Proceedings of GLOGIFT 09
November 12 – 14, 2009
National Institute of Industrial Engineering
Mumbai, India

ENHANCING SUPPLY CHAIN FLEXIBILITY THROUGH CONSOLIDATION OF SHIPMENTS

Manu Shekhar
Post Graduate Diploma in Industrial Engineering
National Institute of Industrial Engineering (NITIE)
Mumbai, India
manushekhar2005@gmail.com

Prof. Ashok K. Pundir
National Institute of Industrial Engineering (NITIE)
Mumbai, India
pundir.ashok@gmail.com,
ashokpundir@nite.edu

Prof. L. Ganapathy
National Institute of Industrial Engineering (NITIE)
Mumbai, India
lganapathy@nitie.edu

Prof. N. Sambandam
National Institute of Industrial Engineering (NITIE)
Mumbai, India
samnitie@nite.edu

ABSTRACT

In this era of time-based competition characterized by shrinking delivery times, the ability of the supply chain to respond to and meet the demands of customers while ensuring that the supply side is synchronized with the peaks and troughs on the demand side is clearly of practical importance. The problem becomes more acute in the case of new products due to unknown markets and relatively low volumes, resulting in less than truckload shipments to multiple locations. The problem is more critical for a perishable product with a small shelf life. In this paper, we examine the problem of reducing the shipment costs and transit time based on consolidation of several smaller shipments into a larger vehicle to be transported together. We discuss a case study in a FMCG company for a new product launch with relatively unknown demand and short shelf life. We propose a simple heuristic to illustrate the consolidation of shipments of the new product with those of existing products, resulting in time and cost savings.

Keywords: *New Product Logistics, Flexibility, Shipment Consolidation*

1. Introduction

In this era of time-based competition characterized by shrinking delivery times, the ability of the supply chain to respond to and meet the demands of customers while ensuring that the supply side is synchronized with the peaks and troughs on the demand side is clearly of practical importance. While the importance of time as a

strategy tool to address competition has been recognized since the early days of JIT, it has become more crucial in recent times. Traditionally, businesses have achieved shorter response times by adding to cost of operations. For example, distribution of less than truckloads (LTL) instead of waiting for full truck load (FTL) is one of the costlier options that save time. Third party logistics providers are often willing to provide quicker service for a premium. Such LTL carriers demand higher rates per shipment from customers in return for faster transport and convenient destination.

With a continuous pressure from the customers to reduce costs as well as time, companies can no longer afford to pay more for premium services on a routine basis. Increasingly, this is becoming a difficult problem for many companies. Companies are looking at a variety of opportunities for cost reduction in the logistics function, including the leasing or purchasing costs of vehicles, the fuel energy costs of operating freight vehicles, the cost of additional storage space and the costs of workforce responsible for shipment, storage and handling. In each category, there could be fixed as well as variable costs. For example, there could be fixed costs for each warehouse, worker, vehicle, trip, week, etc. Thus, the fixed costs will accrue due to number of warehouses, workers, vehicles, trips, and so on. Further, in each category there could be variable costs, based on factors like hours of operation, length of trip, etc. that contribute to the total variable cost of operations. Under severe time constraints, companies are looking at strategies that can significantly reduce the fixed and variable costs incurred in logistics without missing deadlines.

This paper looks at one such major cost driver that increases costs with the increase in number of shipments made. The method of reducing the shipment costs is based on consolidation of several smaller shipments into a larger vehicle to be transported together, thus sharing the total cost over a larger number of shipments. This is particularly useful for larger companies that have adequate shipment volumes and can utilize the consolidation strategy to reduce logistics costs.

However, achieving significant cost benefits still needs innovative use of existing facilities. Due to the presence of local and regional hubs in the company's distribution network, a full (or consolidated) truckload often needs to travel through this network with multiple stops. In this situation, a FTL shipment that can be assigned to a dedicated route serving an individual shipment can result in shorter travel times as compared to a LTL shipment that needs to be consolidated by the logistics provider by loads from other clients. Balancing the conflicting requirement of reduced delivery time and cost of logistics requires considerable effort.

