizations ensures the backload and reduces the empty run. Technology will play a vital role along with the coordination to minimize the empty run and guaranteed return helped to fill the truck and minimize the transportation cost. As per The National Logistics Policy 2022, Unified Logistics Interface Platform (ULIP) initiative has been conceptualised. It will help to integrate platform that can be effectively utilized by the truckers to identify the source of information for transport demand identification to reduce empty movement, waiting time. It will reduce the operations and maintenance cost for the truckers which will improve efficiency and reduce the logistics cost of India.

6.5.5 Physical loading Activity (LAP)

As per fuzzy TOPSIS methodology based on existing literature and experts opinion 'Physical loading activity' came up as one of the solution to overcome the constraints related to lower vehicle fill rate. Knight et al. (2008), Slob (2013), McKinnon (2010), Morabito et al. (2000), Jordan (2011), Hosseini and Shirani (2011), A.T. Kearney Management Consultants (1997); Cruijssen (2012); McKinnon (2000) considered physical loading activities as a solution for filling the truck efficiently. Physical loading is an art and brings efficiency with practice along with experience. Under this category five number of sub-categories are identified which are part of physical logistics activity - reorganizing the cargo is packing (LRC), appropriate loading method selection (LAL), stacking height increase (LSH), on top loading (LOT) and training on loading activity (LTL).

Reorganizing the cargo packing (LRC)

Jordan (2011) identified this as a solution to overcome the constraints related to vehicle fill rate. Reorganizing the boxes inside the truck as per load plan is an important activity. Day to day basis loaders along with their supervisor doing this activity based on their experience. For FMCG products number of product mix is high hence reorganizing the cargo inside the trucks is critical since all the box sizes are different. Different box size will occupy different space and will create obstacles to load optimization. Along practical experience, 3D load building will give better result. Following the 3D load building is also an art. It may increase the loading time significantly unless cargo is packed and reorganized properly by the loaders.

Appropriate loading method selection (LAL)

How to load a vehicle with full of mix SKU is a very critical question to answer. One simple answer is not available for the same. Load plan given to the loader based on available order and truck size. Based on the load plan and dimension of vehicle loader is choosing the loading method. For single SKU, loading method will be different compared to multiple SKU. Similarly for heavy material loading method will be different compared to lighter material. Mix of SKU with higher weight and light weight will have different loading pattern. Currently in India most of these loading methods are manual and depending up on personal expertise of the loader, which they have gained from his experience. But important thing is, in most of the cases loaders are not bothered about optimization of the load. They are filling the truck as per their daily practices not considering the optimization at the back of their mind. Mix load makes their life difficult compared to single material loading. 3D load building can guide them to follow certain method. 3D load formation along with that their personal expertise will be helped to define a method of loading to fill more material in a same truck. Hence choosing right loading method is important to overcome constraints related to good vehicle fill rate.

Stacking height increase (LSH)

Inside the vehicle boxes are stacked in a manner so that materials transported properly and efficiently. McKinnon (2000) suggested to increase the stack height to load more in a vehicle. Number of stacks inside the vehicle depending upon the strength of the packaging material. Static load carrying capacity and dynamic load carrying capacity of a box is different hence inside the vehicle stacking norms is also different compared to stack formation at warehouse. Stack height also depending upon the side wall of the vehicle. From experts opinion it was found that various size of side walls are available in India. Most of the cases it is depending upon origin state. At Punjab most of the vehicle is having high side wall which supports the stacks better compared to Andhra body vehicle where side wall is shorter. In southern region of India side wall is lower compared northern and eastern part of India. Most of the vehicles are having all India permit and it can move across India. Hence it is difficult for the loader to predict which state origin vehicle will come to load. Post getting the vehicle inside the premises loader must take a call what should be the stack height. Permissible stack height is defined by the packaging team. Within that how to manage the load is depending upon the loader who is deciding the stack height. By increasing the stack height loader can load more in a truck. Depending upon arrival of the vehicle, loader will decide the stack height to form fit the material inside the truck. Higher the stack height better the loadability in a truck and it is depending upon the loader.

On top loading (LOT)

In developed countries most the of the FMCG materials are despatched in palletized load. Pallets are having certain weight baring capacity hence stacks kept according to that only. Various types of stacking is possible in a platter best on stack ability and best fit in a pallet. Most of the time palletized load is not exceeding the vehicle height hence there is always some empty space between the box kept on the topmost lot and the roof of the vehicle. Above that if someone put some load then it will fill up those empty space and will have better vehicle utilization. Slob (2013) shared the same opinion to optimize the vehicle fill rate. He has studied the same for P&G, which is also a FMCG organization. In Indian context also it is possible though palletized load is not formed in India. Stack are kept based on restriction given for stacks. Above that there is some extra space available one can load above that as a loose case not as a stack. It will give stability to the stack also. It will help to load more in a same vehicle.

Training on loading activity (LTL)

Loading activity is an art. Efficient loading is depending upon physical loading. Till date efficient loading is dependent on personal expertise, since system support is very minimum in context with load formation and physical execution. Day to day activity will help to gain experience regarding arrangement of load inside the truck. On job training will help to gain knowledge about filling the truck. Training arrangement through loading experts also helped to improve the fill rate of vehicle. Training always helps to gain knowledge and improve execution. Training on usage of 3D load building and execution as per that will also help to load more material in same vehicle. Hosseini and Shirani (2011) in their study also suggested the training activity to improve the load. Sharing of knowledge regarding loading activity will create value between the organizations, which is one of the applications of Knowledge based view.

From the above discussion it is evident that physical loading is an important strategy to overcome the constraints related to vehicle fill rate in road freight transportation in Indian FMCG sector.

6.5.6 Product and packaging design (PPD)

To have good loadability in a truck product and packaging design is essential. Good product design along with good packaging helped to stack in a vehicle in a better manner. Through fuzzy TOPSIS methodology it was came up in ranking, which was prepared based on experts opinion and exiting literature. McKinnon (2000), McKinnon et al. (2003), Gustafsson et al. (2004), Jordan (2011), Wu and Dunn, (1995), Pålsson et al. (2013) – all of them picked up product and packaging design as one of the solutions for vehicle fill rate. In general, FMCG product are packed in laminates and corrugated boxes and transported post that. Corrugated boxes are easy to handle compared to bags or any other mode of packaging. Corrugated boxes are reusable by nature hence it is preferred by most of the FMCG organizations. Shapes of the boxes varies as lot based on the need. Better packaging helped to stack the material in a better way. More number of stacks helped to load material in the same vehicle.

Redesigning dimensions and shape of packaging (PRD)

Dimension and shape of the boxes is one of the major parameters which helped to stack the material in a better manner. Wu and Dunn (1995), McKinnon (2000), Gustafsson et al. (2004) also expressed the same view. Dimension and shape are not only decided by packaging development, but it is also jointly decided with sales and marketing team. In a box how many pieces will be packed is the call taken by sales and marketing team based on feedback received from the customer or distributor. Based on the input received from sales and marketing team, packaging department decided the dimensions of the boxes and shapes of the material. Most of the cases rectangular shaped boxes are found followed by square shaped boxes. Based on pack configuration the dimensions of the boxes are changing. Since the number of SKU is high in FMCG industry, dimensions variations are also high. It is creating the difficulties in loadability inside the truck. Same dimension and same shape boxes always give better results in vehicle fill rate compared to variation in boxes.

More efficient packing for every loading unit (PEL)

More the number of plies used to form the corrugated box helped to pack a greater number of units in a box. The strength of boxes decided the stacking norms in a truck. Strength of the boxes lies on four corners of the boxes. If the shapes and dimensions are same, it helped to stack the material in a better manner. More number plies lead to higher packaging cost, and it is recurring by nature. Hence cost benefit analysis is required between the strength of the shipper and stack ability of the material. Since most of the organizations are having thin margin with high competition, they are trying to reduce the number of plies in a shipper. Earlier FMCG industry most of the cases used five ply shipper and now most of the SKU is packed with two plies or three-ply shippers. As a result, stack ability is reducing day by day and product damage issues are increasing due to buckling and budging issues. To avoid that scientific packaging is planned along with technological support so that same shipper can pack more efficiently in each loading unit. More efficient packaging leads to more load in a vehicle.

Choosing appropriate packaging system (PCA)

To pack more units in same boxes choosing appropriate packing system is important. Pålsson et al. (2013) also expressed the same view. Now a days variety of packaging system is available. It is not only dependent upon secondary packaging. Primary packaging is equally important since shapes and primary packing material decided how many units packing is possible in a box. Not only corrugated boxes many other types of packaging are available in India, but it is also depending upon the physical aspect of the product. Shrink wrap, stretch wrap, tins, plastic jars, reusable folded boxes are some of the examples of packaging other than corrugated boxes, which is suitable for liquid. Choosing appropriate packing system helped to increase the fill rate in a vehicle. For an example soft drink companies or mineral water companies using stretch wrap to pack their bottles instead of corrugated boxes. It gives them better vehicle fill rate compared to packed in corrugated boxes. Also stretch wrap reduced the packaging cost. Similarly bulk oil buyers like hotels, restaurants, roadside eateries preferred to have 15Kg tin instead of pouches. Based on packaging handling of the material varies. Tins always have best vehicle utilization in terms of weight compared to pouches or bottle. Compared to that oil is packed in Jar also. It is not helping in weight utilization, but it will help in volume utilization since jar is voluminous by nature. Hence appropriate packaging plays a significant role in vehicle fill rate and continuous innovation is happening for the same. Based on the packing material placement of product also varies, which was discussed earlier in stacking of material section.

6.5.7 Order Management pattern (OPP)

Ordering pattern identified as one of the solutions to overcome the constraints of vehicle fill rate. Existing literature and experts identified it as a solution and ranked through fuzzy TOPSIS analysis. McKinnon et al. (2003), McKinnon (2010), Jordan (2011), Hosseini and Shirani (2011), Piecyk and McKinnon (2010), Baumgartner et al. (2008), Kohn and Brodin (2008), Santén and Rogerson (2014), Islam et al. (2019) identified order management as one of the solutions for vehicle fill rate. Under this order management pattern category of solution six sub-categories of solutions were identified - multi drop delivery (OMD), route planning (ORP), postponement of delivery (OPD), load Consolidation and collaboration (OLC), nominated day for delivery (OND) and reducing order size variation (ORV).

Multi drop delivery (OMD)

For FMCG organizations service gets equal priority along with cost. Hence servicing the small order along with big orders getting the same priority. Mixing of orders helped to get better fill rate in a truck. Hence multi point delivery is preferred solution for FMCG organizations. Hosseini and Shirani (2011) identified it as one of the solutions for vehicle fill rate. Small orders of customers clubbed together in a vehicle and multi point delivery is planned based on routes. It is not only giving the opportunity to the FMCG organizations to cater the customer in small loads with logistics cost efficiency, but it also helped to fill the vehicle since clubbing of order is happening in a same truck. Route planning one of the important aspects for multipoint delivery.

Route planning (ORP)

Route planning is one of the important features in Transport Management System (TMS). It is very common feature for FMCG product delivery but very useful features. In exiting literature many authors suggested these solutions to get good fill rate. As per experts, route planning helped in multipoint delivery. Santén and Rogerson (2014) suggested route planning as one of the solutions. Route planning is very essential element for multi-point delivery. Route planning is possible with support of system based on algorithm. Manual route planning is also possible, but it is not giving optimum result. With high volume and multiple customers manually route planning is not possible also. Clubbing the load of all customer system-based route planning gives optimum result for vehicle fill rate. It also ensures the serviceability for small quantities.

Postponement of delivery (OPD)

Hosseini and Shirani (2011) suggested the postponement of the delivery concept to have better vehicle fill rate. Postponement of the delivery is required to have better route planning. If by holding a day's order if vehicle is getting full load, it is better for the customer as well as for the shipper. Since it brings down the freight cost compared to under load delivery. But it is also depending upon the customer, whether the customer is willing to wait or not. Mutual consensus between the customer and shipper is very much important for this type of solution. Most of the cases it is applicable for smaller quantity delivery or to send the material in bigger truck by clubbing the load.

Load Consolidation and collaboration (OLC)

Consolidation of load and sending in a bigger truck instead of sending multiple smaller load with less than a truck load is preferred option to reduce the transportation cost. To fill the truck load consolidation is one of the preferred options. Different organization can plan for the delivery in a same route by consolidation of load. In many European countries follow this load consolidation procedure by using common platform through mutual collaboration. Even sometimes this consolidation happened between the competitors also. But collaboration and system support are very much needed to have this load consolidation between the organizations. Within the organizations also load consolidation is happening but that also required coordination. Small loads consolidated to form a full truck load and despatched in a bigger size vehicle helped to fill the truck as much as possible. McKinnon et al. (2003), McKinnon (2010), Jordan (2011) also supported this load consolidation and coordination.

