# SOME PRACTICAL ISSUES ON MODELING TRANSPORT.

Gabriela Gaviño Ortiz, M. Liliana Antonia Mendoza Gutierrez, Rodolfo Espíndola Heredia and Enoc Gutiérrez Pallares
Unidad Académica y Profesional de Cuautitlán Izcalli.
Universidad Autónoma del Estado de México

**ABSTRACT**
We present a mathematical model, which is considered a strategic alliance of two or more companies that hire and subcontract respectively, a service charge. It is considered a cost function to consider amending the alliance, justifies the need for the alliance and observed decrease in costs to service users.

**KEYWORD**s: Modeling and interdisciplinarity, Operations research,

**MSC:** 00B55, 97M10, 97M40

**RESUMEN**
Presentamos un modelo matemático el cual considera una alianza estratégica entre dos o más compañías que son contratadas y subcontratadas para un servicio de transporte de carga, el modelo considera una función de costo que toma en cuenta la alianza, justificamos la necesidad de la alianza y mostramos un decremento en el costo por el servicio de varios usuarios.

## 1. INTRODUCTION

Logistics is an application area of management and mathematics, which studies the different logistics systems, it is dedicated to design and manage transportation systems, to manage the flow of information and materials throughout the supply chain from the suppliers to the end user. Their goal is to create competitive advantages that enable an organization to successfully insert successfully to an increasingly globalized market.

A fact that has characterized the freight system in recent years has been the emergence of companies dedicated exclusively to transport services (Baumann, 2006), 3PL logistics operators (third part logistics). In traditional distribution networks, a production company organizes and manages its own transport, so that makes transport shipments from a limited number of its production to each customer or market. However, the inefficiencies of these networks by asymmetries of shipments, its temporal variation or high investment costs required for vehicles or resources have been outsourcing the distribution of its products to third parties. These subcontractors will provide their transportation and distribution services to various production companies, so that the same course or route of transport may be shared by multiple clients. The direct effect of this mode of operation and service is the ability to consolidate a greater amount of charge on each route of the network, making it feasible to use large capacity vehicles and lower unit costs. (M. Estrada, 2007).

Communication systems have experienced in the last twenty years, an astonishing progress. It has contributed in this advance in electronics, as well as increasing the scope of the networks through which information flows, and favored by the development of satellites and communications.

In this regard, networks and services, timing and intervals of transmission, are adjusted so that the total capacity of the vehicle is occupied by the goods or shipment. This type of service is known as Full Truckload (FTL). (Estrada, 2009).

These transportation services are considered as a resource management problem, since it is difficult to predict and temporarily adjust the shipping demands and requests, specifically, their empty returns the target point to the origin, which is for the company a high cost, and without productivity and profitability for the carrier.

By taking into account the above conditions, it becomes necessary to develop a mathematical model of logistics, which optimizes resources throughout the supply chain, to consider the establishment of strategic alliances between companies to achieve greater coverage, reduced logistics costs, increasing the response capacity and meet the needs of customers.

This paper is organized as follows: in principle show an initial proposal that our mathematical model is developed from the cost function for a single transportation (LD Burns et Al. 1985), which occurs from a point source to a point sink, with one stop. In Section 2, we incorporate the information needed to develop the model, about the cost function as well as the ratios used for its construction, then in section 3, we add the concepts used to study the proposed problem, then section 4 we present and discuss our model obtained so far, and finally in the last section present our main conclusions. In the appendix we make a simple hypothetical exercise to show the effectiveness of the model.

## 2. THEORY

For a property that is different additive components such as mass, volume, etc. It can be defined according to the following expression:

$$P_t = \sum_{i=1}^{n} P_i \tag{1}$$

The fractions associated with different components shall be as follows:

$$f_i = \frac{P_i}{P_t} \tag{2}$$

With the normalization property:

$$\sum_{i=1}^{n} f_i = 1 \tag{3}$$

In (LD Burns et al. 1985), it determines the structure of transportation costs for direct shipments where we make a stop for merchandise, the shipping cost of transport can be decomposed into several terms and express it as follows:

$$F = \gamma + \sigma + \alpha D \tag{4}$$

Where γ is the fixed cost of starting a consignment (€ / load), σ the fixed cost of a stop (€ / stop), α transport cost per unit length (€ / km), D shipping distance between the point of production and point of delivery. Regarding inventory costs, they depend on the time between production and consumption by customers. According to the following expression:

$$Z = F + PR + \left(\frac{V^2}{Q} + V\tau\right) \tag{5}$$

Where Q is the flow (ton / day), □ = travel time through the arch (day), R is the money price of the material in inventory (€ / €-day), P is the value of the unit goods transported (€ / ton)

## 3. METHODOLOGY

The proposed transport model in operations research, involves a number of sources, e.g. (m), where you are required to send a certain number products (u), to a final destination number (n), which receive a product number (v) other than generally sent by a source in general. This model provides the fundamental idea as to shipping cargo through different alternatives in seeking to minimize costs, of course, the actual demand can be much more complex than the linear programming model.

