Framework For Optimizing Secondary Logistics Of Automotive Fuels In Downstream Petroleum Industry In North India

Bhuwan Chandra Joshi, Binod Kumar Singh

Abstract: The objective of the present study is to develop a framework for optimizing secondary logistics of Automotive fuels i.e. Motor Spirit and High Speed Diesel in North India. Literature review identified the variables of Cost, Customer Satisfaction, Lead time, Level of Service, Product Quality, Responsiveness, Reliability, Flexibility and Market reach as variables in optimisation of secondary logistics. Factor Analysis of survey from Subject Matter Experts reduced these to four underlying factors namely Cost, Performance, Service and Market Reach. The relative weight of these factors were established using Analytical Hierarchical Process. The service has the highest weightage followed by Cost, performance and Market reach in that order. A framework for optimization developed using Delphi method where service level used as the starting point depending upon the company strategy. This is in variance to the current industry practice of using cost optimization techniques to the secondary logistics.

Index Terms: Logistics framework, Logistics strategy, Secondary Logistics, Petroleum Industry Logistics, Petroleum optimisation, Downstream Petroleum Logistics, Auto Fuel logistics, Indian Petroleum logistics .

1. INTRODUCTION

PETROLEUM Industry in India is at an inflexion point. The auto fuel policy of the government has mandated to the automotive fuels to leapfrog from Bharat Standard IV to Bharat Standard VI by the end of financial year 2019-20. An expert committee has recommended reduction of entry barriers in the retailing of Petrol and Diesel. Huge foreign investments have been pledged in production and retailing of automotive fuels. Alternative energy is getting competitive and is vying to replace the petroleum fuels significantly. At present the marketing of automotive fuels in India is dominated by public sector oil companies. The private retailers have not been able to make any significant dent in the market due to volatility of crude prices and government subsidies made available to the public sector oil companies in the past. The development of shale oil companies in US has been a balancing factor in crude prices as these are less capital intensive and have flexible production capabilities. The policy support to electric vehicles in view of the rising environmental concerns has forced automotive and oil companies to amend their demand forecasts. These developments are forcing the oil marketing companies in India to rethink on their supply chains to optimize their operations in order to remain competitive.

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2 INDIAN DOWNSTREAM PETROLEUM INDUSTRY

India imports 83% of its crude requirements and processes it in its refineries. The primary logistics of the automotive fuels starts from Refinery tanks where the products are certified to be fit for marketing. These products are then brought to the storage terminals of oil marketing companies (OMCs) through pipelines, rails or ocean tankers. The companies use least cost models to optimize primary logistics and also use inter-company swapping of product to reduce transportation cost. The part of supply chain from storage terminals to the retailers or end consumers is called secondary logistics and is the topic of current study. This being the last mile of the petroleum value chain, involves oil company, transporter, retailer and end consumers as supply chain partners. The custody of the product is handed over by oil marketing company to the transporter who in turn hands it over to the retailer or the end consumer. India's downstream petroleum sector is dominated by three public sector oil marketing companies (OMCs). Indian Oil Corporation Ltd (IOCL), Bharat Petroleum Corporation Ltd (BPCL) and Hindustan Petroleum Corporation Ltd (HPCL).

3 ROLE OF SECONDARY LOGISTICS IN INDIAN DOWNSTREAM PETROLEUM INDUSTRY

As demonstrated Secondary Logistics is essentially the last mile connectivity between the OMCs and the retailer and is essentially accomplished through road. The mode of transportation is flexible to the extent that the supplies can be made in the remotest parts of the country wherever road network is available. The tank trucks used by transporters are dedicated to the particular category of products and cannot be used for other products. For example the tank trucks used for transportation of white oils i.e. MS and HSD cannot be used for black oils e.g. FO and LDO. These tank trucks are contracted by the OMCs for the supplies from their storage terminals and are attached to that terminal only. The automotive fuels i.e. Motor Spirit (Petrol) and High Speed Diesel (HSD) are sold on volume basis and their carriers (Tank Trucks) are calibrated to fixed capacity and certified by Legal Metrology Department. The number of tank trucks contracted at a location are dedicated and their numbers are fixed. This

