Criteria for decision-making in Transportation Logistics Function
Multicriteria Decision Network for transport logistics costing and level service

Johanna Trujillo Díaz (Author)
Industrial Engineering Program. Faculty of Engineering.
Catholic University of Colombia
Bogotá D.C., Colombia
jtrujillo@ucatolica.edu.co

Mario Martínez Rojas (Author)
Systems Engineering Program. Faculty of Engineering.
Catholic University of Colombia
Bogotá D.C., Colombia
mmartinez@ucatolica.edu.co

Carlos Franco Franco (Author)
Industrial Engineering Program. Faculty of Engineering.
Catholic University of Colombia
Bogotá D.C., Colombia
cafranco@ucatolica.edu.co

Andrés Tarcisio Velásquez Contreras (Author)
Industrial Engineering Program. Faculty of Engineering.
Catholic University of Colombia
Bogotá D.C., Colombia
atvelasquez@ucatolica.edu.co

Holman Bolívar (Author)
Systems Engineering Program. Faculty of Engineering.
Catholic University of Colombia
Bogotá D.C., Colombia
hdbolivar@ucatolica.edu.co

Jaime Fernando Pérez González (Author)
Systems Engineering Program. Faculty of Engineering.
Catholic University of Colombia
Bogotá D.C., Colombia
jfperez@ucatolica.edu.co

Abstract—This paper presents the first phase of a methodology for making decisions in transportation for the Supply Chain (SC), in the first part is presented the importance of transactional costs in transportation and the decision levels. Then the interrelationships and dependencies are shown for criteria in Transportation Logistics Function (TLF). Finally, is presented the design of the Multicriteria Decision Network (MCDN), used to support decision-making by managers of goods and transportation companies for modes or carriers selection in the Supply Chain, together with theirs concepts for to standardize the criteria from the literature review.

Keywords—transportation, criterion, multicriteria decision making, decision levels, network multicriteria network decision

I. INTRODUCTION

A. Supply Chain and logistics

There is a difference between Supply Chain Management (SCM) concept and the traditional concept of logistics.

The logistics is a set of management activities, implementation and control in the Supply Chain (SC) that generate value to a product or service at any echelons of the SC: supplying, production and distribution. In these echelons are expected to be lean logistics, efficient and effective functions: a) planning service technology; communications and infrastructure; b) management of demand and supply; c) storage and inventory management; d) production of goods and/or services, e) internal and external handling of materials, products and/or services; f) transportation [1-4], seeking to maximize the total value generated form a product or service [5] (see Figure 1), service level (in time and place) [1, 5-9] and minimizing transaction costs [1, 7-14].

The logistics integrated vertically the SC exists in the distribution channel vertical integration forward the client, find the timing of production and marketing processes; and the supplying channel forwards with suppliers synchronizing procurement processes and production [14].

Supply Chain Management (SCM), is an acronym in English recognizes that each firm or company is a net with three echelons and six logistics functions. The SCM is composed for two or more SC as a collaborative network that unite their efforts to coordinate logistics functions in order to deliver products and/or services to the level of market expectations [4], minimize costs [15], maximize the benefit of the formation of the network and the combined activities of logistics functions by strengthening marketing activities, research and development (R & D), financial and customer service [4].

B. Levels of decision Logistics Function of Transportation (TLF) for SC

In the TLF planning levels [16] are as three levels of decision: strategic, tactical and operational [7, 16, 17], which involve physical and human aspects (static and dynamic) [13]. In the TLF the dynamic actors are CS: users, non-users [18] and carriers [13]. The decision levels for TLF defined are:
Strategic (long-term) implies the highest level in the design management policies and tariff guidelines, development and operation; can be international, national and regional. Includes physical network design, procurement and resource allocation, evolution or improvement. At company level, planning usually involves the highest level, requires large capital investments in long-term term [7, 16] usually is given by the managers or governmental directors.

Tactical (medium-term), determines the objectives, rules, limits, an efficient allocation and use of resources to achieve the best possible performance of the entire system (routes, rates, hours of service, vehicle fleet replacement, etc.) [7, 16]. The transportation is the most important tactical problem of SCM [19, 20].

Operational (short-term), is carried out by dispatchers who handle the courtyards; their main concern is the time and operational decisions; implementation and adaptation of hours of services, equipment, maintenance activities, issuance and delivery of vehicles and equipment, dynamic allocation of scarce resources [7, 16].