The demand service directly influences the diversity of strategies to cover the demand points, network storage, consolidation centers and other logistics business The optimal strategy for a distribution system responds to the balance of the various logistics costs involved, for example, transportation costs, inventory costs (both "origin and destination" or like product), handling costs and amortization associated with storage and consolidation centers. There are basic strategies that are used to plan a given distribution system, and is set forth below:

Direct shipments (many-to-many): It is the transport model proposed by operations research in its purest applicability This strategy supports some distance to travel, a large number of vehicles for distribution, so it is only considered when the vehicle service costs (F) are reduced or when the associated demand between all source and sink-points fill the capacity of the vehicle or when the temporal constraints of the problem have significant importance (M. Estrada, 2009)

Shipping hub-&-spoke In this kind of strategy enables the location of freight consolidation centers, which are called hubs (Rodriguez, 2002), Which allows merchandise concentration in the central and then be sent to their final destination. Optimizes vehicle capacity in places where the spatial distribution of demand is not uniform at these points. It also allows to increase the load factor of the vehicles and therefore reduces the unit cost of transportation to the general level of the entire network as well as the total time of the distribution. (Campbell, 1997)

Shipments with multiple stops The application of this strategy allows a comparatively small number of paths composed of a large number of stops in each of them .It´s application can be performed when the cost and time to make an additional stop on a route are reduced and in scenarios with reduced service costs of vehicle F are relatively high.

However, when the demand for goods between origin and destination exceeds the vehicle capacity, the goods can be divided or split into individual items associated with different routes to meet the capacity constraint In these cases, as with a cargo shipments well below capacity, there will be at least one vehicle that present a low occupancy, not use its full potential for transport. These cases, known as Less Than Truckload (LTL) constitute a strategic field for applying consolidation strategies (Estrada, 2009)

## 4. RESULTS

### 4.1 Model

Our model takes as a starting point, a strategy many-to-many, where considered one shipment between a point source and a point sink. In this submission is considered a procedure LTL, which from equation (5), which is the cost function given by (LD Burns et Al. 1985), we seek a new cost function which implicitly considers the alliance strategic freight transport.

The expressions given by (4 and 5) represent the cost of shipment from an origin to a destination or source or sink, making one stop to reach the destination, all merchandise shares the same fate and is single transport user.

Our model proposes a series of strategic alliances to reduce costs for transportation of cargo goods, we suppose that we have at least two companies within the strategic alliance, sharing transportation service. The first one uses a higher volume than the second business use, but not cover the entire container transport volume. The gain for the carrier is independent of fill or not fill the entire space.

An alliance between at least two companies that need to transport, represents a reduction in the cost for the first user and the second subcontractor savings. The problem is analyzed in two cases presented below:

### 4.2 Case 1

The cost for transportation start $\gamma$ is absorbed by the company contracting in the first instance. The cost per stop, as well as the transportation cost per unit charge, must be shared by the companies that maintain the alliance, therefore states that:

$$\sigma_a = \sum_{i=1}^{n} V_{f_i}\,\sigma \tag{6}$$

where we have used the form of the expression (2), considering the fraction of the volume occupied by each of the companies in the container, within the strategic alliance

In this case, it is considered that if the total available space is fully occupied with the products of the companies in the alliance, the empty space must be paid by the companies that subcontract, for it modifies the expression (6) being as follows:

$$\sigma_a = \left(V_{f_1} + \sum_{i=2}^{n} V_{f_i} + \frac{1}{n-1} V_{f_r}\right)\sigma \tag{7}$$

Where n ≥ 2, the case n = 1, is shown in the expression (4) and represents a limiting case of the expressions (6) and (7), $V_{fr}$ represents the void volume fraction in the container loading, which is expressed as follows:

$$V = V_t - \sum_{i=1}^{n} V_i \tag{8}$$

In such a way that if the sum of the volume fractions of companies, occupy the whole of the container, then $V_r = 0$. $V_{fr}$ is defined

$$V_{f_r} = \frac{V_t - \sum_{i=1}^{n} V_i}{V_t} = 1 - \sum_{i=1}^{n} V_{f_i} \tag{9}$$