provides inflexibility to the system and the seasonal and daily demand fluctuations are to be attenuated by creating storage tanks both at Terminal and retailer end. The tank trucks take supplies from a particular storage terminal, deliver to the retailers or consumers and return back empty to the Terminal. The transporters are paid on the basis of round trip distance (RTD) travelled during the trip. The secondary logistics involves selection of storage Terminal for each market, selection of carriers, number of tank trucks, capacities of tank trucks to be contracted and day to day planning and scheduling. OMCs enter into contract with the transporters and remuneration in the form of transportation bills based on the distance travelled and quantity of product delivered. The retail outlet dealers are paid commissions based on quantity of product sold. The contracts have provisions to eliminate malpractices like adulteration, short delivery, tampering, route deviation, non- delivery etc by the carrier. The product changes hands from OMC to transporter to the retailer in the process. The role of secondary logistics is to deliver right quantity of the product to the retailer at the right time while maintaining the quality of the product and safety of handlers and public. The selection of secondary logistics model requires identification of factors for optimization and determination of relative weight of those factors. Hence the problem here is essentially multi objective so that the logistics delivers the objectives as per company strategy and bring competitive advantage to the supply chain. Logistics costs are controllable and have significant contribution to expenses in the oil industry running on low margins. The Oil Marketing Companies (OMCs) are using various models for optimising primary logistics. In the past secondary logistics optimisation has been limited to supplies from the nearest available source. Secondary logistics can be key distinguisher in the service delivery of OMCs. Cost , Service, Performance and Market Reach are the four factors identified for optimization of secondary logistics of automotive fuels i.e. Motor Spirit (MS) and High Speed Diesel (HSD) in India. The objectives of the channel partners have to be considered and balanced while constructing optimisation models for secondary logistics and aligned with company's strategy. The study has been limited to the highest selling petroleum products MS and HSD sold through retail channels of OMCs which affect the day to day life of the Indian consumers. North India is farthest from the sea so is more dependent on surface transport and has high volume sales and high complexity so the model developed here may be applied to other areas with suitable modifications.

4 LITERATURE REVIEW

Petroleum is the world's major source of energy and is a key factor in the continued development of world economies (1) Crude oil transportation starts at the wells and production platforms to the final customers, i.e., refinery, international market. The crude oil usually is transported through pipeline and marine transports, i.e., oil tanker, vessel, and barge. (2). The crude transformation planning is certainly one of the most complex and important chemical processes in the refinery and petrochemical industries. This process contains particular procedures that can be done by several possible designs. The main purpose of this process is to change crude oil into intermediate and final refinery products with a higher value chain. (3).The refinery products have two kinds of distribution in their journey to reach the end consumers: primary and secondary. Primary distribution consists of shipping products from refineries to depots. The other one is the final transportation that ships products from depots to final markets and customers. Primary distribution modes are usually pipelines, marine transportation, railcars, and road vehicles (4)Transportation for the crude oil covers the movement of crude oil from oil wells to ports to refineries, and the movement of finished products from refineries to the retail outlets (5). Petroleum products comprise of Petrol, Diesel, ATF, Naphtha, Fuel Oil, Light Diesel Oil, Bitumen, LPG, lubricants, paraffin wax, petroleum coke etc. The movement of these products from refineries to storage points and finally to retail outlets is carried out using the least cost mix of rail, coastal shipping, roads and pipelines. Modes of transportation of petroleum products from the refineries to secondary storage facilities include: pipelines, road transportation, water transportation and rail transportation. Pipelines are most suited for transporting liquid substances and hence widely used in the petroleum industry((6)). (7) states that to construct an integrated supply chain requires the management of material flow from three perspectives: strategic, tactical and operational . He also mentions that a company can measure the supply chain performance by inventory level, service level, throughput efficiency, supplier performance and cost. The primary movement of petroleum products, from refineries to storage depots is through pipelines, or coastal shipping. The secondary movement of petroleum products i.e. from storage depot to the retail outlet, viz. last mile is necessarily through roads, irrespective of the mode used for the primary movement. Finding options for optimization of the oil supply chain is important because any cost saving means vast amounts of money for the oil companies, therefore optimization is at the centre of attention in the oil supply chain management (8). Despite the economic importance and the complexity of supply chain management in the oil industry, oil supply chain optimization is still in its infancy. (9)The increasing level of competition and requirements of high quality increase the complexity of the oil supply chain which also has a negative effect on the flexibility (8). The long lead time, fixed manufacturing capacity and limited means of transportation are the major reasons of inflexibility in supply chain. The long distances between supply chain partners and the slow means of transportation increase the lead time from shipping point to the end users. It becomes hard to meet a required service level but it also could hurt customers who have to keep costly safety stock (9). Using reliable transportation mode and placing inventory closer to the final users enhances the customer satisfaction because faster lead time and faster product availability can be achieved (10). Jenkins and Wright (1998) suggest focusing on the means of transportation, especially on road transport and its tankers as well as drivers. It is mostly because they believe these are highly flexible elements of the inflexible oil supply chain and these could be a good area for optimization and reduce cost. As lead time is long and many variations of means of transport is possible, with excellent IT software such as the fleet scheduling package and using the supply chain management model, optimization can be achieved (11). These are cost effective, increase flexibility which contributes to higher customer satisfaction and they also improve planning and controlling the supply chain (12). Not to mention it helps to avoid run outs and retains customers at the filling station (13).

