Selecting the Logistics Service Providers: Towards a Mathematical Modeling Approach

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Abstract With the increased competitiveness of the global market, the use of logistics services in Morocco has become an urgent necessity in order to optimize costs and the quality of services. As a result, an adoption of the logistics outsourcing strategy is in high demand. To succeed in this strategy, we propose guidelines for the support of Decision Makers (DM). One of the fundamental pillars of this strategy is based on the choice of an efficient Logistics Service Provider. The main challenge is to always seek the effectiveness and sustainability of the relationship at the level of a network, often very complex of potential partners. To this end, an eminent need to model this relationship between the actors of this network is required. The study conducted consists of modeling the problem of the choice of the provider as well as the assignment of the service to be outsourced to the appropriate LSP as part of the success of the logistics outsourcing strategy of a DM. The linear model developed takes into account qualitative and quantitative criteria to be complementary to our previous work. These criteria are expressed in the constrained part of the model.

1   Introduction

The emergence of business networks from the 90s concretizes the strategic alliances that companies must forge in order to solidarize and share financial risks as well as to find the industrial and technological complementarities necessary for their development. However, with the volatility of markets and the evolving requirements of competitiveness, several companies have found themselves forced to take into account the logistics dimension as a competitive weapon, allowing them to optimize costs and improve the quality of their services [1].

As a result, and for reasons of rationalization and optimization, DMs tend to gradually outsource their logistics activities to qualified service providers [2] and [3], so optimization has been at the center of any decision-making problem.

Currently, the major problem of supply chain management is to want to control all the activities involved in the creation of a finished product [4]. Hence the need to use a wide range of Logistics Service Providers (LSPs).

As a result, ordering companies are in contact with a large number of LSPs, among which they must choose the most suitable for their requests. The sustainability and efficiency of this relationship positively influences supply chain management by making it easier to maintain a competitive advantage [5] and [6].

Given that the analytical capacity of a human being is limited to consider simultaneously the possible compensation and substitution effects related to thousands of interdependent choices [7], as well as the lack of certain methods such as MCDMs in terms of expression of needs in the form of constraints , especially since these methods are based on human judgment which often has an instinctive non-objective character. Asa result, we have opted for mathematical modeling that will allow us to overcome this deficiency.

Our modeling approach is part of the application of Operational Research Methods for the improvement and support of decision support processes. Our situation is a matter of mathematical modelling, making it possible to formally evaluate different alternatives and anticipate their impacts [8].

2   Literature Review

2.1   Modelling

The literature aimed at studying the logistics outsourcing of Moroccan companies as well as the management of relations between actors in a supply chain contributing to the success of this strategy is almost absent [9]. Indeed, the resulting supply chains involve a large and growing number of logistics players, subsequently requiring robust methods for the selection of the latter. Their roles are therefore becoming increasingly important [10]. The model developed will be supported by Ods in order to opt for this strategy without hesitation regarding fears about the choice of LSPs.

However, the literature review shows the need for an integral system of measurement indicators to assess the performance of actors that derive from the supply chain as a whole [12].

Indeed, mathematical programming models are the most used for modeling in logistics network planning as well as for the evaluation of 3PL providers [12].

An optimization model for the selection of LSPs in the field of transport has been developed by [15], for the case of »Reynolds Metal Company«, opting for the method (Mixed Integer Programming) for the selection and deployment of carriers.

In the same vein, a mathematical programming model for the selection of a 3PL type LSP for storage outsourcing was established by [13]. However [14] have opted for a multi-objective programming model for the problem of choosing LSPs involving a set of often contradictory multi-objective criteria.

Other researchers have developed approaches to solve the problem of selecting providers for the transport service. It is a multi-objective mathematical programming model, acting on the minimization of the total cost [15].

In addition, [16] addressed the problem of selecting carrier-type LSPs with the reliability of the transportation network in order to find the best choice using (Optimal Carrier Selection problem based on Network Reliability).