The expression (7) implies a decrease in the fixed cost per stop for the case of initial contracting the service, who in turn absorbs initial shipping cost, just as, we obtain a lower cost to the subcontractors that are within strategic alliance and a constant gain, i.e. without loss to the carrier.
Clearly, if the next term is the cost $\alpha_a$ which corresponds to transport per unit length, should be shared between the initial contracting and subcontracting service, the expression is similar to equation (7) and $\alpha_a$ is expressed as follows

$$\alpha_a = \left(V_{f_1} + \sum_{i=2}^{n} V_{f_i} + \frac{1}{n-1} V_{f_r}\right)\alpha \tag{10}$$

Finally the total cost is expressed as follows:

$$F_a = \gamma + \sigma_a + \alpha_a D \tag{11}$$

**4.3 Case 2**

This is considered to start shipping cost is shared by all users of the service, then the first term we have:

$$\gamma_a = \sum_{i=1}^{n} V_{f_i}\gamma \tag{12}$$

term representing a decrease in cost for the initial contracting and subsequent savings for service contracting in the strategic alliance.
However, it is necessary to assume as in Case 1, that not all of the entire space is occupied by all the parties, which would produce a remaining volume should charge carrier equally by the parties, then, to make use of the expressions (8 and 9) and considering that the volume fraction remaining to be paid by all the contracting of service and be added to the corresponding fraction of the volume occupied, we obtain:

$$\gamma_a = \sum_{i=1}^{n} \left(V_{f_i} + \frac{1}{n} V_{f_r}\right)\gamma \tag{13}$$

$$\gamma_a = \sum_{i=1}^{n} \left(V_{f_i} + \frac{1}{n}\left[1 - \sum_{j=1}^{n} V_{f_j}\right]\right) \tag{14}$$

where it is clear that for *n=1*, we recover the original expression for a single user service, this is $\gamma_a = \gamma$, similarly, treatment for$\sigma$and for $\sigma$ have the same shape as costs are divided in the same proportion, then define the function $\psi$ of the amount that is indicated in the expression (14), it is:

$$\psi = \sum_{i=1}^{n} \left(V_{f_i} + \frac{1}{n}\left[1 - \sum_{j=1}^{n} V_{f_j}\right]\right) \tag{15}$$

and we get the following result:

$$F_a = \psi F \tag{16}$$

which implies that:

$$F_a = \sum_{i=1}^{n} \left(V_{f_i} + \frac{1}{n}\left[1 - \sum_{j=1}^{n} V_{f_j}\right]\right) F \tag{17}$$

**5. CONCLUSIONS**

The model presented is based on the classic transportation problem with one source and one destination. Until now consider the costs shared by a contractor and multiple subcontractors, considering or not filling all available space for loading and representing a saving for both users of the service, provided that the source and destination is shared. It also preserves the gain for the carrier.
Currently we are in a position to propose and deliver meaningful results for cases where there exists only one stop, i.e. if we could extend the hub or Peddling case where part of the goods need to be transported from a central service to its final destination, representing a network of services and type of treatment is Hub & Spoke.
Also the immediate step is to assign even more value to the expressions (11 and 17) to consider the need for inventory cost at the fixed points, i.e. when the goods are at the point source, during transit and upon reaching his final destination, obviously considering the inventory involves an increase in the cost to be included within the strategic alliance signed by the companies.

**Acknowledgements:** The authors wish to express their gratitude to the Universidad Autónoma del Estado de México, particularly the Unidad Académica y Profesional de Cuautitlán Izcalli and especially to the coordinator, for the facilities provided during the course of this work.

**RECEIVED MAY , 2013**
**REVISED OCTOBER, 2013**

## REFERENCES

[1] BAUMANN, K. (2006): **Third-Party Logistics Market Research and Consulting Services**.Maves International Software: President's Executive Council.

[2] BURNS L. D., HALL R. W., BLUMENFELD D. E., DAGANZO C. F.( 1985): Distribution Strategies that Minimize Transportation and Inventory Costs. **Journal: Operations Research** , . 33, 469-490,

[3] CAMPBELl, J. F. (1997): Hub location and the p-hub median problem. *Location Science* 5, 3 203-203.

