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Groupage transportation cost model

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Abstract

Today it is very common to use freight groupage to collect or deliver products. Even in the management of services routing problems are often used to optimize the mission of the operators. The estimate of actual costs is complex and influenced by many variables, so the authors suggest a new approach easy to apply in real cases.

Keywords: transportation costs, cost-to-serve, cost allocation, routing problems, groupage.

1. Introduction

Economies in road haulage transportation are often greatly related to distances, costumers density, trucks load rate and capacity, product characteristics, i.e. volume, value, quantity etc. (Carter and Ferrin, 1995; Caputo et al., 2005; Sahin et al., 2009; Creazza ret al., 2010). Freight groupage is an effective method for achieving cost savings in the delivery of large product variety in low quantities, by consolidating multiple consignments into one large transport load. In this context, one of the most important aspects to be controlled is the cost of the transportation service adsorbed by each delivery point. Each supplied delivery point, in fact, differently contribute to the construction of the overall transportation cost. Due to

determine an optimal transportation management, inefficiencies and costs need to be correctly identified, in order to clearly understand profit margins linked to each customer/delivery point. This paper proposes a new simple theoretical model for transportation cost allocation purposes, by exploiting the well-know “cost-to-serve” concept. By applying the model here proposed, a company is continuously aware of current profit margins and is quantitatively supported in strategic choices and daily distribution planning activities. The model, by considering a large set of delivery routes performed in a given period of time, is able to take into account the synergies between points visited by the same vehicle, thus finally lead to a satisfactory cost-to-serve estimation.

2. Literature review

“Cost-to-serve” has become a common expression which is related to the need of understanding the total cost of servicing customers. This may help companies in their sales and marketing activities as well as in their distribution planning activities. Various authors have emphasized the relevance of measuring customer-service costs (e.g. Blattberg and Deighton, 1996; Anderson et al., 1997): especially when profitability is low, the management of resources related to customer service can have a significant impact on business results. In literature, some studies emphasize how customer-service costs and logistics activities are closely related (Lambert and Lewis, 1983; Lambert and Burduroglu, 2000; Cokins, 2003). Most companies fail to recognise the true profitability of their customer. Traditional reporting methods aggregate revenues and costs, to the extent that poorly performing deliveries are hidden from view (Lewczuk and Wasiak, 2011).

With a cost-to-serve computation, a company has the opportunity to have quantitative data to negotiate terms with major customers, to modify distribution modes/service, to revisit routing and delivery quantity decisions, to assist in marketing actions to new customers, to achieve

new consciousness for pricing determination, to improve customer profitability as well as improve processes.

However, having even a modest idea about how much it costs to serve customers is not an easy task (Braithwaite and Samakh, 1998; Norek and Pohlen, 2001). Given these circumstances, many managers and operatives report that they necessitate a reliable tool to establish the effects of customers' cost on profitability (Norek and Pohlen, 2001).

The material delivery is an important decision problem especially related to efficiency of vehicles usage and flexibility of transportation services. At the same time, the Vehicle Routing Problem (VRP) usually aims at routing a fleet of vehicles on a given network to serve a set of delivery points under certain constraints (Cordeau et al., 2007; Golden et al., 2008). To do so, the linear programming approach has been commonly proposed by literature, together with a wide offer of sophisticated software for routing optimization. The traditional objective of the VRP are usually related with minimizing the total distance traveled by all vehicles or minimizing the overall travel cost: this often results in high saturated vehicles serving a well defined and dense set of clients, but it risks to fail in analyzing whether a delivery is really convenient, thus if minimized costs are actually lower than profit margins. In fact, if the distribution component fee is smaller than the actual cost-to-serve, for instance, profit margins will be smaller or even negative.

A new quantitative theoretical model is here developed: it highlights that road distribution network management may achieve great benefits by correctly allocating transportation costs to delivery points and then, by identifying critical customers, thus making use of service-cost information and customer-profitability analysis. Cost-to-serve information may be used in different situation: the model may both quantitatively assess the effects of the adopted transportation decisions and support in solving daily routing problems (e.g. prioritizing deliveries in case of unforeseen product shortages) and optimizing the shipping strategies. From a marketing point of view, cost-to-serve can also be used to identify critical or first-

class costumers as well as areas, enabling to focus on “high cost-to-serve areas”, on one side, hoping to add additional customer to drive down the cost-to-serve per costumer, and on “low cost-to-serve areas”, on the other side, aiming to acquire new clients.