Nominated day for delivery (OND)

McKinnon (2000), Jordan (2011) suggested to have fixed day of delivery for the customer. Fixing the days of delivery within a week is a very important parameter. It helped to form a load on a particular day. According to that routes planning with load consolidation is possible. Fixed days of invoicing helped to generate orders on a fixed day. From the experts opinion it was found that, most of the FMCG organization's order generation system is based on replenishment mode. In replenishment mode nominated day delivery system plays a significant to role generate the orders. In a nominated day a consolidated order will be generated, which helped to form a full truck load within a week. It helped the customer also to plan their working capital in a better manner. Space crunch of distributor is a common phenomenon, fixed days of delivery helped to solve the issue along with load formation for a truck. Routing along with load consolidation in a fixed day of invoicing helped to fill the truck.

Reducing order size variation (ORV)

Piecyk and McKinnon (2010) suggested to have lesser order variation in one order size which will help to form a truck load in a systematic way. To form a load on a regular basis consistency in load formation helped a lot. Lesser the variability better the predictability of forming the load plan. Clubbing of load, route planning, load consolidation all are based upon consistency in order size. If orders are generated in a systematic way and if the variation is very minimum it will assist to fill the truck in a better way since planning is happening accurately to form a truck load. Hence to have better predictability of load formation reduction of variation of order size is important. Hence it is also picked up as one of the solution to overcome the constraints of vehicle fill rate in road freight transport for FMCG sector.
From the above mentioned six sub solutions related to order management it is very much evident that systematic order management will help to fill more load in a truck.

6.5.8 Warehousing Related Changes (WRC)

Among the eight categories picked up as a solution 'warehousing related changes' picked up as a last solution for vehicle fill rate through fuzzy TOPSIS analysis. Authors like Aronsson and Brodin (2006) suggested this as one of the solutions. Increasing size of warehouses (WIS), Reducing the number of Warehouses (WRN), Relocating warehouses (WRW) are identified as sub-categories under this category. Changes in warehousing helped to consolidate the load in one place which will support to fill the trucks in a better way.

Warehouses size increase (WIS)

Aronsson and Huge Brodin (2006) picked it up as one of the solutions for vehicle fill rate. Bigger the size of the warehouse, more the load consolidation possibility. In bigger warehouses two step picking helped to load the vehicle efficiently since space is there to keep the material in staging area before loading. Moreover, in bigger warehouse load consolidation possibility is more compared to smaller one. Post GST era in India consolidation of warehouse and increasing the size of the warehouse is of the common feature for all the FMCG organizations.

Number of Warehouse reduction (WRN)

Aronsson and Huge Brodin (2006) suggested this solution to overcome the constraints related to vehicle fill rate in road freight transportation. Some experts also suggested it as one of the solutions. Lesser the number of warehouse possibility to club the loads, multi point deliveries, route planning, consolidation of load, product mixing all is possible along with support of IT solutions. It will help to build the load for the customer efficiently compared to those small warehouses. In bigger warehouses load consolidation and despatches in a bigger size truck is possible with multi point delivery. Post GST scenario one of the major activities for every big FMCG organizations is to reduce the number of warehouse and consolidate the load in better manner. It also proved that this solution is needed to have better fill rate in a truck.

Relocating warehouses (WRW)

Relocation of warehouses is another solution to overcome the constraints related to vehicle fill rate. Aronsson and Huge Brodin (2006) also having the same view. Distribution network redesign (DNR) helped to relocate the warehouses in a area from where the customer serviceability is maximized at an optimum cost. Relocation of warehouses is also a common feature in post GST scenario in India. It also ensures the better fill rate of truck through load consolidation and clubbing of load.

From the above mentioned eight categories of solution it was every much evident that in depth study in existing literature and experts opinion will help to overcome the constraints. Fuzzy TOPSIS helped to ranked the solution so that it was implemented in practical scenario to cross the hurdles related to vehicle fill rate and can load more material in same vehicles which will help the Indian FMCG organization to grow optimally, competitive in global market.

6.6 Sensitivity Analysis of the prioritized solutions

Sensitivity analysis is used to finish to look at the reliability, consistency of the proposed solutions. Sensitivity is used to measure the resilience of the planned framework. Conveying a better insight to prioritize the strategies for overcoming the constraints related to vehicle fill rate in road freight transport for FMCG industries. Moreover, it imparts about proposed integrated system which ranked the specific strategies. To reach these level nine iterations have been conducted. It is reflected in table number 6.12. The value of the solution having maximum weight is substituted while weight of other solutions remain unchanged. Post that based on that ranks are considered for all the solutions. The result of sensitivity analysis is graphically represented below. The final results of sensitivity analysis shows that Implementation of IT based solutions (IOI) has maximum value after nine iterations. All rank remains same like the results of fuzzy TOPSIS. The highly prioritized solution weightage was changed from 0.253 (IOI) to 0.253*0.9, 0.253*0.8…0.253*0.1. The final results indicates that IT based solutions (IOI) having the highest rank after so many iterations, followed by Government Support through Law enforcement regarding harmonization of truck size and carrying capacity (GSL), Choosing Right Truck Type (RTT) and others**.** From this it is proven that the proposed framework to overcome the constraints is reliable.

Solution	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9
IOI	1	1	1	1	1	1	1	1	1
GSL	2	2	2	2	2	2	2	2	2
RTT	3	3	3	3	3	3	3	3	3
CAA	4	4	4	4	4	4	4	4	4
LAP	5	5	5	5	5	5	5	5	5
PPD	6	6	6	6	6	6	6	6	6
OPP	7	7	7	7	7	7	7	7	7
WRC	8	8	8	8	8	8	8	8	8

Table 6.12: Sensitivity Analysis

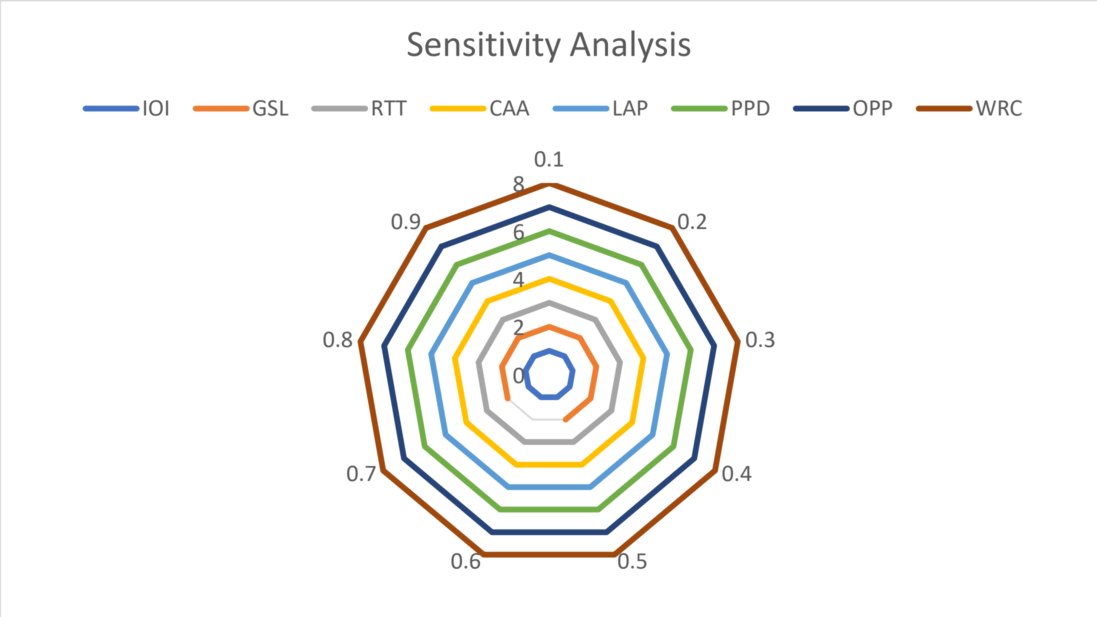


Figure 6.2: Results of sensitivity analysis for solutions

6.7 Chapter Summary

This chapter discussed about the analysis of based on data obtained on strategies to overcome vehicle fill rate in road freight transport for FMCG industry along with the methodology of analysis. Fuzzy TOPSIS methodology was deployed to identify the ranks of the identified solutions. In each stage how the results are accomplished was discussed in detail. Based on the criticality of the solution, ranks are identified to overcome the constraints related to vehicle fill rate. In this chapter all the eight solutions and their sub-categories of solutions were discussed in brief. To check the reliability and consistency of the overall framework sensitivity analysis was executed. Next chapter conclusion will be drawn for the overall research along with possibilities of further research on vehicle fill rate.

Chapter 7
Conclusion, Recommendation and Future Research

Overview

This chapter deliberated a whole summary of the research work which was carried out in this thesis. Inferences and outcome of the research work discussed in length. This section shares the contributions to the existing literature in details. Practical recommendation gathered from this study also shared separately. Limitations of the study and scope of future research work discussed in this chapter.

7.1 Introduction

In India, the FMCG sector is an important sector which is emerging and rapidly growing sector that has an impact on Indian economy. FMCG sector is having very thin margin due to high competition hence having very high focus on cost. To become competitive in global market elimination of inefficiency is important. Most of the FMCG product is transported by Road transportation in India. Hence elimination of inefficiency in road freight transport is important in India. Within that filling the vehicle efficiently is one of the most important areas, which is not only impacting the cost it is having direct impact on carbon emissions and many more area. The presence of constraints in vehicle fill rate acting as a barrier to the growth of economy of the country. The presence of the constraints and their impact on vehicle fill rate is agreed by industry experts. The influence of the constraints is a concern area for the government hence they are focusing in this area to overcome the constraints which was published in reports published by Niti Aayog in 2022.

However, identifying and understanding the constraints of the vehicle fill rate in Indian context is a challenge in itself due to lack of exiting literature. As per opinion of experts, many constraints exist related to vehicle fill rate but still the focus in this area is very minimum due to lesser understanding on the impacts of vehicle fill rate. For that reason, chapter four was focused only on various constraints related to vehicle fill rate and chapter five shares the degree of impact of topmost identified constraints on vehicle fill rate, impact of vehicle fill rate on freight cost - carbon emissions.

Since India is a developing country and focuses on vehicle fill rate is also in development stage, hence there is hardly any literature is existed on vehicle fill rate in Indian context. From the experts opinion and existing literature (which is matching with Indian context) it was evident that there are many constraints which are impacting the vehicle fill rate badly and some of those constraints are unique by nature. Based on the existing literature and experts opinion categories and sub categories of constraints are identified and evaluated by using the DEMATEL, AHP and Fuzzy AHP technique of MCDM. Based on the criticality ranking of the constraints ascertain through this above mentioned MCDM technique. It was also discussed in chapter four.

Impact of constraints on vehicle fill rate is assessed through linear regression and hypotheses was proven in chapter five. SPSS helped to get the results and proved the hypotheses. This chapter having noteworthy practical implications of vehicle fill rate in respect to freight cost and carbon emissions concerning the distribution of fast-moving consumer goods.

Identification and prioritization of constraints is not adequate. Hence in chapter six, thirty-two number of identified strategies are discussed and ranked by using Fuzzy TOPSIS method of MCDM.

7.2 Contribution to the literature from this research work

7.2.1 Identification and assessment of constraints related to vehicle fill rate in road freight transportation for FMCG sector

In depth literature and Delphi survey with the experts helped to identify the constraints related to vehicle fill rate. 8 categories and 28 sub -categories of constraints are identified through this, which are impacting the vehicle fill rate in road freight transport for FMCG sector. This study also shares how the constraints are affecting the vehicle fill rate in road freight transport for FMCG sector.

Post identification of constraints, these identified constraints are analysed by using DEMATEL and Fuzzy AHP methods. It helped to rank the constraints based on criticality of the constraints.

The stakeholders related to road freight transport should get understanding on the top constraints which are creating impediment to achieve the desired result in vehicle fill rate.

Impact of top constraints are shared in chapter 5, so that stakeholders related to road freight transport in FMCG sector get the full understanding of the impact of the constraints.

All the constraints and their impact should get understand by all the stakeholders. This study shares some practical implications for the higher management of the FMCG organization, who can understand the constraints and their impact on profitability of the business. This study is for Government and the policy makers who can understand the constraints and can explore changes to bring the efficiency and productivity. This study is for transport companies as well as for the truck manufacturers, to understand the constraints and the barriers to carry more load in same trucks. It is necessary and responsibility of the all-stake holders to take actions to overcome the constraints to get the desired results for themselves as well as for the nation.