For the outsourcing of part of the production and to model the fixed and variable costs related to purchase and production, [17] used binary functions.

In addition, a mathematical model of optimization with several suppliers over several planning periods was developed by [18], using mathematical programming and Total Cost of Ownership (TCO) for the supplier choice problem. [19] has developed a multi-objective model of supplier selection.

[20] proved the value of using several claimants through mathematical modelling.

2.2   Mathematical optimization methods

Many academic works focus on the problem of choosing the best provider by opting for mathematical models which are in turn numerous depending on the problem posed, the type of data concerned and the structure studied [21].

In addition, at the level of modelling, operations research is one of the popular analytical methods within the scientific community [22], based on optimization theories, game theory, statistics and algorithmics.

These methods are often formalized in the form of one or more objective functions in order to minimize it or maximize a set of constraints. The models developed are linear, or non-linear with the presence of integer, real, mixed or binary variables, ... [23].

Among the resolution techniques of this type of modeling are linear programming [30], mixed integer programming [24], and multi-objective mathematical programming [18] and [25].

3   Elaborate model

3.1   Context of study

Although the choice of LSPs can be made according to several criteria, focusing only on an evaluation that takes into account only quantitative criteria devalues the importance of qualitative criteria. The latter provide a long-term benefit [26].

Our problem, therefore, is to model the choice of LSPs based on two types of data that are qualitative illustrated by traceability, technological level, level of services offered, range of transport and type of LSP and others that are quantitative illustrated by the fixed cost of choice of LSP and the cost associated with the service offered.
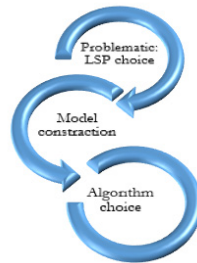
The approach can be summarized in figue 1.

Figure 1: The approach of context study.
Source: own.

3.2   Scenario adopted

At the level of the problem of choosing the LSP, we assume that we have i logistics service providers to choose from among them to provide S services.

The scenario adopted is to consider a predetermined number of services, each LSP providing a single service, as well as a service cannot be supported by only one LSP.

However, the cost of outsourcing is subdivided into 4 categories: a cost associated with the choice of LSP, a cost associated with the performance of service S by provider i, a cost of risk associated with the choice of PLS i and a cost of risk associated with the wrong choice of PLS i for service S.

Overall, we are thus on the side of DM which seeks to minimize the total cost resulting from the choice of better LSP as well as the assignment of service to be outsourced to the right LSP, while seeking in the meantime to maximize criteria.

Our contribution concerns the application of mathematical modelling to combine between qualitative and quantitative variables to fill the gap due to the use of one type of variable without taking into account other types. So our study consists not only in the evaluation of the costs of service encompassing the cost of carrying out the service and the cost generated by the risk that may take place, but we will also take into account, the qualitative aspect associated with the few criteria considered interesting according to previous studies carried out [27], for the choice of LSP. This aspect will be illustrated as a constraint in the developed model.

3.3 Mathematical formulation

We will present the elaborated model as well as the details concerning it, as well as the appropriate method of resolution is explained.

3.3.1 Data

I: the number of the panel of LSPs

S: the number of services to be outsourced

J: Criterion index

Cv_{is} = Cost of outsourcing the service s by the PLS i

Ct_s = Cost of carrying out an internal service

Cf_i : fixed cost of choosing a LSP i

Q_3 : Third quartile of the distribution of LSP scores

W_j : weighting of criterion j

S_{ij} = the score (score) of for criterion j PSL_i

Cr_{is} = the risk-related cost of a service provided by a PLS i

Cr_i = the cost related to the risk of poor choice of a PLS i

ξ : a margin of tolerance

p_i : multiplying the score by weighting criterion j for all services $S_{ij}W_j$

3.3.2 Decision Variables

$\boldsymbol{Y_{is}}$ = 1 if the LSP i supported service s.