Cost allocation is here achieved through a method of computation easily applicable to real world contests. As highlighted in Savelsbergh (2009), the “devil” in cost-to-serve computation is often in the detail: the model proposed in this work offer an easy to use methodology able to estimate consistent results in different kind of distribution network.

3. Theoretical formulation

The mathematical formulation that follows proposes a new approach for transportation cost allocation purposes, i.e. the “cost-to-serve” a certain delivery point from a transportation point of view. As previously mentioned, the model is based on allocating transportation services costs to the carrier’s clients, aiming to find actual share of clients in total costs, identify real margins, critical clients and drive optimization actions. The allocation can be driven either by the product quantity which concur to load the vehicle or by the delivered product value.

First, we introduce the notations used in the paper as follows:

$I = \{1,2,\dots,i,\dots I\}$	set of delivery points
$J = \{1,2,\dots,j,\dots J\}$	set of employed routes
$P_i(a_i, b_i)$	generic delivery points with coordinate (a_i, b_i)
R_j	generic employed route
Q_{ij}	material quantity delivered to costumer i during route j [kg, m, m ³ ...]
V_{ij}	monetary value delivered to costumer i during route j [€ \$, ..]
d_j	distance related to route j [km, miles, ..]
C_j	transportation cost related to route j [€ \$, ..]

T_j	time related to travel route j [hours]
N_j	number of clients served during route j
C_{ij}^Q	transportation cost per delivery point i during route j allocated by means of carried quantities [€/delivery point]
C_{ij}^V	transportation cost per delivery point i during route j allocated by means of carried monetary value [€/delivery point]
c_{km}	transport cost per kilometer: this is often a function of the distance range and vehicle type [€/km]
c_{op}	operator cost per unit of time [€/h]
c_{ij}^Q	specific transportation cost per delivery point i during route j allocated by means of carried quantities [€/unit delivery point]
c_{ij}^V	transportation cost rate per delivery point i during route j [%]
\overline{C}_i^Q	average transportation cost per delivery point i allocated by means of carried quantities [€/delivery point]
\overline{C}_i^V	average transportation cost per delivery point i allocated by means of carried monetary value [€/delivery point]

The first formula is an expression of the mean delivery point cost in function of the product quantity averagely sent. The second one can be interpreted as a percentage.

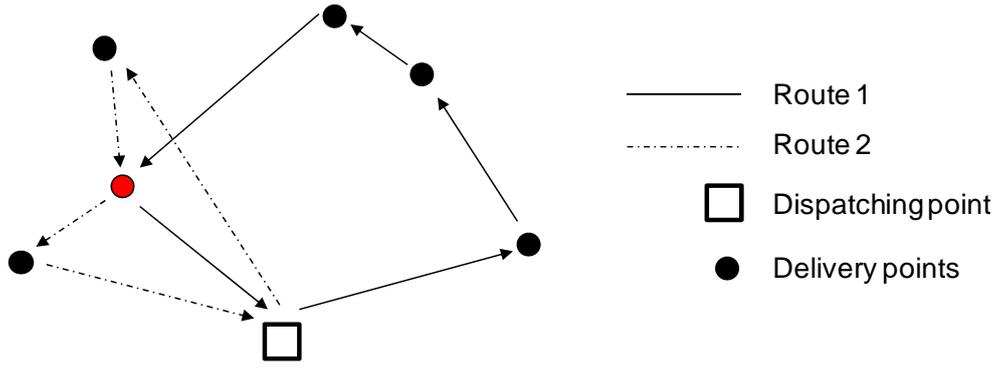


Figure 1 – General distribution structure with one depot and different daily delivery routes

Let $I = \{1, 2, \dots, i, \dots, I\}$ be the set of delivery points served by the carrier. We assume a generic delivery point P_i is placed on a two-dimensional plane with real location $P_i(a_i, b_i)$.

Receiving points are assigned to routes grouping them according to geographical direction and distance. A number of J routes (performed by the company in a give time period T) is given as a set $J = \{1, 2, \dots, j, \dots, J\}$.

Each route begins and ends at central depot “0” (Fig. 1). Material quantity and material value delivered to a costumer i by a route j can be expressed as follows:

$$V_{ij} = \begin{cases} V_{ij} & se \ V_{ij} \geq 0 \\ 0 & se \ V_{ij} = 0 \end{cases}$$

and

$$Q_{ij} = \begin{cases} Q_{ij} & se \ Q_{ij} \geq 0 \\ 0 & se \ Q_{ij} = 0 \end{cases}$$

The unit of measure for the quantity is trivial (i.e. kg, m³, tons, etc.).