II. TRANSPORT AS HORIZONTAL INTEGRATION STRATEGY

The TLF is responsible for placing the product from point of origin to a destination [1, 21], refers to more than just the physical movement of the product [9] and the choice of transport mode [1, 22, 23]. The TLF is a horizontal integration strategy for the CS, which seeks the forward and reverse flow of information, goods and/or services in order to meet consumer expectations [1-4] in the channel of supply and distribution, at a cost, time and minimum distance, always maximizing the service level collaboratively.

In emerging countries making strategic decisions for the TLF is not always designed to reduce the market price of a product; currently operational design of SC is imposed for families with collaborative network strategies. In order to make decisions with long term certainty and improve the performance of collaborative logistics network, making strategic decisions involves investment in physical infrastructure, collaborative design of Information Systems, Communication Technology and Software (ICT&S) for integrating CS, creating strategic alliances, the design of the clusters, the use of advanced operational techniques, modeling and business intelligence with interfaces as e.g. software, radio frequency (RF), geo referencing, etc.

In the literature review of this research the tactical decision-making is usually done empirically both National Transportation Companies (NTC) and International Freight Agents (IFA), due to the level of complexity missing standardization of criteria, the decision alternatives and immediacy of them.

This research has shown that most authors develop static for operational decisions that are validated for a single CS models. These are hard to replicate because they are: a) designed for expert modeler disclaims all interactions and interrelationships of the members of the network; b) Systematic data collection is manual; c) the algorithm consumes high runtimes; to be dynamically replicated for making periodic decisions.

The decision maker and network designer must consider the types of decisions for the TLF collected in the literature:

A. Tactical Decisions
   a) Transportation Modes (TM); b) Types of Carriers (TC); c) Selection of carriers (SC); d) Degree of Consolidation (DC) [24, 25].

B. Operational Decisions
   e) Mixed Fleet Transport (MFT); f) Allocation of Vehicles (AV); g) Routing (R), h) Vehicle Scheduling (VS); and i) Cargo Plans (CP) [24, 25].

III. RESEARCH METHODOLOGY

The research methodology is in Figure 1.

IV. NETWORK MULTICRITERIA DECISION (NMCD) FOR TLF

A criterion identifies patterns or frameworks that measures designed targets using tools (test or indicators) [13] evaluated at different levels of decision to take action in processes [18].

For the TLF, the criteria for decision making are not fully developed, has been found in the literature that each author and/or decision maker in the SC, used only a few own criteria when selecting a mode of transportation, a carrier and/or a degree of consolidation of cargo. To which within this document a Network of Multiple Criteria Decision for Decision-Making in the SC made from the literature review and pre-assessed by managers and directors of national and international TC’s [6, 8, 18], logistics operators (distribution centers) that store and distribute goods.

The complexity of decisions in the TLF in SC depends on the level, the process and echelons inside the SC; depend on the selection criteria, existing alternatives in the market, restrictions on infrastructure of a country and other social, environmental and economic issues.

One of the contributions of this work is this concept of NMCD for TLF, which seeks consolidation, definition and interrelation of the elements, exposed as a tool of reply to any method, technique, model or methodology required for this development TLF in the Figure 1: the nodes are the criteria, the lines indicate the interrelationship or dependence on other criteria The NMCD answering questions such as support the decision maker for selecting which transport e.g. how, what, etc.

Each organization has a goal of transportation, which is independent and unique and must answer to a why and a wherefore. In NMCD presented in the figure, the nodes together, aggregated or disaggregated are decision making in the SC, and answer questions which can be used for the fulfillment of the transport plan, policies design and strategic objectives in supplying and distribution set by the company, supplier or
customer according to the type of service e.g. Degree of Consolidation (DC) is contained as a node, because this solved the Transportation Mode (TM) problem, it answers the question ¿what, where and how to transport a product from a source to a destination?, e.g. taking into account the criteria management, efficiency and service level.

If the carrier provides multimodal services, consolidation, mobilization, should decide and advise on the selection of the problematic TM: the modality more convenient than providing your customer: ¿What TM can I use?; when is a consumer of freight the question is: ¿Who have selected and what Types of Carriers (TC)?.

V. Service performance measurement for NTC and IFA

A. Level of service (LS) or quality level

The Level Service leads to compliance with a set of features and performance measures, as assessed individually or in groups [1, 8] looking to meet service requirements and exceed expectations for stakeholders [1, 7, 9, 16], as a competitive advantage [1], for some decision makers is not a decisive criterion [7], but for most TC the transportation cost services is directly proportional to LS [6], however when there is a maximum LS at minimal cost low of transportation, the NTC or IFA has a differentiating strategy that creates a competitive advantage in the marketplace.