7.2.2 Identification of the strategies to overcome the constraints related to vehicle fill rate in road freight transportation for FMCG sector

Similar to identification of constraints strategies are also identified basis on the existing literature and survey conducted with the experts. 8 number of strategies and 32 number of sub-categories of strategies are identified, which often explained as a solution to overcome the constraints related to vehicle fill rate in road freight transport for FMCG sector.

These strategies are selected in a way so that all the categories and sub-categories of constraints are covered and helped to overcome the effect of the constraints.

Implementation of all the strategies at a time is not possible hence ranking of the strategies are evaluated by using the Fuzzy TPOSIS technique. Based on criticality, the strategies are evaluated.

Identified topmost constraints is unique for India, which was not covered by any of the previous studies. This study submits the Fuzzy AHP, DEMATEL and Fuzzy TOPSIS integrated framework to rank the constraints and assess the strategies to conquer the constraints. This work is unique by nature. Yuen and Thai (2017), Zhang and Lam (2019) followed this similar approach but the context is totally different compared to this study.

Base data can be used by analyst, policy makers for further analysis since this primary data is not readily available. This integrated approach can be used by managers working in industry, supply chain analyst, strategy makers, policy makers, manufacturers, transporters and government to further analyse and evaluate the impact of constraints on vehicle fill rate. This analysis will also help to check the impact in their respective organization and industry as a whole and the solutions will help to overcome the constraints to smoothen the whole truck loading procedure along with efficiency. This Fuzzy AHP, DEMATEL, Fuzzy TOPSIS integrated framework is unique by nature and has not performed earlier for vehicle fill rate or container loading problem.

7.2.3 Theoretical implications of the research

The research topic is relatively new for India since there is very minimum focus on vehicle fill rate. This research also shares a distinctive analytical and methodological approach. Extensive literature study done to check the vehicle fill rate in road freight transportation for FMCG sector. After extensive literature survey it was realised that no study was conducted for identifying and analysing the constraints of vehicle fill rate in Indian road freight transport context for FMCG Industry. Moreover, it was the first study in Indian context which identified and analysed 8 types of categories of constraints related to vehicle fill rate. Those are structural constraints, constraints related to vehicle, constraints related to box, constraints related to cargo, constraints related to load, order related constraints, packaging related constraints and coordination-collaboration related constraints. The selection of constraints are based on review of exiting literature and confirmed by subject matter experts of industry working related to vehicle fill rate in road freight transport. This study is more comprehensive study where all the identified constraints are evaluated in depth and unique constraints are came up which are not covered in existing literature. This identified categories and sub-categories of the constraints are covering all the aspects like operational, managerial, research and development related aspect, existing policy related aspect, quantitative as well as qualitative aspect. DEMATEL, Fuzzy AHP-TPOSIS based integrated approach is unique while presenting the constraints and the solutions related to vehicle fill rate in road freight transport for FMCG sector in Indian context. Moreover, this study covers the degree of impact on vehicle fill rate due to variation of topmost identified constraints which was never covered any of the exiting literature. With linear regression it was proven that variation of truck size, variation of truck carrying capacity and usage of nut bolt, angles impacting the vehicle rate badly. These structural issues of trucks, which are identified as topmost constraints by Fuzzy AHP and DEMATEL method were never covered in any existing literature. This is a non-standard procedure of making the trucks. It is applicable for India and might be applicable for other developing or underdeveloped nations. This study will help in predictability of vehicle fill rate in respect with the variation through linear regression, which was never done before. It will enrich the literature. The industry experts who have participated in this study are also very keen to know the results of the study since it was never done so systematically earlier. They are also keen about the ranking of the constraints.

As per Theory of Constraints (ToC), organization should focus on one constraint at a time. Topmost constraints should take into consideration first. Once the constraints are no more acted like a limiting factor for that particular process then next constraints should take into account. This theory is very much applicable for this study and also helps to get better result. Related constraints can be clubbed under one header to optimize the vehicle fill rate but taking constraints one at a time will gave better results. For an example, for an organization structural constraint is the topmost constraints compared to other seven constraints. That organization will take the structural issue as an only constraint, no other constraints will be taken into consideration for that organization at that point of time. Prioritization of constraint will vary between the organization, depending upon their organizations processes. They can pick and choose the topmost constraints from this literature which is having similarity to their constraints in their organization and also can pick the solutions which will fit for their organization. Post eliminating that constraints for vehicle fill rate, they will focus on next topmost constraints which is affecting the vehicle fill rate. It is a continuous improvement journey for the organization, which will continue even there is a scope for half per cent improvement since it generates savings and having direct impact on company's bottom line. In this way this study is justifying the usage of Theory of Constraints (ToC) and adding value to the body of literature.

Similarly, this study also contributing to Resource Based View (RBV) theory. Trucks are treated as tangible resource for the FMCG organization for vehicle fill rate. FMCG Organizations with standard truck size having better vehicle fill rate compared to nonstandard trucks used by other FMCG organizations. Not only fill rate it is having direct impact on per unit transportation cost which was proven in chapter 5. Every cost is having impact on company's bottom line and for FMCG organization it is very much true due. Hence standard truck acting as a strategic resource for FMCG organization which brings sustainable competitive advantage, until it is emitted by other organization. By having this strategic resource many organizations performing great in terms of VFR and having competitive edge over their competitors. Similarly, many other resources FMCG companies are having which act a strategic resource for the organization in terms of vehicle fill rate. In this way this study is justifying the usage of Resource Based View (RBV) theory and adding value to the body of literature.

This study also contributing to Knowledge Base View (KBV) theory. For an example, one of the important solutions for having good vehicle rate is having expertise in loading. This skill is developed through experience and knowledge of loading. Knowledge is treated as resource which is having highest value. Till time in India this knowledge of vehicle loading is treated as exclusive tacit resource and having high strategic value, which can be shared between the firms to add value for all the FMCG organization. Similarly, sharing knowledge of back loading or vehicle sharing will add value for entire FMCG organization in terms of vehicle fill rate in India. Here knowledge as well as flowing of information plays a vital role. Many more solutions or strategies are there where knowledge on that particular solutions acted like a highest resource which is having strategic value and sharing that knowledge between the organizations will help to improve the vehicle fill rate for FMCG sector. Hence it is cleared that our study will also contribute to the knowledge-based theory.

Apart from constraints, this study focused on the strategies also which will help all the stakeholders who are involved in vehicle fill rate. For the stake holder this study will be end to end process, starting from constraints to ending with solutions. The research attempted to contribute to both the field of theoretical and analytical aspect through the integrated framework for vehicle fill rate. Through this study Integrated framework of DEMATEL, Fuzzy AHP-TOPSIS helped to rank the constraints, solutions and the interaction between the constraints, solutions and the vehicle fill rate. This study significantly contributed to the existing literature. 32 numbers of solutions are discussed related to vehicle fill rate, whereas most of the literature is covered limited number of solutions in piece meal basis. In the study 28 number of constraints and 32 number of solutions are covered through this integrated Fuzzy AHP, DEMATEL and Fuzzy TOPSIS framework. All the constraints and solutions are discussed in detail so that literature is enriched. The study had made three important contributions. First, most of the earlier studies focused upon the solutions which are supported by system only. But not covered the end-to-end process starting from the constraints and ended with the solutions. Prerequisite to run the system-based solutions were not covered. Hence covering entire vehicle fill rate process will add value to existing literature. Second, most of the existing literature is confined to developed countries where most of the things are standardized by nature. But in developing and underdeveloped countries these types of study are very limited. Hence all the constraints are not captured in existing literature. During this study it was observed that whatever constraints are mentioned in existing literature all of them is not applicable to developing county like India. Hence by considering India's vehicle fill rate in road freight transport in FMCG sector, the current study will add value to the literature for developing and underdeveloped countries. Third, usage of linear regression to get the relation between the constraints and vehicle fill rate in not evident in Indian context. Unique constraints like ‘structural issues of truck’ in developing countries like India studied thoroughly and predicted the impact on vehicle fill rate, which will add value to the existing literature.

7.2.4 Practical implication of the research

This study is having potential to implement practically and will help the FMCG organizations to bring efficiency into the system to become competitive in global market. This study not only help the FMCG organizations, but it will also help many relevant stake holders who are involved in road freight transportation. This study identified 28 number of constraints related to vehicle fill rate. These many constraints are not available in the existing literature, especially Indian context. These constraints are not only approved by subject matter experts, but they have also decided the rank. It is not necessary that all the constraints will be applicable for all the FMCG organizations, but majority of the constraints will be applicable since these are vetted by subject matter experts of the industry only.

Different stake holder will this information differently. For shipper or manufacturer who are despatching the material for them it will be matching of constraints and picking up the solutions from this study to eliminate the inefficiency from their system.

For Transporter, it will help to get more loads in the same truck. For them this study will help to understand why standardization of trucks are important for the nations. Ignoring the safety aspect of the driver making the non-standardized vehicle will not help them in longer run, since one accident will wipe out all the profit whatever they have earned by getting some extra load.

For executor of vehicle loading activity, this study will help to identify various types of constraints and follow the solutions. Only execution based on daily experience is not adequate, which was proven in chapter 5. Support of IT based system will help to load efficiently.

The study will also assist the government and policy makers since this study identified ‘structural issues of truck’ as a topmost constraint. They might be aware of this non standardized process of making the truck, but they are not aware of the impact of this process. In chapter 5, detailed impact on vehicle fill rate was share due to this variation of truck size, truck carrying capacity and usage of nut and bolt and angles. It will help them to understand why other developed countries are ahead of India in filling the truck efficiently and can implement the IT based truck load building planner so easily. In India standard truck type is missing, which is a prerequisite to run the IT based solutions. Hence it is always giving sub optimal result. Simulation activity to identify the impact on freight cost and carbon emissions will help the government and policy makers to create a path to strengthening the existing policy. Primary data related to truck size and truck carrying capacity variations is shared in annexure since this practical data is not readily available. It will act as a sample of a bigger population of truck.

This study will also help the truck manufacturer to get a sense how the constraints impacting the FMCG organizations and the nation as a whole. It may direct them to collaborate with government for change in policy. Proposed changes may help them to earn more as a manufacturer, compared to current stage.

This study will help the analyst to analyse the data which are not readily available. Through this primary data various types of further analysis is possible. This primary data will act as a sample or as a base for further analysis.

This study not only identified 28 numbers of constraints, 32 number solutions are also suggested to overcome the constraints. Through systematic and proven methods like DEMATEL, Fuzzy AHP, Fuzzy TOPSIS the constraints and strategies are ranked. Implementation of all solutions at a time is not possible hence strategies are ranked, so that implementation is prioritized as per criticality and need. Implementation of IT based solutions (IOI), Government Support through Law enforcement regarding harmonization of sizes of truck and load carrying capacity (GSL), Choosing Right Truck Type (RTT) are the top three solutions identified to overcome the constraints related to vehicle fill rate for road freight transport applicable for FMCG industries. Combinations of these three top solutions will help to eliminate maximum inefficiencies in vehicle fill rate and it was also supported by industry experts.

The study had made three major contribution which is having managerial and practical implications. First, Identification of 28 number of constraints and 32 number of solutions in Indian context which will help the FMCG industry to match the issues respective to their organizations. It will help to improve the system and bring the efficiency to make the FMCG industry competitive in global markets. Second, the topmost identified constraint 'structural issues of truck' is very much localised and practical by nature in Indian context. This was not covered in existing literature and it was identified as topmost constraints by the experts in the industry. Hence getting solution through this study regarding 'structural issues of truck' will help the industries to fill more material in same truck. Third, linear regression helped to predict the impact on vehicle fill rate due to variation in vehicles capacity and size. Predictability of variation will help to plan and execute in better manner. Simulation activity with respect to freight cost and carbon emissions will help the analyst, policy maker and government to think about changes in exiting policy and law related to motor vehicles. Impact is visible and evidence of proofs in terms of primary data are also present in this study. It will bring benefits to the nation in long run.

Experimental study was organised to compare the pre and post implementations of some of the prescribed solutions on vehicle fill rate. Stack height is identified as a constraint. One of the solutions 'double deck vehicle' is implemented at one of the renown Multinational Company (MNC). Encouraging results obtained. They have earned a savings of Rs1208 in per Metric Ton for their 1Ltr pack and Rs 1111 in per Metric Ton for their 180ml pack. Per metric ton savings is very high, which helped to make huge profit for the FMCG organization. Profitability details shared in Table number 7.1.

Description	Fright for full truck	Loadability in cases for 1ltr pack	GVW	PMT Freight	Loadability in cases 180ml pack	GVW	PMT Freight
15 Ton Truck	₹ 82,000	1,050.00	13650	₹ 6,007	2,100.00	12600	₹ 6,508
32 Ton Double Deck	₹ 1,36,000	2,180.00	28340	₹ 4,799	4,200.00	25200	₹ 5,397
Benefit per ton due to Double Deck vehicle				₹ 1,208			₹ 1,111

Table 7.1: Freight benefits comparison from Double Deck Vehicle

Another study conducted in another Indian FMCG organization. Here Order related constraints is identified as a constraint. System-based order management solutions implemented in this Indian FMCG organization, which helped to gain 4% more vehicle fill rate in 2022 and helped to earn savings of 3.5 Crore in a year.
From the above two examples of industry, it is evident that prescribed solutions are helping to overcome the constraints related to vehicle fill rate.