There are other disadvantages of a shipment consolidation strategy as well. Most methods of shipment consolidation tend to increase inventory holding time of shipments, and so costs of carrying inventory also go up. Smaller companies have another problem in that they may not have enough shipments ready for consolidation at any given time to justify the large costs of owning and operating their own transportation network. Therefore, smaller companies with limited shipments have to rely on public LTL carriers, who in turn have to consolidate shipments from multiple companies. Such consolidation also increases material handling at multiple locations along the route, increasing chances of damage and misplacements. Considering these risks and costs, a company may opt to own a transportation network that can efficiently acquire the physical resources to significantly decrease logistics cost and transit times and dedicated to sites having limited shipment quantities. This paper

addresses these issues and discusses a case study where shipment consolidation was justified.

2. Literature Review

LTL dispatches contribute to several difficulties in distribution logistics. Some of these are: increased lead time (waiting for FTL), damage in transit (since it will be combined with other unknown LTLs), higher costs (since transporters charge premium rates for LTL), non-availability of right-size trucks, problems in tracking of transit materials, and stockouts (due to variable lead times). This has attracted the attention of researchers because of the practical usefulness in solving such problems.

Significant research in consolidation strategy began in the early 1980's, when consolidation was becoming a practically viable method to significantly decrease costs of delivering shipments. Masters [1980] identified some variables that affect the performance of consolidation practices with respect to both cost and service level considerations. Jackson [1981] studied the effect of the number of hubs, length of maximum holding time and the shipment release strategy on consolidation costs. His study found that consolidation cycle times increased for low-volume systems and longer shipping intervals resulted in lower costs. Cooper [1984] devised performance measures for varying distribution strategies- traditional LTL from a warehouse, consolidated shipments from plants and warehouses, and LTL from plants. Hall [1987] analyzed the consolidation tradeoffs between the benefit of lower transportation charges and the penalties of increased inventory costs, longer vehicle routes, and added terminal operating and ownership costs. He also developed simple optimization procedures to find the minimum-cost network flow from many supply sources to many destinations. Pooley and Stenger [1992] found that 97% of firms that used some sort of consolidation used a multi-stop strategy. Their study also showed that results varied significantly for various firms, and consolidation strategy might be affected by the specific problem instance.

Lium et al. [2006] studied the importance of uncertainty in a service network design problem during the planning phase by investigating the relative behavior of the deterministic and stochastic models. Min et al. [2006] suggest a mixed-integer, nonlinear programming model and a genetic algorithm to solve a reverse logistics problem involving both spatial and temporal consolidation of products returned from online and retail sales. Jian et al. [2007] propose a linear programming (LP) model to solve the routing problem of a real-life LTL carrier to minimize the long-haul cost with constraints of service time, capacities of different vehicles and management rules.

In several studies, reduction of transportation cost and transit time was preferred over reduction of inventory carrying costs. This indicates a tendency towards quicker response in meeting customer demands by carrying higher inventory. The main disadvantages reported were longer order cycle and additional staffing requirements. The most common reported problems were meeting scheduled deliveries, availability of sufficient number of orders for consolidation, wrong or damaged deliveries and educating all key stakeholders- from vendors to customers. The most common reasons for failure of a consolidated shipment were insufficient volume and meeting desired customer service levels.

3. Consolidation Strategy

Many of these issues in consolidation of shipments can be overcome through a robust and responsive supply chain network. Broadly speaking, consolidation refers to the bundling of shipments from multiple sources onto a single vehicle. Thus, consolidation is an approach aimed at maximizing the usage of cubic space on a truck / trailer by collaborating with multiple suppliers so that the right combinations of shipments can be combined into full truckloads. Since such consolidation needs to be done on a continual basis (daily, weekly, monthly, etc.), it will help to have a model in place that can simplify and help in routine consolidation (Fig.1).