The LS is a criterion that measures the performance of the service as a qualitative measure representing the union of multiple criteria decision as a competitive advantage [1]: a) opportunity, b) flexibility, c) cost, d) efficiency and productivity, e) ICT&S tools.

1) Opportunity

Reliability in the literature is synonymous with punctuality, compliance [7, 9, 16] opportunity [1]. Reliability determines the level of uncertainty in the performance [1] of a driver, measuring the variability [1, 26] in terms of time (speed), shape (management) and place of transport (accessibility) for one or more, the which are compared with the contracted limits [7, 16], by the above, it is a unitary qualitative measure for the carrier, and individually or weighted or several contracts shuttle.

Planning in decision-making in the TLF minimizes transportation costs [26] and maximize the likelihood of compliance with a carrier, excluding incidental causes eg natural disasters, protests, etc. which are beyond the control of driver [1].

2) Flexibility

Flexibility [27, 28], refers to the availability [1, 13, 19], "ubiquity" or presence, of the alternatives has a means to access the system and meet the path between two or more terminals [13]; is the ability of a carrier to be elected or hired [19] and satisfy any unforeseen [26]; e.g. a road is more ubiquitous than a railroad [13] with flexibility and speed in decision making and inversely to the cost [26]

3) Transaction costs for SCM
Transportation is a major component of the cost of any country [7]. Total logistics costs vary widely by industry, market and business characteristics or Supply Chain (SC); these may represent between 10% to 30% of sales [22], between 1/3 and 2/3 of the total costs of the SC [1], however the TLF is one of the two thirds of the total logistics costs.

The product cost and/or service can be minimized through good design, integration, configuration and management that add value to a product [22, 23] and the level of cooperation of the members of the network along the CS. The main criteria that significantly influence the price of a product for a SC are: a) the relative market [11], b) the economies of scale, c) the transportation mode, because it is lowest for modes higher capacity and higher for faster mode, d) the complexity of the operation, e) the distance between warehouses and plants, among other considerations [1].

Usually, the transportation cost [28] or freight rate [9, 11, 13] is the most important and representative logistic costs and final product cost [1, 8], the transportation management departments undertake and manage over 60% of logistics costs [8], which can be internal and external [10].

Internal transport costs are divided into: 1. capital cost or infrastructure cost (buildings, facilities, terminals, docks, vehicles and other equipment); 2. Fixed costs, insurance, taxes, depreciation, maintenance and management overheads and fleet management and opportunity costs [8, 12]; and 3. variable operating costs: labor, fuel, tires, batteries, lubricants, tolls, tolls (rights of way), wear parts, maintenance and management of facilities and equipment [8, 9, 12], changes in travel time, vehicle operation, safety and changes in the level of service [13]. 4. External costs include accidents, emissions, noise and associated with the provision, operation and maintenance of public facilities [10].

4) Productivity and efficiency

Productivity is a status indicator while the efficiency is an indicator of improvement, in most cases add several concepts; well, productivity is measured in order to assess and improve resource efficiency. The shuttle service management seeks efficiency [13] infrastructure designing skilled operations and preventive maintenance to improve the speed and reliability of deliveries [9] work. Efficiency is measured e.g. regarding the operational transportation cost (month)/number of trips (month) and productivity for eg resource number of trips vehicle/vehicle resource, fleet or invested weight is measured; transported units / time [13].

There are some fundamental economic principles that affect the efficiency of transport which are: 1. The economy of scale means that the transportation cost per unit decreases with increasing size of the shipment and vice versa; 2. The economy away means that the transportation cost per unit will be lower when distance is less and vice versa [8]; 3. The economics of regulation vs. demand is when the transportation cost is fixed by a regulator on a source or destination regardless of the distance of a route, because there is high demand and transportation costs are insignificant. 4. The economy of need, is when the transportation cost is valued according prioritization need or have a shipment due to shortages and affordability.

5) Technological

The integration of ICT&S progressing in Transportation Systems [9, 16], makes the strategic planning process of the SC logistical and timing of collaborative networks involving changes in the use of existing infrastructure and/or proposed new construction projects and operating facilities, looking for traceability in global markets of economies of scale, variability in fuel prices and with limited resources [16].