Jha and Deshmukh (2009) emphasise that the cost and level of service have to be in centre of the attention. It is also important in the downstream oil supply chain that the distribution occurs from the refinery or from the storage facilities. Mode of transportation, fleet size, shipment routes and quantity of the delivered products are the factors which determines the distribution planning (14). A secure and reliable transportation mode and carrier gives the ability to position decoupling point which reduces the bullwhip effect and ensure that inventory could be closer to the customers (10)The activities that comprise the oil supply chain are divided into three major segments: upstream, midstream, and downstream. The upstream segment includes the exploration and oil production. The midstream is an intermediate segment and consists of the refining activity which includes the transportation of crude oil from the production site to refineries. The logistical tasks necessary to move the refined products from the refinery to the points of consumption are in the downstream segment (15). Strategic (long-term) planning determines the structure of the supply chain (e.g. facility location).Medium-term (tactical) planning is concerned with decisions such as the assignment of production targets to facilities and the transportation from facilities to warehouses to distribution centers. Finally, short-term planning is carried out on a daily or weekly basis to determine the assignment of tasks to units and the sequencing of tasks in each unit. At the production level, short-term planning is referred to as scheduling (16). Historically, refinery planning models for oil industry were based on LP and MILP. The computational and algorithmic complexity of NLP and MINLP inhibited the model development in this area. The first application is from 1997 however, the applications of MINLP are still considered a challenge. The petroleum refining and petrochemical companies are engaged in more integration projects but little research in the open literature is available due to confidentiality reasons. This render the development of a systematic framework of network integration and coordination difficult (17). The Annual reports of three public sector oil marketing companies of India has been studied to find the transportation costs. Indian Oil Corporation Ltd (IOCL) is the largest OMC having spent Rs 8,442 Cr on transportation for a total sale of 89.9 MMT in 2018-19 which is 12.5% increase over the previous year. The increase in retail selling price of HSD which is fuel for the carriers has been 2.4% in 2018-19 (18)Bharat Petroleum Corporation Ltd (BPCL) expended Rs 6930 Cr in transportation of 43.30 MMT products in 2018-19 registering a 12.5 % increase over the last year (19). Hindustan Petroleum Corporation Ltd (HPCL) has shown expenses of Rs 6162 Cr for transportation of 38.71 MMT of product in 2018-19 which is 5.1% increase over the previous year (20). Adding up the figures of all three OMCs, the average transportation charges in 2018-19 have increased by 10.3% against 2.9 % increase in sales and 2.4% increase in RSP of HSD. In other words the oil companies have incurred a loss of 5% on the transportation charges of Rs 21534 Cr amounting to Rs 1077 Cr. Thus there is huge scope of optimization in petroleum logistics in India. The OMCs in India have realized the importance of optimization of their supply chain. The market leader, Indian Oil Corporation Limited (IOCL) has implemented Honeywell's Supply Chain Management solution to integrate and optimize the supply chain of its five separate refineries targeting higher margins and increased profitability. The Crude selection and allocation process involving product demands, refinery capabilities and effect of crudes already procured, Optimal refinery production planning considering crude assays, unit capacities, product specifications and demands; and feedstock availability, Optimal distribution planning considering transportation costs, taxes and duties and transportation constraints (21) . Bharat Petroleum Corporation (BPCL) formed Supply Chain Optimisation (SCO) Department in Nov' 2006 and launched its initial project CRESCENDO (Crude Refining Supply Chain Network & Depot Optimization). The OMC started integrating its six core Supply Chain processes namely Demand Planning, Monthly Distribution Plan, Inventory Management, Crude Evaluation Selection & Nomination, Refinery Monthly Plan and Product Exchange Plan. The company included Distribution optimization in retail logistics based on freight cost and linkages. (22)