As per National Logistics Policy 2022, India targeted to reduce their logistics cost from 14 per cent of GDP to 8-10 per cent. As per report of Niti Aayog (2021), also targeting to reduce carbon emissions by 70 per cent by 2050. Both are important parameter for any nation. This study will take part to achieve this target. It was also observed that our study will enrich the literature which was identified as one of the lever to achieve the above mentioned two targets. Detailed discussion is available on the constraints and the solutions, which will help the strategists, policy makers, decision makers, regulatory bodies and academicians who are working to improve the filling rate of vehicle for India. By testing the framework policy makers can emphasize on the possibility of filling more in trucks in India.

7.3 Recommendations and Conclusions

7.3.1 Identification and analysis of constraints related to vehicle fill rate by using DEMATEL and Fuzzy AHP technique and building the relationship between the variables and vehicle fill rate through Linear Regression

Vehicle fill rate is an important lever to bring efficiency in the system. FMCG organizations are also growing sector in India which touched all the citizens of India in everyday basis. Hence it is very much clear that to become competitive in local as well as in global market bringing down the cost is important. FMCG sector is highly cost competitive by nature hence any types of optimizations will play a significant role to bring the cost. For FMCG sector apart from raw material and manufacturing cost, cost of distribution plays an important role. In the distribution cost road transportation plays the most important role since most of the FMCG products are transported by road. Hence filling the trucks in an efficient way will help to bring down the distribution cost. One of identified lever to bring down the supply chain cost is filling the vehicle efficiently. In developing country like India vehicle fill rate is not only a financial issue, it is an operational issue also. This research achieves an empirical analysis of constraints like structural constraints of truck, constraints related to vehicle, constraints related to box, constraints related to cargo, constraints related to load, constraints related to order, packaging related constraints and inter and intra coordination and collaboration related constraints. Out of these 8 main categories of identified constraints, structural constraint of truck is predominant, which gives a clear indication to government that government should regularize the standard of vehicle to rip the benefits in long run. Rest of the developed countries having standard trucks hence they are getting the benefits of technology and yielding high fill rate. Bringing 1 per cent of benefits in Crores of freight spend will be huge, which will help to bring cost competitiveness. In India, the vehicle fill rate is much lower compared to other developed county hence more the efficiency in vehicle fill rate more the cost benefits industry will get in return.

Under 8 categories of constraints 28 numbers of constraints are identified. Out of so many constraints one need to identify most critical one. Hence ranking of constraints is important. DEMATEL and Fuzzy AHP were used to rank the constraints as per criticality and those are confirmed by industry experts.

Sensitivity analysis was performed to get the consistency and reliability of the outcome received through DEMATEL and Fuzzy AHP. All the process ensures that the ranking of constraints is robust.

Not only ranking of the constraints, but linear regression method also helped to predict the vehicle fill rate variation with a variation of structural constraints. In this case vehicle fill rate is a dependent variable and parameters of structural constraints acted as a independent variables. The predictability of vehicle fill rate is measured with respect to all the truck types used in India to transport the FMCG goods with respect to variation in sizes of truck and load carrying capacity of a truck. This predictability will help to shape the logic in software to optimize the load building. Further research in this direction is possible by adding the constraints to optimize the fill rate.

7.3.2 An integrated framework for identifying and analysing the solutions and strategies to overcome the constraints by deploying Fuzzy TOPSIS

This study is limited to identification of constraints only. Building the relation between the variables is the starting point to the solutions of the constraints for vehicle fill rate. Predictability of variation for vehicle fill rate is a part of solution building activity only. 32 numbers of solutions were identified which are grouped in 8 categories. To eliminate 28 numbers of constraints 32 number of solutions were suggested. But prioritizing the strategies are important hence again MDCM technique was used. This study submits an integrated framework after recognising the solutions and evaluating them with Fuzzy TOPSIS method to overcome the constraints. Solutions are graded to overcome the constraints and Implementation of IT based solutions (IOI) ranked first, followed by Government support through law enforcement regarding harmonization of truck size and carrying capacity (GSL) and choosing right truck type (RTT).

Compared to current scenario in India, where only experience is used to form a load or to execute the load support from IT based system is very much needed. Hence IOI came up as solutions with multiple subcategories of solutions. Since there is variability in truck size and truck carrying capacity IT based software will not work as per expectation like it worked in other developed countries. Hence two stage optimization is required, one at the time of load building and another one at the time of physical truck receiving for loading. With two stage optimization strategy IT based solution will be able to give more loads in same truck.

To have more efficient results through IT support, Government Support through Law enforcement regarding harmonization of truck size and carrying capacity is very much needed. It is identified as second-best solutions. It will not give immediate result. But in longer run it will bring huge benefits which will continue more than a decade. Future proof solution. If government fix the dimensions and carrying capacity of the vehicle it will not impact the vehicle fill rate immediate basis since in general the life of a truck is not more than fifteen years. The truck which was manufactured this year it will continue with the old regulations for another fifteen years. Hence it is predicted this solution will not harp the benefits immediate basis, it will take time to implement but benefits will come in long run. Other developed countries having stringent motor vehicle act, which helped them reap the benefits by using the information technology-based solutions. For this IT based solutions sizes and load carrying capacity of the vehicle is acted as a fixed variable which helped to build the load plan more efficiently, which is not possible at India in current scenario.

Choosing right truck type is third ranked solution. Under this category of solutions some sub-categories of solutions are identified. Out of that 'double deck vehicle', 'high cube containerised trucks' are some of the proven solutions which are already tested in some of the FMCG organizations as a part of this study. 'Right truck type' helped to get the benefits through available resources and sharing this knowledge through this study will help other FMCG organizations to load more material in same truck type. Those organizations having these types of resources getting the competitive edge over the competition, which supported the resource based view theory. This exclusive knowledge of two stage optimization or exclusive truck type related knowledge are the most strategically significant resources for a firm which will create values through output of optimized fill rate of trucks. It supports the knowledge-based view theory.

Five more categories of strategies are ranked and discussed earlier which will help to conquer the constraints related to vehicle fill rate in road freight transport for Indian FMCG industry. To find the robustness and reliability of the results sensitivity analysis was deployed. Eight categories and 32 subcategories of solutions with this integrated approach will help to fill more loads in a truck for FMCG sector in India to bring competitive edge in global market.

7.4 **Limitations**

Every management research having its own limitation. This study is also having certain limitations. The constraints are identified and ranked by using two methods of MCDM which are DEMATEL and Fuzzy TOPSIS but many other MCDM approaches can be tried such as ANP, value analysis (VA), BWM, PROMETHEE. Same thing is applicable for ranking the solutions also. Only fuzzy TOPSIS method is deployed to evaluate the ranking, other MCDM method are also available to test.

7.5 Scope of Future Research

This research is based on Indian context only. Same constraints may be available to other developing or underdeveloped countries. Data from other countries can also be tested to check the uniformity of the constraints which is used for model development. Linear regression is deployed to find the relation between the variables and proved the hypotheses. It can be extended to Structural Equations Model (SEM) to measure and analyse the causal relationship between the variables. Basis on the constraints and primary data collected a software can be developed for two steps optimization to get the optimum results related to load building activity.

This study is focused on FMCG sector only, but it can be extended to other sectors to check the possibilities of generalization of the identified constraints and solutions.
This study is focused on road freight transport since FMCG organization is fully dependent on road movement. Second best mode of transport in India is rail freight transport. Similar study can be extended to rail freight transport to check the possibility of generalization and uniformity.

7.6 Chapter Summary

Final insight of the study on vehicle fill rate in road freight transport for FMCG sector provided in this current chapter. This section also discussed who all can use the insights and how it can be implemented to get the desired results. In this chapter, all the important recommendations were shared but in brief. These recommendations will help the practitioners and policy makers to take necessary steps for the future. Moreover, this chapter shares the limitations and future scope of this study in vehicle fill rate in road freight transport for FMCG sector.

References

Abate, A.M., Kveiborg, O., (2013), Capacity Utilisation of Vehicles for Road Freight Transport, Emerald group publishing ltd, 281-298, https://doi.org/10.1108/9781781902868-014.

Abdou, G., Elmasry, M., (1999), 3D random stacking of weakly heterogeneous palletization problems. International Journal of Production Research 37, 1505– 1524, https://doi.org/10.1080/002075499191102.

Ahmed, F., Kilic, K., (2019), Fuzzy Analytic Hierarchy Process: A performance analysis of various algorithms, Fuzzy Sets and Systems, 362 (1), 110-128, https://doi.org/10.1016/j.fss.2018.08.009.

Ahmad, S., Utomo, S.D., Dadhich, P., Greening P., (2022), Packaging design, fill rate and road freight decarbonisation: A literature review and a future research agenda, Cleaner Logistics and Supply Chain, 4, https://doi.org/10.1016/j.clscn.2022.100066

Alonso, M., Alvarez-Valdes, R., Iori, M., Parreno, F., Tamarit, J., (2017), Mathematical models for multi container loading problems, Omega, 66, 106–117. https://doi.org/10.1016/j.omega.2016.02.002

Alonso, M., Alvarez-Valdes, R., Iori, M., Parreno, F., (2019), Mathematical models for multi container loading problems with practical constraints. Computer and Industrial Engineering. 127, 722–733. https://doi.org/10.1016/j.cie.2018.11.012

Amico, D.M., Furini, F., Iori, M., (2020), A branch-and-price algorithm for the temporal bin packing problem, Computers and Operations Research, 114, https://doi.org/10.1016/j.cor.2019.104825.

Anupama, S., Dharmajan, D., Nair, R., (2022), Fast Moving Consumer Goods sector in India – Tending towards oligopoly? Arab Economic and Business Journal, 14 (1). https://doi.org/10.38039/2214-4625.1004

Aronsson, H., Brodin, H.M., (2006), The environmental impact of changing logistics structures. The International Journal of Logistics Management, 17 (3), 394-415, http://doi.org/10.1108/09574090610717545

Aritua, B., Havenga, J., Simpson P.Z., Chiew L.W.E, (2018), Unlocking India's Logistics Potential – The Value of Disaggregated Macroscopic Freight Flow Analysis, World Bank Policy Research Working Paper No. 8337, https://ssrn.com/abstract=3123483.

Araújo, P.J.L., Özcan, E., Atkin, D.A.J., Baumers, M., (2018), Analysis of irregular three-dimensional packing problems in additive manufacturing: a new taxonomy and dataset, International Journal of Production Research, 57(18), 5920-5934, https://doi.org/10.1080/00207543.2018.1534016.

Bansal, N., Han, X., Iwama, K., Sviridenko, M., Zhang, G., (2006). Harmonic algorithm for 3-Dimensional Strip Packing Problem. In: Bansal, N., Pruhs, K., Stein, C. (Eds.), SODA '07 – Proceedings of the 18th Annual ACM-SIAM Symposium on Discrete Algorithms. Society for Industrial Mathematics, Philadelphia, 1197–1206.

Barney, J.B., (2001). Resource-based theories of competitive advantage: a ten-year retrospective on the resource-based view. J. Manage. 10.1016/S0149-2063(01) 00115-5. https://doi.org/10.1177/014920630102700602

Barney, J.B., (1996). The resource-based theory of the firm. Organ. Sci. https://doi.org/ 10.1287/orsc.7.5.469.

Barratt, M., Oke, A., (2007). Antecedents of supply chain visibility in retail supply chains: A resource-based theory perspective. Journal of Operations Management, 25(6), 1217-1233. https://doi.org/10.1016/j.jom.2007.01.003.

Bhatia, M.S., Srivastava, R.K., (2018), Analysis of external barriers to remanufacturing using grey-DEMATEL approach: An Indian perspective, Resources Conservation and Recycling, 136(6), 79-87, 10.1016/j.resconrec.2018.03.021.

Birasnav, M., (2013), Implementation of Supply Chain Management Practices: The Role of Transformational Leadership. Global Business Review, 14(2), 329–342. https://doi.org/10.1177/0972150913477525

Bischoff, E.E., (1991), Stability aspects of pallet loading. Operations Research Spectrum, 13, 189–197. https://doi.org/10.1007/BF01719394.

Bischoff, E.E., Marriott, M.D., (1990). A comparative evaluation of heuristics for container loading. European Journal of Operational Research, 44 (2), 267-276. https://doi.org/10.1016/0377-2217(90)90362-F.