6) Speed

The speed [6, 7, 9, 13], is a quantitative indicator that is presented in units of distance / travel time, applies for passengers and goods, regardless of the mode or combination of modes to use [9, 11-13] in literature speed is synonymous to quickly transport time [9, 11-13]. The purpose of a service is fast "quick delivery or within specified limits" [16], e.g. if the distance is short and the speed is high, the service has a good chance of being delivered in a less "transport time expected", so the service will be "fast" [26] or faster; On the contrary, if the distance is large and the speed is low, the "transport time expected" could be high.

The distance is deterministic, depends on criteria such as e.g. infrastructure, geographic extension (roads) and accessibility policies and regulations that exist between a source to a destination. The transport time and speed are performance measures that range [1, 7, 13, 28] with respect to the distance the criteria described above, the mode of transport and traffic [13] or mobility [13, 31] and the decision maker will seek to increase the speed and minimize transport time designing optimal routes at minimal cost, regardless of the combination of modes.

The transport time, some models includes waiting times, loading, unloading, transshipment, among others [1, 9].

7) Handling of goods

The handling of goods is a criterion related to the type and size of the products, the degree of consolidation, complexity and frequency of operation [1, 11, 26]. The operation cost is lower when the products have uniform physical characteristics [11].

8) Ability

The capacity of the transport vehicles is measured in volume and weight. The density is a criterion that relates weight/volume of a product [11] used to determine the mode, the number and capacity needed to transport vehicles.

The transport capacity [8, 17] is directly related to the market demand, the facilities, the number of vehicles and space that can be occupied demanded products within the same restrictions under size, shape, and other fragile physical characteristics [11].

The volume is used to calculate the appropriate mode of transport and freight costs, determining the use of cubic bulk products, which have no packaging or packaging [11]. Moreover, the weight is an inverse approach to the volume, which is calculated on the amounts unit according to the nature of the products.

9) Accessibility
The accessibility and market coverage [11, 12, 17], depending on the extent geographically, road infrastructure and the availability of facilities (docks, ports, terminals or wagons) [11-13, 17], refers to the ability has a carrier to provide a shuttle service at a cost competitive.

10) Safety and risk

The criterion for load security [1, 9, 13, 26, 28], does not consider fortuitous events and reverse the risk. Therefore, the greater safety, less risk or probability of loss, theft or damage. However, the risk is directly proportional to the product price and when the products are expensive and have high risk [1, 9, 11, 26]. Like, the transport mode with the device consolidation, labor and insurance coverage also indicate inherently "safe" and therefore the higher the transportation cost, greater safety and lower the risk.

11) Environmental impact

It is a responsibility [11] social at a sector and market, because at present impose new policies and legislation driven by sustainability and sustainability which have generated concern environmental and energy efficiency seeking new designs for operation transport [16], energy alternatives to minimize contamination [32-35], new processes and models of reverse logistics, transport control for products and illicit elements [9, 36].

ACKNOWLEDGMENT

We thank the Catholic University of Colombia for their collaboration in the allocation of resources for this research.

CONCLUSIONS

The price of transport corresponds to the line rate, the use of terminals and other facilities provided [1], however, may vary depending on different criteria: number, distance, speed of delivery, priority demand [9], the product cost [6], the operation, transport, etc. Can be decisive for the selection of the mode of transport and carriers, but at times may be minor [1, 9].

Not all types of carriers are trained to provide services in any type of transport, or all modes of transport are suitable for all products according to the market price because of transport.

The proposed criteria were defined for decision making executives of the SC, who need to design transport and logistics operations are the first phase of research in the art that allows for any SC standardize products or services.

The NMCD, is the most important contribution of this research for decision making in transportation, either for the selection of carriers, modes of transport, location of facilities, development of infrastructure investment projects, etc.

The definition of the criteria is the first phase recommended decision theory, because it allows standardize the use of terms for any process and the personnel involved. Therefore, the second major contribution of this research is that the definitions of the criteria were based on the literature review and not by experts.

The methodology used in the design NMCD for TLF, can be transferred to any problem that involves decision making with several non-standardized criteria and personnel of different levels, areas, departments or processes.

RESEARCH PERSPECTIVES / FUTURE RESEARCH

Validate NMCD for TLF using various techniques of making decisions e.g. PROMETHEE, ELECTRE and diffuse, in order to diversify their use and standardize its conceptualization in various levels of the SC decision making strategic, tactical and operational.

Present design NMCD several types of SC products and services, in order to validate its structure, interrelationships and dependencies in making transportation decisions.

REFERENCES