5 FACTORS OF SECONDARY LOGISTICS

The performance of a supply chain can be ascertained from various perspectives. These have been identified as Customer, Financial, Internal Business, Innovation and Learning Perspectives. The Customer Perspective involves Product Quality, Product Service Level, Customer Satisfaction, Responsiveness and Market Reach. The Financial Perspective means Adherence to Budget, Transportation Costs, Operating Costs, Inventory and Cost Savings. The Internal Business Perspective caters to Timeliness, Waste Reduction, Accuracy, Utilization of Resources, and Shipment Visibility. The Innovation & Learning Perspective leads to Automation, Learning and Growth. Out of these Customer perspective have been found to be the most important followed by Internal Business, Financial and Innovation and Learning in descending order of importance (23).

Customer Perspective :

Product Quality : The prices of diesel and petrol have been deregulated in India and change on daily basis. Deregulation was aimed at better service delivery to customers in view of increased competition (24). The quality of product is the most important hygiene factor to retain the customer. The petroleum product logistics should have a system to minimise the chances of adulteration or short delivery of product. Crude, the mother of all petroleum products, occurs in nature and its characteristics are not uniform. Standards are available to fix the quality parameters of the product and the same are required to be maintained. The quality of the refined product at refinery gate is required to be maintained throughout the supply chain till the product reaches the consumer. The OMCs are in full control during the primary logistics but the control is least during duing secondary transportation when the custody is with transporter or retail outlet dealer.

Service Level : A motor vehicle owner or driver is a typical customer at a retail outlet. The customer visits a Retail Outlet of an OMC with a purpose to refuel the vehicle. The customer can have different categories e.g. bike owner, car owner, commercial vehicle owner. The levels and type of service expected by each category are varied. In general, the customer expects ready availability, Vehicle guiding, prompt delivery, accurate measurement. Availability of wash-rooms, air and water facilities, flexibility in mode of payments and other add-on services. The service level of Retail Outlet creates differentiation among them. The retail outlet dealer is an intermediate customer and is the recipient of secondary

logistics services and expects timely delivery of product from OMC terminal, financial flexibility in payments, optimal inventory management and logistics information support from the OMCDealer's Perspective : The retail outlets in India are single brand dealers and are affiliated to a single OMC. The relationships can be different depending on the ownership of land, buildings and facilities. The goal of a dealer is to maximize sales using its superior services as there is very low pricing flexibility available. The dealer would like to minimise the operating cost and would expect expeditious delivery of product whenever a demand is placed. The OMCs also offer credit facilities to select high selling dealers to encourage them to keep inventory of products as this brings reliability into the supply chain and shields it from dry-outs during supply disruptions. Th information flow regarding product availability, product quality, Tank Truck loading, availability of balance amount with OMC enables retail outlet dealer to plan its business activities optimally. Many of the dealers have their own tank trucks under contract with OMCs and their optimum utilisation adds to the profitability of the dealer.

Transporter's Perspective :
The transport fleet of each storage terminal is dedicated bound by a contract. The optimum utilisation of this fleet is essential from transporter's perspective. A transporter has to have adequate return on investments to ensure timely delivery of product while maintaining its quality and quantity. Indian OMCs in public sector are engaging individual transporters through public tender. The profitability of transporter shall depend on the maximisation of on road time as it is paid by Kilometres run by its tank trucks since their capacity is constant and transportation rates are pre-determined through the contract. The transportation rates are established for distance travelled in Kilometres multiplied by the volume carried by the tank truck. However for short distances a minimum rate is fixed or per Kilolitre of product supplied. The transporter can offer lower rates at the locations where business volume is more and its fleet is optimally utilised.

Internal Business Perspective:
Operating cost of a storage depot comprises of inventory carrying cost, wages and overtime to workers, product handling losses, power and utilities cost, facility maintenance cost etc. Financial Perspective : The cost of placing the product in a market has significant impact on the bottom line of the OMCs. In the primary logistics, the choice of mode of transportation significantly changes the logistics cost whereas in secondary logistics the road transportation is the only mode available. The objective of reducing the logistics cost has to be balanced with those of channel partners.