Bischoff, E.E., Ratcliff, M.S.W., (1995). Issues in the development of approaches to container loading. Omega International Journal of Management Science 23(4), 377-390. https://doi.org/10.1016/0305-0483(95)00015-G.

Biswas, R. and Anand, N. (2022), Impact of Non-standardized Trucks on Vehicle Fill Rate (VFR) and Cost in Indian FMCG Sector: A Study. Springer Nature Singapore Pte Ltd. 2022 V. P. Singh et al. (eds.), Sustainable Infrastructure Development, Lecture Notes in Civil Engineering 199. Springer, Singapore. https://doi.org/10.1007/978-981-16-6647-6_15

Bortfeldt, A., Gehring, H., (1997), Applying tabu search to container loading problems. In: Operations Research Proceedings, Springer, Berlin, 533-538. https://doi.org/10.1007/978-3-642-58891-4_84.

Bortfeldt, A., Wäscher, G., (2012), Container Loading Problems – A State-of-the-Art Review, European Journal of Operational Research, 229(1), 1-20, https://doi.org/10.1016/j.ejor.2012.12.006.

Carpenter, H., Dowsland, W.B., (1985), Practical considerations of the pallet-loading problem, Journal of the Operational Research Society, 36(6), 489-497, https://doi.org/10.2307/2582821.

Chan, F.T.S., Bhagwat, R., Kumar, N., Tiwari, M.K., Lam, P., (2006), Development of a decision support system for air-cargo pallets loading problem. Expert Systems with Applications, 31 (3), 472–485. https://doi.org/10.1016/j.eswa.2005.09.057.

Christensen, S.G., Rousøe, D.M. (2009), Container loading with multi-drop constraints. International Transactions in Operational Research, 16(6), 727-743, https://doi.org/10.1111/j.1475-3995.2009.00714.x

Che, C. H., Huang, W., Lim, A., Zhu, W., (2011), The multiple container loading cost minimization problem. European Journal of Operational Research, 214 (3), 501–511. https://doi.org/10.1016/j.ejor.2011.04.017

Chen, C. S., Lee, S. M., Shen, Q. S., (1995), An analytical model for the container loading problem, European Journal of Operational Research, 80 (1), 68-76, https://doi.org/10.1016/0377-2217(94)00002-T.

Chen, Y., Yu, J., Khan, S. (2010), Spatial sensitivity analysis of multi-criteria weights in GIS-based land suitability evaluation. Environmental modelling & software, 25(12), 1582-1591, https://doi.org/10.1016/j.envsoft.2010.06.001

Christopher, M., (1999). Logistics and Supply Chain Management: Strategies for reducing costs and improving service, International Journal of Logistics Research and Applications, 2(1), 103-104, https://doi.org/10.1080/13675569908901575.

Chen, S. J., Hwang, C. L. (1992). Fuzzy multiple attribute decision making methods and applications, Lecture Notes in Economics and Mathematical Systems, Springer, 375, 289-486, https://doi.org/10.1007/978-3-642-46768-4.

Costa F., Granja A.D., Fregola A., Picchi F. (2019), Understanding Relative Importance of Barriers to Improving the Customer–Supplier Relationship within Construction Supply Chains Using DEMATEL Technique, Journal of Management in Engineering, 35(3), https://doi.org/10.1061/(ASCE)ME.1943-5479.0000680.

Craighead, C. W., Hult, G. T. M., Ketchen Jr, D. J. (2009), The effects of innovation–cost strategy, knowledge, and action in the supply chain on firm performance. Journal of Operations Management, 27(5), 405-421. https://doi.org/10.1016/j.jom.2009.01.002.

Creswell, J. W. (2014), Research Design: Qualitative, Quantitative and Mixed Methods Approaches (4th ed.), Sage.

Curado, C. (2006), The knowledge based-view of the firm: from theoretical origins to future implications, working paper 1/2006.

Dereli, Z.T., Das, G.S., (2010), A hybrid simulated annealing algorithm for solving multi-objective container-loading problems. Applied Artificial Intelligence 24, 463–486, https://doi.org/10.1080/08839514.2010.481488

De Castro, Silva, J.L., Soma, N.Y., Maculan, N., (2003), A greedy search for the three- dimensional bin packing problem: the packing stability case. International Transactions in Operational Research 10 (2), 141–153. https://doi.org/10.1111/1475-3995.00400.

de Oliveira, Wilk, E., Fensterseifer, J. E. (2003), Use of resource-based view in industrial cluster strategic analysis. International Journal of Operations and Production Management, 23(9), 995-1009. https://doi.org/10.1108/01443570310491747

Dorer, K., Calisti, M., (2005). An adaptive solution to dynamic transport optimization, AAMAS '05: Proceedings of the fourth international joint conference on Autonomous agents and multiagent systems, 45-51, https://doi.org/10.1145/1082473.1082803.

Dychhoff, H., (1990), A typology of cutting and packing problems, European Journal of Operational Research 44(2), 145-159, https://doi.org/10.1016/0377-2217(90)90350-K.

Eidhammer, O., Andersen J., (2014), A socio-economic analysis of harmonizing the dimensions of lorries and loading docks in Norwegian cities – costs, benefits and logistic efficiency, Procedia – Social and Behavioural Science, 151, 37-47, https://doi.org/10.1016/j.sbspro.2014.10.006.

Egeblad, J., Garavelli, C., Lisi, L., Pisinger, D., (2010), Heuristics for container loading of furniture. European Journal of Operational Research, 20 (3), 881–892, https://doi.org/10.1016/j.ejor.2009.01.048.

Eley, M., (2002), Solving container loading problems by block arrangements. European Journal of Operational Research, 141(2), 393–409. https://doi.org/10.1016/S0377-2217(02)00133-9.

EI-Ashmawi, H.W., Elminaam, A.S.D.(2019), A modified squirrel search algorithm based on improved best fit heuristic and operator strategy for bin packing problem, Applied Soft Computing, 82, https://doi.org/10.1016/j.asoc.2019.105565.

ElWakil, M., Eltawil, A, Gheith, M., (2022), On the integration of the parallel stack loading problem with the block relocation problem, Computers and Operations Research, 138, https://doi.org/10.1016/j.cor.2021.105609.

Erbayrak, S., Ozkır, V., Yıldırım, M. U., (2021), Multi-objective 3D bin packing problem with load balance and product family concerns, Computers & Industrial Engineering,158, https://doi.org/10.1016/j.cie.2021.107518.

Ercan, I., Yazici, B., Sigirli, D., Ediz, B., Kan, I. (2007), Examining Cronbach alpha, theta, omega reliability coefficients according to sample size. Journal of modern applied statistical methods, 6(1), 27.

Faisal, M. N. (2011), Prioritising agility variables for cold supply chains. International Journal of Logistics Systems and Management, 10(3), 253-274.

Feng, H., Ni, H., Zhao, R., Zhu X., (2020), An enhanced Grasshopper Optimization Algorithm to the Bin Packing Problem, Journal of Control Science and Engineering, https://doi.org/10.1155/2020/3894987.

Fekete, S.P., Schepers, J., van der Veen, J.C., (2007), An exact algorithm for higher-dimensional orthogonal packing. Operations Research 55, 569–587. https://doi.org/10.48550/arXiv.cs/0604045.

Filella, G.B, Trivella, A., Corman, F., (2022), Modeling soft unloading constraints in the multi-drop container loading problem, European Journal of Operational Research, 308, 336-352, https://doi.org/10.1016/j.ejor.2022.10.033.

Fontela, E., Gabus, A. (1976). The DEMATEL observer, DEMATEL 1976 report. Switzerland Geneva: Battelle Geneva Research Center.

Fuellerer, G., Doerner, K.F., Hartl, R.F., Iori, M. (2010), Metaheuristics for vehicle routing problems with three dimensional loading constraints. European Journal of Operational Research, 201(3), 751-759, https://doi.org/10.1016/j.ejor.2009.03.046.

Fugate, S.B., Sramek-Davis, B., Goldsby, J.T. (2009). Operational Collaboration between shippers and carriers in the transportation industry. The International Journal of Logistics Management, 20(3), 425-447, https://doi.org/10.1108/09574090911002850.

Gajda, M., Trivella, A., Mansini, R., Pisinger, D. (2022). An optimization approach for a complex real-life container loading problem. Omega, 107, https://doi.org/10.1016/j.omega.2021.102559

George, J. A., Robinson, D. F., (1980), A Heuristic for Packing Boxes into a Container, Computers and Operations Research 7 (3): 147–156.

Gehring, H., Bortfeldt, A., (1997), A Genetic Algorithm for Solving the Container Loading Problem, International Transactions in Operational Research, 4 (5-6), 401-418, https://doi.org/10.1016/S0969-6016(97)00033-6

Gonçalves, J., Wäscher, G., (2020), A MIP model and a biased random-key genetic algorithm based approach for a two-dimensional cutting problem with defects, 286(3), 867-882, European Journal of Operational Research. https://doi.org/10.1016/j.ejor.2020.04.028.

Government of India, Ministry of Road Transport and Highways. (2018). Road Accidents in India – 2018.

Government of India, (2020), Road Transport Year Book 2017-18 and 2018-19, Ministry of Road Transport and Highways Transport Research Wing.

Government of India, (2020), Road Accidents in India 2019, Ministry of Road Transport and Highways Transport Research Wing.

Government of India, (2020), Road Transport Ministry notifies standardised transport vehicles dimensions on international norms, Ministry of Road Transport and Highways.

Gendreau, M., Iori, M., Laporte, G., Martello, S. (2006). A tabu search algorithm for a routing and container loading problem. Transportation Science, 40(3), 342-350, https://www.jstor.org/stable/25769310.

Göçer, A., Vural, C.A. and Deveci, D.A. (2019), Drivers of and barriers against market orientation: a study of Turkish container ports, Maritime Economics & Logistics,21, 278–305, https://doi.org/10.1057/s41278-017-0092-6

Goldratt, M. E. Cox, (1984), "What is this thing called THEORY OF CONSTRAINTS and how should it be implemented?", The Goal.

Grant, R. M. (1991). The Resource-based Theory of Competitive Advantage: Implications for Strategy Formulation. California Management Review, 33(3), 114-135.

Gupta, C.M., Boyd, L.H., (2008), Theory of constraints: A theory for operations management, International Journal of Operations & Production Management.

Gürbüz, Z.M., Akyokuş, S., Emiroğlu, I., Güran, A., (2009), An Efficient Algorithm for 3D Rectangular Box Packing, Applied Automatic Systems: Proceedings of Selected AAS 2009 Papers.

Hameed, PK. S., Prathap, C.R., (2018), Study on Impact of Vehicle Overloading on National Highways in Varying Terrains. International Journal of Engineering Research and Technology (IJERT), 7(1), 10.17577/IJERTV7IS010135.

Handfield, R., Walton, V.S., Sroufe, R., Melnyk, A.S., (2002), Applying environmental criteria to supplier assessment: A study in the application of the Analytical Hierarchy Process, European Journal of Operational Research, 141,70-87.

Hult, G. T. M., Ketchen, Jr, D. J., Slater, S. F. (2004). Information processing, knowledge development, and strategic supply chain performance. Academy of management journal, 47(2), https://doi.org/10.5465/20159575

Hakim, M.I., Abbas, H.M.F., (2019), Optimization Model of Truck Utilization to Minimize Outbound Logistics Cost, Association for Computing Machinery, 62-66, https://doi.org/10.1145/3364335.3364362.

Hart, S.L. (1995). A natural-resource-based view of the firm. Academy of Management Review, 20(4), 986-1014, https://doi.org/10.2307/258963

Hajlaoui, Y., Jaoua, A., Layeb B. S. (2022). Deep reinforcement learning for solving the single container loading problem. Engineering Optimization, DOI: 10.1080/0305215X.2021.2024177

Hifi, M., (2004). Exact algorithms for unconstrained three-dimensional cutting problems: a comparative study. Computers and Operations Research 31(5), 657–674. https://doi.org/10.1016/S0305-0548(03)00019-4.

Ho, W., He, T., Lee, CKM., Emrouznejad, A., (2012), Strategic logistics outsourcing: an integrated QFD and fuzzy AHP approach. Expert Systems with Applications;39(12):10841–10850. https://doi.org/10.1016/j.eswa.2012.03.009

Hosseini, V. S., Shirani, M, (2011), Fill Rate in Road Freight Transport, Chalmers.

Huang, H.Y., Hwang, J.F., Lu, C.H., (2016), An effective placement method for the single container loading problem, Computers & Industrial Engineering, 97, 212-221, https://doi.org/10.1016/j.cie.2016.05.008.

Hwang, CL, Yoon, KP (1981), Multiple Attribute Decision Making: Methods and Applications, A State-of-the-Art Survey. Lecture Notes in Economics and Mathematical Systems, Springer Berlin, Heidelberg, https://doi.org/10.1007/978-3-642-48318-9.