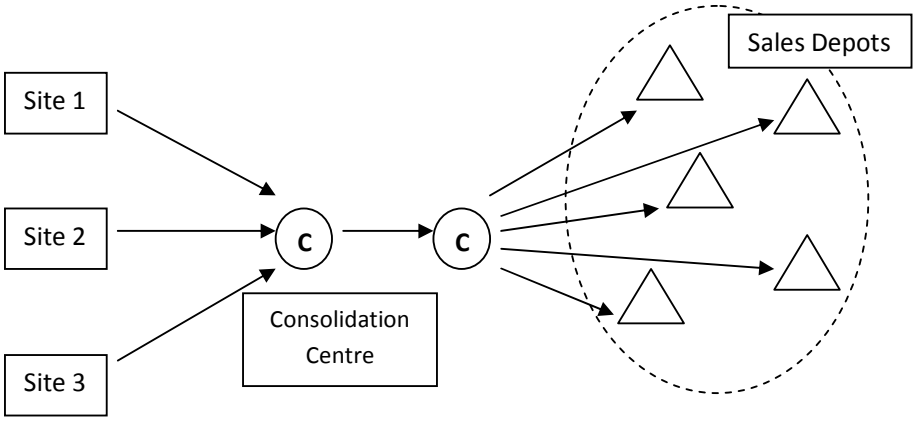

Fig 1: Model for Consolidation of shipments in a network

Broadly, there are three major types of freight consolidation strategies that are practiced by commercial carriers (or third party logistic providers) as well as supplier companies that engage such service providers for LTL shipments. These are route consolidation, time consolidation and facility consolidation. In the route consolidation strategy, the logistics service provider combines LTL shipments that have destinations along a common route. So, the same vehicle can service all the customers on that route. In the time consolidation strategy, multiple LTL shipments with the same destination but ready for dispatch at different times are combined by delaying the early consignments to achieve a FTL shipment. In the facility consolidation, LTL shipments traveling over long routes and having a significant portion of routes in common are consolidated to ensure that FTL shipments travel over the long common route. In such cases LTL may be used for small portion of the route at both the ends that is not shared with other routes. This approach is suitable for many manufacturing companies that do not share logistics with other clients, forming a hub and spoke model of consolidation, transport and distribution.

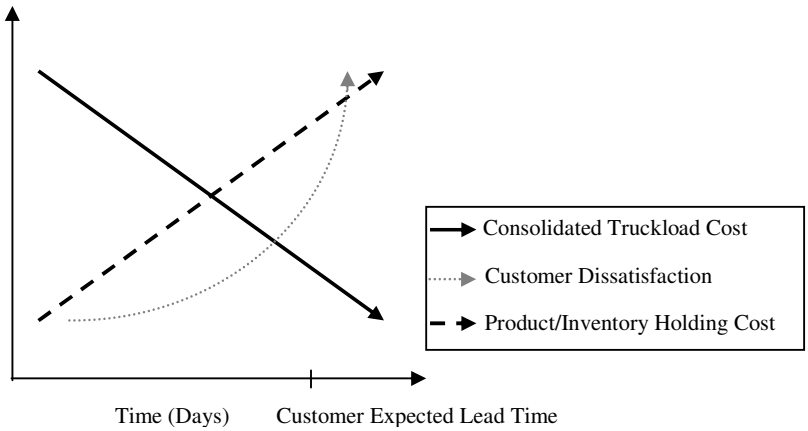

Fig 2: Effect of consolidated shipment waiting time on consolidation performance

(Source: Sean Carr, *Hub Arc Selection for LTL Consolidation*)

A critical issue in consolidation is the availability of adequate volumes at the hub. Otherwise, the LTL shipments will have to wait for additional LTL shipments to arrive to complete the FTL. Adequate volume ensures customer satisfaction, timeliness, and overall lower costs of transport. By better utilizing the capacity of the long haul vehicle, shipments share more of the long haul costs. However, by waiting longer to consolidate more, customers might have to wait longer for their shipments. Therefore, the vendor should incur some sort of customer dissatisfaction penalty. Fig. 2 depicts that consumer dissatisfaction is more prominent when the deliveries are delayed beyond the customer expected lead time.