[4] ESTRADA ROMEU, M.. . (2007): **Análisis de estrategias eficientes en la logística de distribución de paquetería.**

[5] ESTRADA M., and F. ROBUSTÉ. 2009): Long-Haul Shipment Optimization for Less-Than-Truckload Carriers. **Transportation Research Record: Journal of the Transportation Research Board** 2091, 12-20.

[6] RODRIGUEZ, M. V. (2002): **Metodología para determinar la ubicación de hubs con capacidad limitada**. PhD diss., Tesis Doctoral, Tecnun, Universidad de Navarra,.

## APPENDIX

**Case1**

$$V_1 = \frac{3}{6}V_T ; V_2 = \frac{2}{6}V_T ; V_r = \frac{1}{6}V_T \text{(A1)}$$

Then

$$\sigma_a = \frac{1}{V_T}\left(\frac{3}{6}V_T + \frac{2}{6}V_T + \frac{1}{2-1}\left(\frac{1}{6}V_T\right)\right)\sigma \tag{A2}$$

$$\sigma_a = \left(\frac{3}{6} + \frac{2}{6} + \frac{1}{1}\left(\frac{1}{6}\right)\right)\sigma \tag{A3}$$

$$\sigma_a = (1)\sigma \tag{A4}$$

However, the cost for the first contractor according to the expression (11) is written as:

$$F_1 = \gamma + \frac{3}{6}\sigma + \frac{3}{6}\alpha D \tag{A5}$$

And subcontractor cost is expressed as follows

$$F_2 = \frac{3}{6}\sigma + \frac{3}{6}\alpha D \tag{A6}$$

In such a way that adding (A5 A6) is recovered (4) expression to take as base.
We now consider an example where the first contracting occupies 3/6 of the container, with a first sub-contractor using 2/6 and a third subcontractor occupying 1/12 of the volume, for the expression (17) of the second case where there is 1/12 of the total volume unoccupied.

**Case2**

$$V_1 = \frac{3}{6}V_T ;\ V_2 = \frac{2}{6}V_T ; \tag{A8}$$

$$V_3 = \frac{1}{12}V_T ;\ V_r = \frac{1}{12}V_T ; \tag{A9}$$

Then

$$\gamma_a = \frac{\gamma}{V_T}\left(\frac{3}{6}V_T + \frac{1}{3}\left(\frac{1}{12}V_T\right) + \frac{2}{6}V_T + \frac{1}{3}\left(\frac{1}{12}V_T\right) + \frac{1}{12}V_T + \frac{1}{3}\left(\frac{1}{12}V_T\right)\right) \tag{A10}$$

$$\gamma_a = \left(\frac{3}{6} + \frac{1}{3}\left(\frac{1}{12}\right) + \frac{2}{6} + \frac{1}{3}\left(\frac{1}{12}\right) + \frac{1}{12} + \frac{1}{3}\left(\frac{1}{12}\right)\right)\gamma \qquad \text{(A11)}$$

$$\gamma_a = \left(\frac{3}{6} + \frac{2}{6} + \frac{1}{12} + \frac{1}{12}\right)\gamma = \left(\frac{3}{6} + \frac{2}{6} + \frac{1}{6}\right)\gamma \qquad \text{(A12)}$$

$$\gamma_a = (1)\gamma \qquad \text{(A13)}$$

Similarly, equation (17) can be displayed which is obtained:

$$F_{1_a} = \left(\frac{3}{6} + \frac{1}{3}\left[1 - \left(\frac{3}{6} + \frac{2}{6} + \frac{1}{12}\right)\right]\right)F \qquad \text{(A15)}$$

$$F_{1_a} = \left(\frac{3}{6} + \frac{1}{3}\left[\frac{1}{12}\right]\right)F \qquad \text{(A16)}$$

$$F_{1_a} = \left(\frac{18}{36} + \frac{1}{36}\right)F \qquad \text{(A17)}$$

$$F_{1_a} = \frac{19}{36}F \qquad \text{(A18)}$$

Thus

$$F_{2_a} = \left(\frac{12}{36} + \frac{1}{36}\right)F \qquad \text{(A19)}$$

$$F_{2_a} = \frac{13}{36}F \qquad \text{(A20)}$$

And finally

$$F_{3_a} = \left(\frac{3}{36} + \frac{1}{36}\right)F \qquad \text{(A21)}$$

$$F_{3_a} = \frac{4}{36}F \qquad \text{(A22)}$$

What would represent 52.78% of the cost for the first contracting a 36.11% of the total cost for the second contractor 11.11% of the cost for the third contractor, also translates into savings for the first contractor for 47.22% and gain of 100 % for the carrier.