IEA. (2019), CO2 Emissions from Fuel Combustion (2019 Edition). International Energy Agency.

Isdarayanto, I. S., Teknik, F., Jend, J., (2019), Improve Truck Utilization to Minimize Transportation Cost Study Case in Retail Distribution, International Journal of Scientific & Engineering Research, 10(1).

Islam, S., Ahmed, U. J., Shi, P., Uddin, J., (2019), Minimization of empty container truck trips: insights into truck-sharing constraints, The International Journal of Logistics Management, 30(2), 641-662. https://doi.org/10.1108/IJLM-08-2018-0191.

Jansen, K., Solis-Oba, R., (2006), An asymptotic approximation algorithm for 3D-strip packing. In: SODA ‘06 – Proceedings of the 17th Annual ACM-SIAM Symposium on Discrete Algorithms. Society for Industrial Mathematics, Philadelphia, doi:10.1145/1109557.1109575.

Jose, T., Sijo. T.M., Praveen, (2013), Cargo Loading Using Dynamic Programming and Comparative Software Study, International Journal of Science, Engineering and Technology Research (IJSETR), 2(2).

Joshi, R., Banwet, D.K. and Shankar, R. (2009), "Indian cold chain: modeling the inhibitors", British Food Journal, Vol. 111 No. 11, pp. 1260- 1283. https://doi.org/10.1108/00070700911001077

Jugović, A., (2020), The Economic Impact of Container-loading Problem, Transactions on Maritime Science, 9(2), https://doi.org/10.7225/toms.v09.n02.010

Junqueira, L., Morabito, R., Yamashita, D. S., (2012), Three-dimensional container loading models with cargo stability and load bearing constraints. Computers and Operations Research 39(1), 74-85. https://doi.org/10.1016/j.cor.2010.07.017.

Kahraman, C., Multi-criteria decision making methods and fuzzy sets, (2008), Grey Fuzzy Multi-Objective Optimization, Springer Optimization and Its Applications, 16, 453-482, 10.1007/978-0-387-76813-7_18.

Kanniga, E., Srikanth, K.M.S., Sundhararajan, M., (2014), Optimization Solution of Equal Dimension Boxes in Container Loading Problem using a Permutation Block Algorithm, Indian Journal of Science and Technology, 7(5), 22–26. 10.17485/ijst/2014/v7sp5.5.

Karabulut, K., İnceoğlu, M.M., (2004). A Hybrid Genetic Algorithm for Packing in 3D with Deepest Bottom Left with Fill Method. In: Yakhno, T. (eds) Advances in Information Systems. ADVIS 2004. Lecture Notes in Computer Science, 3261. Springer, Berlin, Heidelberg. https://doi.org/10.1007/978-3-540-30198-1_45.

Kashav, V., Garg, C.P., Kumar, R., Sharma, A. (2022). Management and analysis of barriers in the maritime supply chains (MSCs) of containerized freight under fuzzy environment. Research in Transportation Business & Management,43, https://doi.org/10.1016/j.rtbm.2022.100793.

Kaur, J., Sidhu, R., Awasthi, A., Chauhan, S. and Goyal, S., (2018), A DEMATEL based approach for investigating barriers in green supply chain management in

Canadian manufacturing firms, International Journal of Production Research, 56 (1-2), 312-332, https://doi.org/10.1080/00207543.2017.1395522.

Kaushik, S., Somvir., (2015), DEMATEL: A methodology for research in Library and Information Science, International Journal of Librarianship and Administration, 6(2), 179-185, http://www.ripublication.com.

Kilincci, O., Medinoglu, E., (2022), An efficient method for the three-dimensional container loading problem by forming box sizes, Engineering Optimization, 54(6), 1073-1088, https://doi.org/10.1080/0305215X.2021.1913734.

Kline, R.B. (2005). Principles and practice of structural equation modelling (2nd edition). New York: Guilford Press.

Kline, R.B. (2015). Principles and practice of structural equation modelling. Guilford publications.

Klundert, B., Otten, B., (2010), Improving LTL truck load utilization online, European Journal of Operational Research, 336-343, 10.1016/j.ejor.2010.10.014.

Krebs, C., Ehmke, F. J., (2021), Axle Weights in combined Vehicle Routing and Container Loading Problems. EURO Journal on Transportation and Logistics 10, https://doi.org/10.1016/j.ejtl.2021.100043.

Krebs, C., Ehmke, F. J., Koch, H., (2023), Effective loading in combined vehicle routing and container loading problems, Computers and Operations Research, 149, https://doi.org/10.1016/j.cor.2022.105988

Kucukyilamz, T., Kiziloz, E.H. (2018), Cooperative parallel grouping genetic algorithm for the one-dimensional bin packing problem, Computers and Industrial Engineering, 125, 157-170, https://doi.org/10.1016/j.cie.2018.08.021.

Kumar, R., Organero, M.M., Agrawal, R. (2010). XML secure documents for a secure e-commerce architecture. Global Journal of Enterprise Information System, 1(2), https://doi.org/10.15595/gjeis/2010/v2i1/33590.

Kumar, R. (2020). E-applications for managing Trans-Logistics Activities in Sugar Supply Chain in North India. International Journal of Asian Business and Information Management, 11(1), DOI: 10.4018/IJABIM.2020010106.

Kumar, R. (2015). Supply chain performance measurement of olive oil industry with KPIs. International Journal of Value Chain Management, 7(3), 271-284, 10.1504/IJVCM.2015.079212.

Kumar, R. and Kansara, S. (2018), Information technology barriers in Indian sugar supply chain: an AHP and fuzzy AHP approach, Benchmarking: An International Journal, 25(7), 1978-1991. https://doi.org/10.1108/BIJ-01- 2017-0004.

Kurpel, V.D., Scarpin, T.C., Junior, P.E.J., Schenekemberg, M.C., Coelho, C.L. (2019), The exact solutions of several types of container loading problems, European Journal of Operational Research, 284, 87-107, https://doi.org/10.1016/j.ejor.2019.12.012

Layeb, S. B., Jabloun, O., Jaoua, A., (2017), New Heuristic for the Single Container Loading Problem, International Journal of Economics and Strategic Management of Business Process.

Landschu¨ tzer, C., Ehrentraut, F., Jodin, D., (2015), Containers for the Physical Internet: requirements and engineering design related to FMCG logistics, Logistics Research,8(1), 1-9. https://doi.org/10.1007/s12159-015-0126-3.

Lamba, D., Yadav, D.K., Barve, A. and Panda, G. (2020), Prioritizing barriers in reverse logistics of E-commerce supply chain using fuzzy-analytic hierarchy process, Electronic Commerce Research, 20, 381–403, https://doi.org/10.1007/s10660-019-09333-y.

Lavassani, M. K., Movahedi, B., (2010), “Critical Analysis of the Supply Chain Management Theories: Toward the Stakeholder Theory”, POMS 21st Annual Conference Paper.

Lewis, M. A. (2000), Lean production and sustainable competitive advantage. International Journal of Operations & Production Management, 20(8), 959-978. https://doi.org/10.1108/01443570010332971.

Li, K., Cheng, K.H., (1990), On three-dimensional packing. SIAM Journal on Computing, 19, 847–867. https://doi.org/10.1137/0219059.

Li, K., Cheng, K.H., (1992), Heuristic algorithms for on-line packing in three dimensions, Journal of Algorithm 13(4), 589–605. https://doi.org/10.1016/0196-6774(92)90058-K.

Li, Y., Chen, M., Huo, J. (2022), A hybrid adaptive large neighborhood search algorithm for the large-scale heterogeneous container loading problem. Expert System with Application, 189, https://doi.org/10.1016/j.eswa.2021.115909

Liljestrand, K., Christopher, M., Andersson D., (2015). Using a transport portfolio framework to reduce carbon footprint. The International Journal of Logistics Management, 26(2), 296-312, https://doi.org/10.1108/IJLM-06-2013-0073.

Lim. A., Ma H., Qiu C., Zhu W (2013), The single container loading problem with axle weight constraints, International Journal of Production Economics, 144(1), 358-369. https://doi.org/10.1016/j.ijpe.2013.03.001.

Lin, YH., Meller, RD., Ellis, KP., Thomas, LM., Lombardi, BJ., (2014). A decomposition-based approach for the selection of standardized modular containers, International Journal of Production Research, 52 (15), 4660-4672, https://doi.org/10.1080/00207543.2014.883468.

Lindqvist, D., Salman, M., Bergqvist, R., (2020), A cost benefit model for high capacity transport in a comprehensive line-haul network, European Transport Research Review, 12, 60, https://doi.org/10.1186/s12544-020-00451-5.

Liu, J., Yue, Y., Dong, Z., Maple, C., Keech, M., (2011). A novel hybrid Tabu Search approach the container loading. Computers and Operations Research 38 (4), 797–807, https://doi.org/10.1016/j.cor.2010.09.002.

Liu, Y., Eckert, C. M., Earl, C., (2020). A review of fuzzy AHP methods for decision-making with subjective judgements. Expert Systems with Applications, 161, 113738, https://doi.org/10.1016/j.eswa.2020.113738.

Liu, N.C., Chen, L.C., (1981). A new algorithm for container loading. In: Compsac '81 – Proceedings of the 5th International Computer Software and Application Conference of the IEEE (November 1981), New York, pp. 292–299.

Liu, F., Aiwu, G., Lukovac, V., Vukic, M., (2018). A multicriteria model for the selection of the transport service provider: A single valued neutrosophic DEMATEL multicriteria model, Decision Making: Applications in Management and Engineering, 1(2), https://doi.org/10.31181/dmame1802128l

Mack, D., Bortfeldt, A., Gehring, H. (2004). A parallel hybrid local search algorithm for the container loading problem. International Transactions in Operational Research, 11(5), 511-533, https://doi.org/10.1111/j.1475-3995.2004.00474.x.

Mangla, S.K., Luthra, S., Mishra, N., Singh, A., Rana, N.P., Dora, M. and Dwivedi, Y. (2018), Barriers to effective circular supply chain management in a developing country context, Production Planning & Control, 29 (6): Supply chain operations for a circular economy, 551-569, https://doi.org/10.1080/09537287.2018.1449265

Mckinsey and Company (2010), Building India - Transforming the Nation's Logistics Infrastructure.

McKinnon, A.C., Ge, Y., (2004), Use of a synchronised vehicle audit to determine opportunities for improving transport efficiency in a supply chain, International Journal of Logistics Research and Application,7(3).219–238. https://doi.org/10.1080/13675560412331298473

McKinnon, A.C., (2007), CO2 emissions from freight transport in the UK, Report prepared for the Climate Change Working Group of the Commission for Integrated Transport, Edinburgh.

McKinnon, A.C., (2010), European freight transport statistics: limitations, misinterpretations and aspirations, Report prepared for the 15th ACEA Scientific Advisory Group meeting, Brussels.

McKinnon, A.C., (2015), Opportunities for improving vehicle utilization, in McKinnon, A.C., Browne, M., Piecyk, M. and Whiteing, A. (Eds), Green Logistics: Improving the Environmental Sustainability of Logistics, 3rd ed., Kogan Page, London.

Mehrotra, A. (2010). Implementing IT in SCM Understanding the Challenges. Global Business Review, 11(2), 167-184, https://doi.org/10.1177/097215091001100204.

Mejía, V.A.C., Neira, G.M.E., Torres, M.R.J., Islam, N.M.S., (2019), Using a hybrid heuristic to solve the balanced vehicle routing problem with loading constraints, International Journal of Industrial Engineering Computations, 11, 255-280, doi: 10.5267/j.ijiec.2019.8.002

Meller, RD., (2012), The Physical Internet. Logistikwerkstatt Graz, Graz.

Miller, S. R., Ross, A. D. (2003), An exploratory analysis of resource utilization across organizational units: Understanding the resource-based view. International Journal of Operations and Production Management, 23(9), 1062-1083. https://doi.org/10.1108/01443570310491774

Ministry of Commerce and Industry, Government of India (2020), Draft National Logistics Policy.

Ministry of Environment Forest and Climate Change. (2018). India: Second Biennial Update Report to the UNFCCC.

Miyazawa, F.K., Wakabayashi, Y., (1997), An algorithm for the three-dimensional packing problem with asymptotic performance analysis. Algorithmica, 18, 122– 144. https://doi.org/10.1007/BF02523692.

Miyazawa, F.K., Wakabayashi, Y., (1999), Approximation algorithms for the orthogonal z-oriented three-dimensional packing. SIAM Journal on Computing, 29, 1008–1029. https://doi.org/10.1137/S009753979631391X.