4. Case Study

4.1 Background

We now discuss a case study of a supply strategy implemented in a FMCG company for a new product. To protect the confidentiality of the company, we do not provide the name of the company, product, or warehouse locations. The company is having ambitious growth plans and is foraying into new products besides the conventional ones to increase its market coverage. To meet these objectives, the supply chain has to be geared up in terms of its structure and processes. The company has launched a new product, which is manufactured by another company on contract basis. While the initial launch requirements (including sales promotion) were met by sending couriers to the depots and arranging for dedicated transportation service, this is not a sustainable cost-effective solution in the long run. Further, being a new product, the dispatch is made on the basis of sales forecasts, and market demand is yet to be established. Since such dispatch is low volume in initial stages, a reliable and cost effective strategy has to be devised for distributing the right quantities, to the right places and at right times. Consolidation of LTL in the case of new product distribution poses an interesting challenge.

The distribution strategy for this new product is devised as follows. In the first stage, distribution is considered only for the major markets. Such markets contribute approximately to three fourths of the total demand and are located at considerable distance from the manufacturing facility (in this case, the contract manufacturer). As pointed out earlier, the requirements of demand for the new product are mostly in

terms of LTLs. So the strategy is aimed at streamlining the LTLs from the new manufacturing facility with the logistics of the existing products using the current distribution network of the company. Currently, the company operates with multiple manufacturing sites, packaging sites and warehouses (one in the North and two in the South). The material that comes at these company owned warehouses does not stay for long and gets shipped immediately to the sales depots, which are located almost one in every state.

4.2 Concerns in Distribution Network

Presently the distribution of this new product is done directly from the (contract) production facility to each of the four regions (North, South, East and West) across the country. The requirements (volumes) at each of the depots in almost all regions are mostly in terms of LTLs. This poses a problem in the efficient and economic delivery of the new product to the depots. The trucks available were of 9T and 15T capacities, having product-specific loadability values. Since the product has been recently launched, in the initial stage, the demand is showing considerable variability as shown in Table 1. Further, being a perishable food product, the shelf life was critical, and it was important to reach the customer as early as possible. These factors cause additional pressure on the supply chain to remain highly responsive to the requirements of customers. Hence, managing the LTL distribution was a main consideration for the company.

	Average Truck Load Variation (Demand)			
	9 T (Min.)	9 T (Max.)	15 T (Min.)	15 T (Max.)
East Region	0.03	0.6	0.02	0.36
South Region	0.28	1.05	0.28	0.63

Table 1: Average LTL requirements of various depots

4.3 Proposed Consolidation Strategy

To cater to the problems related to the distribution of the new product ensuring the service levels as well as optimizing the cost, a supply strategy was devised. The company has two plants P1 and P2 for the existing products, and the new product is being manufactured at another facility, NP. The plan is to consolidate the distribution of the new product with the existing bulk products at a location as follows. It was proposed to club the dispatches from the manufacturing facility to the consolidation station, allowing temporal consolidation of shipments. At the consolidation centre, the new product dispatches are consolidated with existing product dispatches, to make FTL loads for various depot locations. Finally, FTLs are transported from the consolidation station to various depots in East and South region (Fig. 3).