6 OPPORTUNITIES OF OPTIMISATION IN SECONDARY LOGISTICS IN INDIAN PETROLEUM INDUSTRY

The change in ecosystem is forcing the OMCs to take significant measures to optimise their secondary logistics. The newer players are likely to come up with newer transportation models. The OMCs will improve upon the models based on the success of new models. The competition is heating up as the private players are getting comfort in the stable policy framework. However there is enough scope for synergistic co-operation among the oil companies. The OMCs should enter into agreements to share their infrastructure leading to saving in capital cost and optimum. Utilisation of existing infrastructure will be leading to a win- win situation for all the sharing companies. The plan to build world's largest refinery and petrochemical plant at west coast through a joint venture of all three marketing companies is a step in right direction. The scenario of future is likely to be one of intense competition at the customer end and collaboration at the back end. The telecom industry can be taken as a good example where there is cut-throat competition to woo the customers while sharing the mobile tower infrastructure. The GST implementation in all petroleum products shall lead to a tax regime where the entire primary and secondary logistics of petroleum products will have to be re-worked. This will be a great opportunity for optimisation of secondary logistics. Although the petroleum products are not in the list of GST goods currently but there is high probability of their inclusion in the years to come. The availability of high resolution digital maps, accurate GPS systems on Tank Trucks and tracing of routes from storage depots to the retail outlets and automation of retail outlets has opened a vast field for analysing the data available and make logistic decisions and policies. The secondary logistics being the more complicated will benefit the most with the increase in objectivity in decision making. The use of Analytical Hierarchical Process is suggested in the complex and multi-objective decision making process.

7 ANALYTIC HIERARCHY PROCESS

The Analytic Hierarchy Process (AHP) provides the objectivity to process the complex, subjective and personal preferences of an individual or a group in making a decision. With the AHP and one constructs hierarchies or feedback networks, then makes judgments or performs measurements on pairs of elements with respect to a controlling element to derive ratio scales that are then synthesized throughout the structure to select the best alternative. AHP works by developing priorities for alternatives and the criteria used to judge the alternatives. The criteria, whose choice is at the mercy of the understanding of the decision-maker, are measured on different scales, such as weight and length, or are even intangible for which no scales yet exist. Measurements on different scales, of course, cannot be directly combined. First, priorities are derived for the criteria in terms of their importance to achieve the goal, then priorities are derived for the performance of the alternatives on each criterion. These priorities are derived based on pair-wise assessments using judgment, or ratios of measurements from a scale if one exists. The process of prioritization solves the problem of having to deal with different types of scales, by interpreting their significance to the values of the user or users. Finally, a weighting and adding process is used to obtain overall priorities for the alternatives as to how they contribute to the goal. This weighting and adding parallels what one would have done arithmetically prior to the AHP to combine alternatives measured under several criteria having the same scale to obtain an overall result. With the AHP a multidimensional scaling problem is thus transformed to a unidimensional scaling problem. (25). The characteristics of AHP as observed above are ideal for determining the relative weight of the factors of optimization in secondary logistics of automotive fuels as it has multiple objectives and needs judgment of subject matter experts to ensure it to balance the interests of supply chain partners involved.

8 IDENTIFICATION OF FACTORS

The underlying variables identified through literature review were subject to factor analysis after administering a suvey to Subject Matter Experts (SMEs) having a sample size of 72. The 98.6% of the respondents were from operations group of public sector oil marketing company. 16.7% were having experience of more than 30 years, 36.1% having 20-30 yrs experience, 29.2% were having experience in the range of 10 to 20 and rest 18.1% were having less than 10 years of experience. The survey data was fed into the SPSS version 25 software and reliability test was carried out. The test results showed the Cronbach Alpha as 6.02 which is the minimum acceptable. The Factor 1 has components of Overall Cost and Lead Time of Product delivery. These two variables are important for business perspective of the oil marketing company and can be termed as Performance of the logistics. The second factor has Product Quality , Responsiveness and Reliability as components which essentially relates to the Retail Outlet Dealer who is receiver of the services so this may be called Service Factor. Transport Cost and Flexibility are essentially are the concern of the transporter who would require flexibility for optimum fleet utilisation and transport cost. Both are related to the Cost incurred by the logistics provider. The fourth factor is defined by component itself as Market Reach and is the concern of local community.