Miyazawa, F.K., Wakabayashi, Y., (2007), Two- and three-dimensional parametric packing. Computers and Operations Research 34(9), 2589–2603. https://doi.org/10.1016/j.cor.2005.10.001

Miyazawa, F.K., Wakabayashi, Y., (2009), Three-dimensional packings with rotations, Computers and Operations Research 36(10), 2801–2815. https://doi.org/10.1016/j.cor.2008.12.015.

Moura, A., Oliveira, J.F., (2005). A grasp approach to the container-loading problem, IEEE Intelligent Systems, 20(4), 50–57. 10.1109/MIS.2005.57

Moura A., Oliveira J. F., (2009), An integrated approach to the vehicle routing and container loading problems, OR Spectrum,31, 775-800. https://doi.org/10.1007/s00291-008-0129-4

Munien C., Ezugwu E.A., (2021), Metaheuristic algorithms for one-dimensional bin-packing problems: A survey of recent advances and applications, Journal of Intelligent Systems, https://doi.org/10.1515/jisys-2020-0117.

Ministry of Commerce and Industry, Government of India (2022), National Logistics Policy.

Nguyen, T.A., Nguyen, D.L., Hoai, L.L., Dang, N.C. (2015), Quantifying the complexity of transportation projects using the fuzzy analytic hierarchy process, International Journal of Project Management, 33, 1364-1376.

Nascimento, D.X.O., Queiroz, D.A.T., Junqueira, L., (2021), Practical constraints in the container loading problem: Comprehensive formulations and exact algorithm, Computers and Operations Research, 128, 105186, https://doi.org/10.1016/j.cor.2020.105186.

Ngoi, B., M. Tay, E. Chua. (1994), Applying Spatial Representation Techniques to the Container Packing Problem. International Journal of Production Research 32 (1): 111–123. https://doi.org/10.1080/00207549408956919.

Nonaka, I., Takeuchi, H. (2007), The knowledge-creating company. Harvard business review, 85(7/8), 162.

Nishiyama. S., Lee. C., Mashita. T., (2021), Solving 3D Container Loading Problems Using Physics Simulation for Genetic Algorithm Evaluation, IEICE TRANS. INF. & SYST, 104 (11), DOI: 10.1587/transinf.2020EDP7239.

NITI Aayog, RMI, and RMI India June (2021), Fast Tracking Freight in India.

Oelschlägel, T., Knust, S., (2020), Solution approaches for storage loading problems with stacking constraints, Computers and Operations Research, 127, https://doi.org/10.1016/j.cor.2020.105142.

Olavarrieta, S., Ellinger, A.E. (1997), Resource-based theory and strategic logistics research, International Journal of Physical Distribution & Logistics Management, 27 (9-10), 559-87. https://doi.org/10.1108/09600039710188594.

Oliveira, A.D.L., Lima, D.L.V., Queiroz, D.A.T., Miyazawa K.F., (2020), Comparing a static equilibrium based methos with the support factor for horizontal cargo stability in container loading problem, Pesquisa Operacional, doi: 10.1590/0101-7438.2021.041.00240379.

Olsson. J., Larsson. T., Quttineh. N.H., (2020), Automating the planning of container loading for Atlas Copco: Coping with real-life stacking and stability constraints, European Journal of Operational Research, 280(3), 1018-1034, https://doi.org/10.1016/j.ejor.2019.07.057.

Ortega, A., Vassallo, J.M., Guzman, A.F., Martinez, P.J., (2014), Are Longer and Heavier Vehicles (LHVs) Beneficial for Society? A Cost Benefit Analysis to Evaluate their Potential Implementation in Spain, Transport Reviews, 34(2), 150-168, https://doi.org/10.1080/01441647.2014.891161.

Othman, M.K., Rahman, N.S.F.A., Ismail, A. and Saharuddin, A.H. (2020), Factors contributing to the imbalances of cargo flows in Malaysia large-scale minor ports using a fuzzy analytical hierarchy process (FAHP) approach, The Asian Journal of Shipping and Logistics, 36(3), 113-126, https://doi.org/10.1016/j.ajsl.2019.12.012

Padberg M., (2000), Packing small boxes into a big box. Mathematical Methods of Operations Research, 52, 1-21, https://doi.org/10.1007/s001860000066.

Pais, J., Amorim, I.R., Minhoto, M., (2013), Impact of traffic overload on road pavement performance, Journal of Transport Engineering 139, 873–879. https://doi.org/10.1061/(ASCE) TE.1943- 5436.0000571.

Pandza, K., Horsburgh, S., Gorton, K., Polajnar, A. (2003), A real options approach to managing resources and capabilities. International Journal of Operations and Production Management, 23(9), 1010-1032. 10.1108/01443570310491756

Pandza, K., Polajnar, A., Buchmeister, B., Thorpe, R. (2003), Evolutionary perspectives on the capability accumulation process, International Journal of

Operations and Production Management, 23(8), 822-849. https://doi.org/10.1108/01443570310486310

Patil, T.J., Patil, E.M., (2016), Cargo Space Optimization for Container, International Conference on Global Trends in Signal Processing, Information Computing and Communication. 10.1109/ICGTSPICC.2016.7955271.

Parkhi S., Kumar A.R., (2015), A Study on Transport Cost Optimization in Retail Distribution, Journal of Supply Chain Management Systems, 3(4).

Parreño, F., Alvarez-Valdez, R., Tamarit, J.M., Oliveira, J.F., (2008), A maximal-space algorithm for the container loading problem. INFORMS Journal on Computing 20(3), 412–422. https://doi.org/10.1287/ijoc.1070.0254.

Pearson, M., Masson, R., Swain, A. (2010), Process control in an agile supply chain network. International Journal of Production Economics, 128(1), 22-30. https://doi.org/10.1057/9781137541253_7.

Penrose, E. T. (1959), The Theory of the Growth of the Firm. New York, NY: Wiley.

Pino, R. et al., (2013). Application of Genetic Algorithms to Container Loading Optimization. International Journal of Trade, Economics and Finance 4(5), 304–309. DOI: 10.7763/IJTEF.2013.V4.306.

Pisinger, D., (2002). Heuristics for the container loading problem. European Journal of Operational Research, 141 (2), 382–392. https://doi.org/10.1016/S0377-2217(02)00132-7.

Portmann, M.C., (1990), An efficient algorithm for container loading. Methods of Operations Research, 64, 563-572.

Prahalad, C. K., Hamel, G. (1990), The Core Competence of the Corporation. Harvard Business Review, 68(3), 79-91.

Prakash, C. and Barua, M.K. (2015), Integration of AHP-TOPSIS method for prioritizing the solutions of reverse logistics adoption to overcome its barriers under fuzzy environment, Journal of Manufacturing Systems, 37 (3), 599-615, https://doi.org/10.1016/j.jmsy.2015.03.001.

Prakash, C. and Barua, M.K. (2016), An analysis of integrated robust hybrid model for third-party reverse logistics partner selection under fuzzy environment, Resources, Conservation and Recycling, 108, 63-81, https://doi.org/10.1016/j.resconrec.2015.12.011.

Prakash, C. and Barua, M.K. (2016), A combined MCDM approach for evaluation and selection of third-party reverse logistics partner for Indian electronics industry, Sustainable Production and Consumption, 7, 66-78, https://doi.org/10.1016/j.spc.2016.04.001.

Priem, R. L., Swink, M. (2012), A Demand-side Perspective on Supply Chain Management. Journal of Supply Chain Management, 48(2), 7-13, https://doi.org/10.1111/j.1745-493X.2012.03264.x

Puri, S. and Ranjan, J. (2012), Study of logistics issues in the Indian pharmaceutical industry, International Journal of Logistics Economics and Globalisation, 4(3), 150–161. https://doi.org/10.1504/IJLEG.2012.050204.

Pusporini, P., Dahdah, S.S. (2020), The conceptual framework of cold chain for fishery products in Indonesia. Food Science and Technology (US), 8(2), 28-33.

Raghuram, G. (2015), An Overview of the Trucking Sector in India: Significance and Structure, Indian Institute of Management.

Rahman, S., (1998)," "Theory of Constraints – A Review of Its Philosophy and Its Applications", International Journal of Operations & Production Management.

Ramos, G.A., Oliveira, F.J., Lopes, P.M., (2014), A physical packing sequence algorithm for the container loading problem with static mechanical equilibrium conditions, International Transactions in Operational Research, 23, 215-238, https://doi.org/10.1111/itor.12124.

Ramos, G.A., Silva, E., Oliveira, F. J., (2017), A new load balance methodology for container loading problem in road transportation, European Journal of Operational Research,266, 1140-1152, https://doi.org/10.1016/j.ejor.2017.10.050.

Razaei, J., (2020), A Concentration Ratio for Non-Linear Best Worst Method. *International Journal of Information Technology & Decision Making*, 19(3), pp. 891-907.

Respen, J., Zufferey, N., (2017), Metaheuristics for truck loading in the car production industry. International Transactions in Operational Research, 24, 277–301, https://doi.org/10.1111/itor.12306.

Reil, S., Bortfeldt, A., Mönch, L., (2018), Heuristics for vehicle routing problems with backhauls, time windows, and 3D loading constraints, European Journal of Operational Research, 266(3), 877-894, https://doi.org/10.1016/j.ejor.2017.10.029

Rogerson, S., Sallnas U., (2017), Internal coordination to enable high load factor, The International Journal of Logistics Management. 28(4), 1142-1167, DOI 10.1108/IJLM-02-2016-0031.

Samuelsson, A., Tilanus, B., (2002), A framework efficiency model for good transportation, with an application to regional less-than-truckload distribution, Transport Logistics.1(2), 139-151. http://worldcat.org/isbn/1840645512.

Saraiva, D.R., Nepomuceno, N., Pinheiro., (2019), A Two-Phase Approach for Single Container Loading with Weakly Heterogeneous Boxes, Algorithms, 12(4), 67, doi:10.3390/a12040067.

Santén, V. and Rogerson, S. (2014), Influencing load factor in transport operations: a literature review, 19th Annual Logistics Research Network (LRN) Conference, Huddersfield.

Saaty, T.L., (1980), The Analytical Hierarchy Process, McGraw Hill, New York.

Saaty, T. L. (1994), Fundamentals of decision making and priority theory with the analytic hierarchy process. RWS publications.

Saaty, T. L. (2008), Decision making with the analytic hierarchy process. International journal of services sciences, 1(1), 83-98.

Safak Ö., Erdo˘gan G., (2023), A Large Neighbourhood Search Algorithm for solving container loading problems. Computers and Operations Research, https://doi.org/10.1016/j.cor.2023.106199.

Saraiva, D.R., Nepomuceno, N., Pinheiro, R.P. (2019), A Two-Phase Approach for Single Container Loading with Weakly Heterogeneous Boxes, Algorithms, 12,67, doi:10.3390/a12040067.

Sawik, B., (2018), Weighted-Sum approach for BI-Objective Optimization of Fleet Size with Environmental Aspects, Applications of Management Science, 19, 101-116, https://doi.org/10.1108/S0276-897620180000019006.

Saripalle, M. (2018), Determinants of profitability in the Indian logistics industry, International Journal of Logistics Economics and Globalisation, 7(1), 13–27. https://doi.org/10.1504/IJLEG.2018.090498.

Schöneberg, T., Koberstein, A. and Suhl, L., (2011), An optimization model for automated selection of economic and ecologic delivery profiles in area forwarding based inbound logistics networks, Flexible Services and Manufacturing Journal 22 (3),214-235, https://doi.org/10.1007/s10696-011-9084-5.

Singh, K.R., Achraya, P., (2013), Identification and Evaluation of Supply Chain Flexibilities in Indian FMCG Sector Using DEMATEL, Global Journal of Flexible Systems Management. 15, 91-100, DOI: 10.1007/s40171-013-0050-9.

Singh C., Singh D., Khamba, J.S., (2020), Analyzing barriers of Green Lean practices in manufacturing industries by DEMATEL approach, Journal of Manufacturing Technology Management, 32 (1), 176-198. https://doi.org/10.1108/JMTM-02-2020-0053.

Singh, P.K. and Sarkar, P. (2020), A framework based on fuzzy Delphi and DEMATEL for sustainable product development: A case of Indian automotive industry, Journal of Cleaner Production, 246, 118991, https://doi.org/10.1016/j.jclepro.2019.118991

Singh, N., Mishra, T., Banerjee, R., (2021), Emissions inventory for road transport in India in 2020: Framework and post facto policy impact assessment, Environmental Science and Pollution Research, 29, 20844-20863. https://doi.org/10.1007/s11356-021-17238-3.

Simatupang, T., Hun B.B., Sridharan, R, (2004), " Applying the theory of constraints to supply chain collaboration", Supply Chain Management: An International Journal.