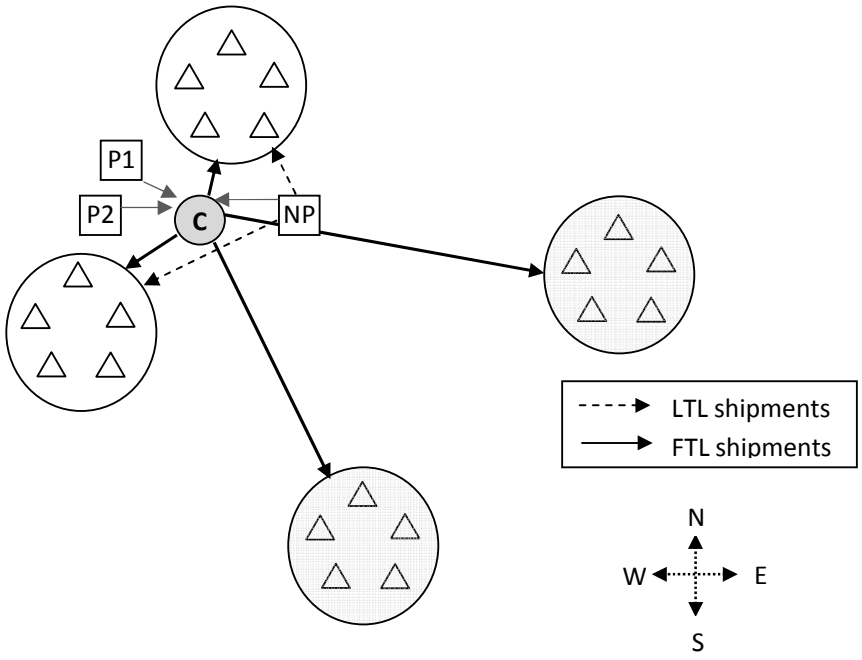

Fig 3: Distribution Network after Consolidation

4.4 Heuristics Methodology

The various locations considered as alternative for a single consolidation station are: A, B, C and D. All of these considered locations have either a warehouse or a depot which can be utilized for the new product also. A heuristic was developed to evaluate these alternatives considering the business requirements. The evaluation of these alternative locations was done on the basis of four major parameters: transit time, transportation cost, warehouse availability, truck availability. Transit time, recorded in number of days, is considered as the time lapsed in sending the product from the production site to the depot. Transportation costs, measured in lakhs of Rupees, include the costs of transportation and material handling. A binary variable is used to denote the presence of a company owned or hired warehouse with sufficient space to accommodate extra volumes of the new product. Another binary variable was used as an indicator for the ease of availability of truck / carrier. It was observed that out of the four parameters considered for evaluation, all were not equally significant. Hence, different weights had to be assigned for these four parameters as shown in Table 2.

Parameter	Weightage (w)
Transit time	0.40
Transportation cost	0.30
Warehouse availability	0.15
Truck availability	0.15

Table 2: Choice of weightages for the parameters

These weightages were obtained by requesting the stakeholders to rate the relative importance of each parameter. Their responses were analysed and the final ratings for various parameters were worked out. It was observed that transit time and transportation costs were more significant than the other two factors i.e. having high weights of 0.4 and 0.3 respectively as compared to 0.15 for warehouse availability and truck availability

The broad steps in the heuristic are now described.

- Each factor was rated on a scale of 0 to 1, where unity is the best value observed by any option and the other options are given rating as a fraction of the best value. This was termed as the observed rating.
- For every factor, the actual rating was calculated as below:
  Actual Rating = Weight * Observed Rating
- Similar ratings were worked out for all the combinations of parameters and locations.
- A total score for each alternative was calculated as a summation of all individual factor scores for that location.

An evaluation matrix is developed to summarize the results of analysis as shown in Table 3. In this table, column I shows the observed (or calculated) value of a parameter and column II shows the converted value of parameter on a relative scale of 0 to 1.

Alternative s		Location A		Location B		Location C		Location D	
Parameters	w	I	II	I	II	I	II	I	II
Transit Time	0.4	12 d	1.0	16 d	0.75	14 d	0.875	13 d	0.8125
Freight Cost	0.3	38 L	1.0	51 L	0.745	85 L	0.447	46 L	0.54
WH Availability	0.15	Yes	1.0	Yes	0	No	0	Yes	1.0
Truck Availability	0.15	Good	0.75	Avg.	0.5	Avg.	0.5	Good	0.75
Total Score (S)	1.0		**0.9625**		**0.5985**		**0.5591**		**0.7495**

Table 3: Consolidation Location Evaluation Matrix

As a result of the above heuristic, location A stood out as the most promising alternative and is selected as the consolidation point for East and South region dispatches in the distribution network of this new product.

4.5 Benefits of Consolidation of shipments

Some of the benefits expected in the proposed distribution network are listed below:

- The supply network was simplified through consolidation, minimizing the complexities and uncertainties in LTL distribution.