9 DETERMINATION OF RELATIVE WEIGHT OF FACTORS

Performance, Service, Cost and Market Reach are the four factors identified for optimisation of secondary logistics of Petroleum products in India. The customer, transporter, retail outlet dealer, crew, community are stakeholders, the least cost methods may affect the competitive position of the company. The description of factors identified has been given as under :

1. Cost : Providing flexible logistics at least transportation cost.
2. Service : Providing best Product Quality with high Responsiveness while ensuring Reliability
3. Performance : The ability to deliver product at least Lead time of delivery and minimum overall cost to company.
4. Market Reach :The ability to serve the remote and uneconomical markets

Framework : The framework for optimisation of secondary logistics needs relative weights of various factors of optimisation to be considered. The Analytical Hierarchical Process of decision making was used for the purpose. A survey was conducted from Subject Matter Experts (SMEs) who were asked to make pairwise comparisons among the various factors on a scale of 1 to 9 where the option 1 denoted that first factor is 5 times more important than the second and 9 denoted that the second factor is 5 times more important than the first. The respondent was asked to select any value in between. The questionnaire was sent to 944 SMEs and 353 responded . The SMEs were asked to determine the relative weight of the the factors of optimisation for MS and HSD supplies in North India. They were asked to provide appropriate response against nine choices for pairwise comparison amongst the factors as under :

1 - Very Strongly agree means first factor is 5 times more important than the second
2- Strongly Agree means first factor is 4 times more important than the second
3- Agree means first factor is 3 times more important than the second
4- Slightly Agree means the first factor is 2 times more important than the second
5- Neutral means first and second factor are equally important
6- Slightly Disagree means second factor is 2 times more important than the first
7- Disagree means second factor is 3 times more important than the first
8-Strongly Disagree means second factor is 4 times more important than the first
9- Very Strongly Disagree means second factor is 5 times more important than the first.

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

Inconsistency	0.07925	
Name	Normalized	Idealized
1 Cost	0.274714728	0.585238241
2 Service	0.46940666	1
3 Performance	0.203548377	0.433629078
4 Market Reach	0.052330234	0.111481661

The inconsistency value of 0.07925 was thrown which is much less than 0.1 and hence acceptable.The comparison matrix states that Cost is equal in importance to performance and Service but is 4 times more important than Market Reach. Service is 4 times more important than performance and 8 times more important than market reach. Performance is

Comparison Matrix :

	Cost	Service	Performance	Market Reach
Cost	1	1	1	4
Service	1	1	4	8
Performance	1	0.25	1	5
Market Reach	0.25	0.125	0.2	1

Framework : A framework for optimization of secondary auto fuel logistics in North India has been proposed keeping customer service at the centre. The service delivery parameters have been defined as product quality assurance, Responsiveness and Reliability. In order to ensure product quality the transporter is the key stakeholder taking custody from the company and handing it over to the retailer or consumer. The oil companies are encouraging the retailers and consumers to become transporters for their own supplies thereby removing the intermediary. However agency problems

still remain and can be addressed using training and ensuring adequate return on investments. Training to the retailers for checking quality of product and creating awareness among the end customers shall go a long way to ensure quality of the product. Responsiveness to the market demand fluctuations shall have to defined in terms of the maximum variation to the average demand that can be met from a terminal. This will be design criteria for the infrastructure development e.g. storage and loading capacity. The reliability will not only be defined by the least uncertaintly but also providing information to the channel partners of supply chain.The second step after fixing the service levels shall be to meet the objective of least cost of logistics which can be achieved by Linear Programming models involving all cost elements as variables and the service levels fixed as constraints. For example the demand to be met in toto from a supply location may be taken as a constraint while optimizing for least cost objective.

The company need to measure the performance of the entire supply chain and look for bottlenecks leading to sub-optimal performance of any of the stakeholders and balance their interests even if it is a deviation from least cost solution. This step is significant as it ensures that all the stakeholders perform to achieve the objectives of supply chain.

10 CONCLUSION

The relative weights of Service, Cost , Performance and Market Reach are 0.46, 0.27, 0.20 and 0.05 respectively. The suggested framework proposes deciding on the Service parameters of quality, responsiveness and reliability first and then using LP model to reach the least cost objective using service levels as constraints. The model can thus be adjusted to meet the performance parameters across the supply chain to balance the interests of stakeholders. The framework suggested is a major deviation from the least cost models being used by the oil marketing companies to optimize their downstream operations.

SCOPE FOR FUTURE RESEARCH

The framework can be validated by SMEs using Delphi method and also can be applied to a test market. The results can be used to adjust the model by using AHP. The study can be extended to primary logistics, refinery operations and even to crude logistics and the models can be integrated to form a single optimization model for the entire supply chain of petroleum.

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