The generic route j should be a function of delivered material value, delivered material quantity, travel distance, transportation costs, transportation time and the number of clients being served. Thus:

$$R_j = f(V_{ij}, Q_{ij}, d_j, C_j, T_j, N_j)$$

Transportation costs related to a generic route j , certainly depends on many factors, consisting of fixed and variable costs (i.e. dependent on mileage and time). In order to determine the actual share of each client to those costs, a new approach is proposed, based on the allocation of them in terms of product quantity or value transported for a certain client .

Due to keep the model simple and rapid to compute, we assume transportation cost related to route j as dependent on two main dimension, which are usually the most significant, such as cost related to traveled distance and cost related to the operator salary (the driver of a vehicle is paid at a wage of c_{op} per unit time (i.e. per hour); being T_j the total time a driver spends on a tour, the total operator cost can then be expressed as $c_{op} \cdot T_j$).

Thus, without losing generality, we can express such a cost as:

$$C_{ij}^Q = \left(c_{km} \frac{d_j}{N_j} + c_{op} \frac{T_j}{N_j} \right) \frac{Q_{ij}}{Q_j}$$

or

$$C_{ij}^V = \left(c_{km} \frac{d_j}{N_j} + c_{op} \frac{T_j}{N_j} \right) \frac{V_{ij}}{V_j}$$

A specific transportation cost per delivery point i during route j allocated by means of carried quantities can also be expressed as:

$$c_{ij}^Q = \frac{C_{ij}^Q}{Q_{ij}}$$

At the same time, transportation cost rate per delivery point i during route j results:

$$c_{ij}^V = \frac{C_{ij}^V}{V_{ij}}$$

Thus, the average cost-to-serve can be allocated to the generic point P_i , through either one of the following formula:

$$\overline{C_i^Q} = \frac{\sum_j c_{ij}^Q \cdot Q_{ij}}{\sum_j Q_{ij}}$$

$$\overline{C_i^V} = \frac{\sum_j c_{ij}^V \cdot V_{ij}}{\sum_j V_{ij}}$$

The first formula is an expression of the mean delivery point cost in function of the product quantity averagely sent. The second one is the average transportation cost per delivery point i allocated by means of carried monetary value.

This approach helps shifting from traditional accounting measures of cost and profitability to a more logistics focused measure of the true cost and profitability of service. Thus, the present paper shows by a simple and easy-to-use approach a computation method capable of calculating a transportation cost per delivery point: the purpose is to achieve a method of computation easily applicable to real world contests. The model may both quantitatively assess the effects of the adopted transportation decisions and support in solving daily routing problems and optimizing the shipping strategies.

4. Conclusions

The paper introduces a theoretical model for allocating transportation cost to a company's delivery points, calculating the "cost-to-serve" a single customer. This is done taking into consideration either the delivered product quantity or its value. To do so, historical data representing deliveries over a significant period of time are analyzed and employed in the proposed computation model, accomplishing a quantification of a cost per client. The achievement of this information brings with it very helpful outcomes. In particular, it helps:

1. creating awareness and sensibility to the criticality of the problem;
2. identifying real company margins and critical/virtuous customers;

3. cost controlling activities;
4. taking real-time decisions, since it facilitates grasping possible consequences in terms of costs;
5. achieving a tool helpful as a means of negotiation with customers;
6. overcome the traditional considerations related to vehicle saturation, which may result misleading especially if coupled with goods characterized by a relative low monetary value (i.e. emphasis on vehicle saturation requirement, do not guarantee positive profit margins).

Thus, the novelty of the approach lies in the diagnostic capabilities of the instrument and in the provided insights about the transportation management. It may be useful for cost-control planning purposes and may lead to revise and optimize routing decisions, shipment consolidation policies, service levels actually granted to each customer and might also guide to other related strategies such as the definition of a minimum purchase quantity, the implementation of promotional strategies to increase the average orders quantity and so on. The model application might be easily extended also to service management problems, where operators have to visit different customers with different locations for providing services, i.e. maintenance interventions.

Further research should be addressed to the development of a dynamic system, enabling operators to see costs to serve delivery points updating in real time. This would lead to an even better awareness of the effects of their daily activities, acting like a precious aid to rapid and difficult real time decisions, such as the outsourcing of most critical and costly deliveries. The presented approach could also be extended, incorporating new logistics costs other than transport, such as picking, loading and unloading activities. Moreover, customer synergies, such as their geographical density and distribution could be emphasized in the model.

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