- Transit time was reduced by 5 days from 17 days to 12 days.
- Improved stock availability at depots, as FTL distribution is relatively fast and risks associated with LTL distribution are prevented.
- Better truck availability for FTLs as it reduces the complexities for the transporters.
- Less possibilities of stock damages or mix up in transit phase as excessive material handling was prevented.
- Savings in terms of transportation costs were approximately Rs.6 LPA (per KT volume). As the volumes are less in present situation, the cost benefits are not too noteworthy. But they can become significant in the likelihood of increase in demand of this new product in near future.

A dispatch plan was prepared for the distribution from the facility to East & South region. The monthly requirements are clubbed for various depots and sent as FTLs as far as possible to consolidation location. A 9T truck is to be used for these dispatches as LTL carrying approximately 3.2T of the new product. It takes two days (including material handling time at both locations) for these dispatches to reach the consolidation warehouse, where the stock is held for two days and FTLs are built with the bulk products ensuring maximum vehicle space utilization. The FTLs are then dispatched to the regional depots. This has a lead time of 8 to 11 days depending upon the location.

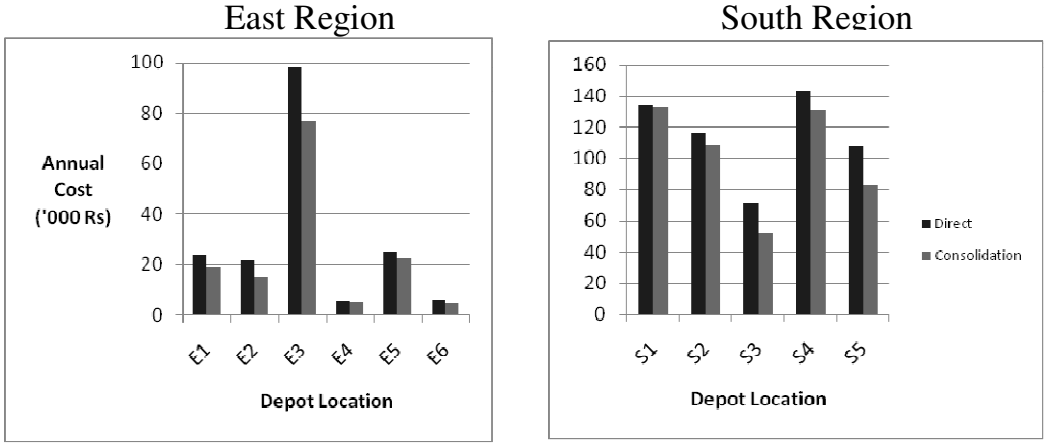

Fig 4: Cost savings (camouflaged) for East & South Depots

The cost analysis (camouflaged) for various depots is shown in Fig. 4. Though the cost savings achieved are not very significant at present, from a practical perspective, these results are very reasonable and encouraging.

5. Conclusions

In this case study, we illustrate the nature of savings obtained using a simple heuristic for shipment consolidation. For complex systems involving more number of plants and depots, one can use specialized algorithms, such as vehicle routing algorithms or linear programming models, to obtain optimal solutions considering the intricacies. We must also be aware of the limitations of this approach in the context of LTL shipping. The stochastic, random, and intermittent nature of demand significantly affects the ability to consolidate enough shipments within a given time frame without excessive waiting time. For example, some time periods will require

more vehicles than others due to demand spikes or seasonality. Likewise, LTL shipment composition and properties also behave randomly, which affects the potential to fully utilize consolidated truckloads. Even if one configures an optimal design, it will not always operate optimally due to changing demands over time, and the savings may taper off. As markets and demands change, the configuration of the consolidation network should change as well. Therefore, the network needs to be reevaluated dynamically with updated data. The main value of our solution approach is in determining the most beneficial set of hubs that result in highest transit time and cost savings through shipment consolidation. The proposed approach is useful particularly at a strategic level for new product launches with relatively unknown demand.

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