Şimşit, T.Z., Günay, S.N., Vayvay, O., (2014), "Theory of Constraints: A Literature Review", 10th International Strategic Management Conference.

Sitompul. C., Horas, M. C., (2021), A Vehicle Routing Problem with Time Windows Subject to the Constraint of Vehicles and Good's Dimensions, International Journal of Technology, 12(4) 865-875, https://doi.org/10.14716/ijtech.v12i4.4294.

Slob, N., (2013), Identifying the best vehicle utilization improvement plan for Procter & Gamble Benelux and the Benelux customers, Eindhoven University of Technology.

Soh, S., (2009), A decision model for evaluating third-party logistics providers using fuzzy analytic hierarchy process, African Journal of Business Management. 4(3), 339-349.

Suhr, D. (2006), The basics of structural equation modelling. Presented: Irvine, CA, SAS User Group of the Western Region of the United States.

Terno, J., Scheithauer, G., Sommerweiß, U., Riehme, J., (2000), An efficient approach for the multi-pallet loading problem. European Journal of Operational Research, 123(2), 372–381. https://doi.org/10.1016/S0377-2217(99)00263-5.

Treitl, S., Nolz, P.C. and Jammernegg, W. (2014), Incorporating environmental aspects in an inventory routing problem. A case study from the petrochemical industry, Flexible Services and Manufacturing Journal 26 (1), 143-169. https://doi.org/10.1007/s10696-012-9158-z.

Tsao, C.Y., Lu,C.J. (2012), A supply chain network design considering transportation cost discounts, Transportation Research Part E: Logistics and Transportation Review. 48(2), 401-414, https://doi.org/10.1016/j.tre.2011.10.004

Tseng, P.H., Cullinane, K. (2018), Key criteria influencing the choice of Arctic shipping: a fuzzy analytic hierarchy process model, Maritime Policy and Management, 45(4), 422-438, https://doi.org/10.1080/03088839.2018.1443225

Tian, T., Zhu, W., Lim, A., Wei, L., (2015), The multiple container loading problem with preference, European Journal of Operational Research, 248, 84-94, https://doi.org/10.1016/j.ejor.2015.07.002.

Treiblmaier, H., Mirkovski, K., Lowry, B.P., Zacharia, G. Z., (2020), The physical internet as a new supply chain paradigm: a systematic literature review and a comprehensive framework, The International Journal of Logistics Management, 31(2), 239-287, 10.1108/IJLM-11-2018-0284.

Trivedi, A., Jakhar, K.S., Sinha, D., (2021), Analyzing barriers to inland waterways as a sustainable transportation mode in India: A dematel-ISM based approach, Journal of Cleaner Production, 295, https://doi.org/10.1016/j.jclepro.2021.126301

Tseng, P.H. and Cullinane, K. (2018), Key criteria influencing the choice of Arctic shipping: a fuzzy analytic hierarchy process model, Maritime Policy and Management, 45(4), 422-438, https://doi.org/10.1080/03088839.2018.1443225

Van Hoek, R., Ellinger, A.E. and Johnson, M., (2008), Great divides: internal alignment between logistics and peer functions, International Journal of Logistics Management, 19(2),110-129, https://doi.org/10.1108/09574090810895924.

Velez-Gallego, M.C., Teran-Somohano, A., Smith, E.A., (2020), Minimizing late deliveries in a truck loading problem. European journal of Operational Research, 286(3), 919-928. https://doi.org/10.1016/j.ejor.2020.03.083

Vieira, M. V.C., Carvalho, M. (2022), Lexicographic optimization for the multi-container loading problem with open dimensions for a shoe manufacturer. 4OR. https://doi.org/10.1007/s10288-022-00522-4

Vishwakarma, V., Garg, C.P. and Barua, M.K. (2019), Modelling the barriers of Indian pharmaceutical supply chain using fuzzy AHP, International Journal of Operational Research, 34(2),240-268, https://doi.org/10.1504/IJOR.2019.097578

Watson, R.T. and Webster, J. (2020), Analysing the past to prepare for the future: Writing a literature review a roadmap for release 2.0, Journal of Decision Systems, 29(3), 129-147, https://doi.org/10.1080/12460125.2020.1798591.

Wei, L., Zhu, w., Lim, A., (2014), A goal-driven prototype column generation strategy for the multiple container loading cost minimization problem, European Journal of Operational Research, 241(1), 39-49, https://doi.org/10.1016/j.ejor.2014.08.015.

Wei L., Luo Z., Baldacci R., Lim A., (2019), A New Branch-and-Price-and-Cut Algorithm for One-Dimensional Bin-Packing Problems, INFORMS Journal on Computing, 32(2), 1-16, https://doi.org/10.1287/ijoc.2018.0867.

Williamson, O. (1979), Transaction-cost economics: The governance of contractual relations. Journal of Law and Economics, 22, 233–261.

Williamson, O. (1986), Transaction-cost economics: The governance of contractual relations. In J. Barney & W. Ouchi (Eds.), Organizational economics. 98–129.

Wu, W.W., Lee, T.Y., (2007), Developing global managers' competencies using fuzzy DEMATEL method, Science Direct, 32, 499-507. https://doi.org/10.1016/j.eswa.2005.12.005.

Wu, H., Dunn, S.C. (1995), "Environmentally responsible logistics systems", International Journal of Physical Distribution & Logistics Management, 25, 2,20-38. https://doi.org/10.1108/09600039510083925

Xiong, Y., Zhao, J., Lan, J., (2019), Performance evaluation of food cold chain logistics enterprise based on the AHP and entropy. International Journal of Information Systems and Supply Chain Management, 12(2), 57- 67.

Yüceer, U., Özakça A., (2010), A truck loading problem, Computer and Industrial Engineering, 58(4), 766-773, https://doi.org/10.1016/j.cie.2010.02.008.

Zadeh, LA., (1965), Fuzzy Sets. Information and Control. 8(3): 338-353. https://doi.org/10.1016/S0019-9958(65)90241-X.

Zhao, X., Bennell, J. A., Bekta¸ S, T., Dowsland, K. (2016), A comparative review of 3D container loading algorithms. International Transactions in Operational Research, 23(1–2), 287–320. https://doi.org/10.1111/itor.12094.

Zhang, X. and Lam, J.S.L. (2019), A fuzzy Delphi-AHP-TOPSIS framework to identify barriers in big data analytics adoption: case of maritime organizations, Maritime Policy & Management, 46 (7),781-801, https://doi.org/10.1080/03088839.2019.1628318.

APPENDICES

APPENDIX I: QUESTIONNAIRE

Questionnaire

Dear respondent,

I am Rudrangsu Biswas, and I am carrying out academic research for my Ph.D. (doctorate) degree on " ANALYSIS AND MANAGEMENT OF VEHICLEFILL RATE IN ROAD FREIGHT TRANSPORT OF FMCG SECTOR". Hence, you are kindly requested to give necessary information for the research questions. Please be assured that the information acquired shall be used purely for academic purposes only and will be kept strictly confidential. Please indicate your level of agreement or disagreement by using (√) mark on the appropriate box given corresponding to each statement. Your co-operation and assistance will be highly appreciated. If you need any clarification or information:

Mob. 9433759222 **E-mail-rudrangsu@gmail.com**

Section I: General Information	Please read each question carefully and make a tick under each value				
Sex	Male		Female		
Age (Yrs.)					
Respondent’s Designation:					
Qualification	MBA	Diploma	Graduation	12th	10th
Relevant Work Experience (Yrs.)	3- 5 years	5-10 years	11-15 years	16-20 years	Above 20 years
Name of the organization currently working with					

Appendix 2 – Section of Questionnaire (used for Constraints analysis)

Do you think below mentioned constraints are impacting the vehicle fill rate/ loadability ? Please rate those constraints; Please put (√) sign for each of the following

Constraints	Very Important (5)	Important (4)	SO SO (3)	Less Important (2)	Not Important (1)
Variability in Truck Size (within same truck type)					
Variability of truck carrying capacity (within same truck type)					
Usage of Angle, nut-bolt inside Truck					
Weight Limits of truck					
Weight Distribution Constraints					
Load limit by volume					
Loading Priorities of stock					
Orientation Constraints of boxes					
Stacking Constraints inside the truck					
Positioning Constraints of material					
Complete Shipment Constraints					
Allocation Constraints of stock					
Service Requirements					
Multi Drop Operation					
Stability Constraints					
Complexity Constraints					
Product Mix					
Orthogonalplacement and No overlap of boxes					
variability of order size					
Routing of deliveries					
JIT/frequency of deliveries					
Unloading Priorities					
space-In efficient packaging					
use of shelf-ready packaging					
Design of products (LBH of Boxes)					
Inter-functional coordination within organization like sales and SCM/ Packaging/SCM					
Inter-Organization coordination (between the organization)					
Within functional coordination within organization (Logistics and Demand Plann ing/ Logistics and Customer Service)					

Appendix 3 – Questionnaire for Expert Inputs

For Main constraints using AHP Analysis

Please rate the following in terms of relative importance on the following scale: Equal Importance - EI; Very Low importance - VLI; Low importance - LI; Average importance - AI; High importance - HI; Very High importance - VHI; and Extremely High importance - EHI.

For example, if SIT has very high importance as compared to VRC then put VHI in

	SIT	VRC	BRC	CRC	LRC	ORC	PRC	ICCC
SIT		VHI						
VRC								
BRC								
CRC								
LRC								
ORC								
PRC								
ICC								

the row of SIT and column of VRC.

For Main constraints using DEMATEL

Please rate the following in terms of influence of one criterion on the other as per the following scale:

Scale	*0*	*1*	*2*	*3*	*4*
Level of Influence	*No influence*	*Low influence*	*Medium influence*	*High influence*	*Very High influence*

	SIT	VRC	BRC	CRC	LRC	ORC	PRC	ICCC
SIT								
VRC								
BRC								
CRC								
LRC								
ORC								
PRC								
ICC								

For SOLUTIONS using FTPOSIS

Please give an appropriate rating on the basis of usefulness of the solution for the corresponding Issue as per the following scale –

LINGUISTIC	Rating
VERY LOW	1
LOW	3
AVERAGE	5
HIGH	7
VERY HIGH	9

	SCT	VRC	BRC	CRC	LRC	ORC	PRC	ICCC
GSL								
RTT								
LAP								
PPD								
CAA								
OPP								
WRC								
IOI								

Research Publication

Research Paper 1 (Published)

"Variance in Truck load Carrying Capacity impacting Truck Fill Rate, Freight Cost and Carbon Emissions" (2023), International Journal of Logistics Economics and Globalisation, 10(2), 165-185, 10.1504/IJLEG.2023.132342

ABDC Journal List – C Category

ISSN: 1741-5373

Research Paper 2 (Published)

"Structural constraints in container loading and its impact on Vehicle Fill Rate - A Study on Indian FMCG Sector" (2023), Manager - The British Journal of Administrative Management, Volume 59 (158), 167-180.

ISSN: 1746-1278

ABDC Journal List – C Category

Book Chapter 1 (Published)

"Impact of Non-Standardized trucks on Vehicle Fill Rate (VFR) and Cost in Indian FMCG Sector: A Study". Springer Nature Singapore Pte Ltd. 2022 V. P. Singh et al. (eds.), Sustainable Infrastructure Development, Lecture Notes in Civil Engineering 199. Springer, Singapore.

Research Paper 3 (Communicated)

"Strategies to overcome constraints in the Vehicle Fill rate of Road Freight Transport for FMCG Sector". Communicated on 10th July'2023.

Research Paper 4 (Communicated)

"Issues in Vehicle Fill Rate in Road Freight Transport in the FMCG Sector: An Integrated Multi criteria Decision Approach". Communicated on 24th Nov'2023.

Brief Background

Name – Rudrangsu Biswas

Qualifications:

- Pursuing PhD at UPES, Dehradun - India.
- MBA in Transportation and Logistics Management at IISWBM, Kolkata

Work Experience: 15 years of industry experience at PAN India level

- Current – June'2023 to till Date
  Organization – **Pernod Ricard India Ltd.**
  Designation – Unit Supply Chain Manager
- Current – Sep'2019 to June'2023
  Organization – **Emami Agrotech Ltd.**
  Designation - DGM - Head of Supply Chain Transformation **(PAN India)**
  Previous Designation - AGM – Head of Logistics and Customer Service **(PAN India)**
- Previous Experience – Sep'2011 to Sep'2019
  Organization – **Nestle India Ltd.**
  Last Designation - Logistics Operations Development Manager **(SAR Region)**
- Previous Experience – July'2008 to Sep'2011
  Organization – **ITC Ltd.**
  Last Designation – Logistics Executive

- Academic Experience – Jan'17 to June'18 and Jan'21 to Dec'21
  Visiting Faculty at **IISWBM**, Kolkata.
  Subject – Road transport, Supply Chain Management

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