$\boldsymbol{Y_{is}}$ = 0 Otherwise.

X_i= 1 if the LSP (i) is retained
X_i= 0 otherwise

3.3.3 The objective function

The objective considered is to minimize the costs related to the choice of suitable LSP as well as the assignment of service (s) to the right LSP then the cost of risk assessment incurred whether it is the risk related to the wrong choice of PLS as a whole or the non-compatibility of the assignment made between the service and the chosen LSP.

At the level of the model cited, the optimized criterion in principle and which is illustrated in the objective function is the cost, but in addition we have explained qualitative criteria that we will point out later in the constraint part.
The objective function is written as follows:

Minimize Z= $+\sum_i \sum_s (Cv_{is} + Cr_{is}) * Y_{is} \sum_i (Cf_i + Cr_i) * X_i$

3.3.4 Constraints

$\sum_i X_i =$S (3.1)
Y_{is} <= s S , i I (3.2)$X_i \forall \in \forall \in$
$\sum_s Y_{is}$<= i I (3.3)$X_i \forall \in$
$\sum_i Y_{is}$= 1 s S (3.4)$\forall \in$
$Cf_i * X_i + Cv_{is} * Y_{is}$<= s+*(s S , i I (3.5) $C_t \xi C_t s$) $\forall \in \forall \in$
$Q_3 \leq \sum_j (S_{ij} * W_j) * X_i \forall$ i I (3.6) $\in$
$X_i \in \{0,1\}$, i I (3.7)$\forall \in$
$Y_{is} \in \{0,1\}$, i I, s S (3.8)$\forall \in \forall \in$

The objective function minimizes the total cost associated with choosing the best LSP and assigns it to the most suitable service, this cost includes two terms, the first is associated with the choice of LSP and the performance of a service(s) and the second is associated with the cost of the risk that may occur due to a bad choice of LSP or the cost related to the non-homogeneity of PLS for such a service. The constraint (3.1) ensures that there will be (S) LSP chosen that will correspond exactly to the number of services to be outsourced. Constraint (3.2) ensures that a service

cannot be outsourced unless a LSP is retained. The constraint (3.3) dictates that a LSP cannot support at most one service (0 or 1). Constraint (3.4) ensures that a service must be supported by a single LSP. For the constraint (3.5) admits that outsourcing can only take place if the cost of outsourcing is less or just exceeding with a small tolerance the cost of internalization of such service. The constraint (3.6) achieves a limitation of the LSP that will be the subject of the study by taking just the third quartile in our case and it depends on the size of the sample used, in the case of large sample size, we can go up to the second quartile. This quartile will be compared with the product of the LSP score calculated by combining the 5 criteria already previously reported which are (traceability, technology, type of PL, range of service and transport modalities), and the weighting of each criterion according to the opinion of the Ods. The two constraints (3.7) and (3.8) relate to the binary nature of the decision variables associated with the selected LSP and the assignment of each service to the correct LSP.

This model is a linear program with binary variables.

4   Conclusion

In this article, we have focused on the problem of deciding on the choice of the best LSP as well as the allocation of services to be outsourced. We have taken a view based on LSP modeling and services in the supply chain. Thus, we studied the design models of the latter in a supply chain in order to be able to establish a mathematical modeling of the decision problem based on the cost criterion as well as other qualitative criteria that we explained in the model.

Elsewhere, the costs relating to each situation of outsourcing each service to a given LSP by making a comparison with the cost of developing the same service internally.

The purpose of this mathematical modeling is to allow the company to choose, for part of its activities between the option of doing it internally or do-it-yourself by choosing the LSP that will be solicited between a candidate panel. We thus place ourselves on the side of the DM company which seeks to minimize the total cost relative to the two options, as well as maximize the quality criteria existing in the LSP and minimization of the risk that can be generated due to the choice of either bad service to outsource or the wrong choice of LSP for this mission. The

constraints are related to the cost of carrying out services internally, also to the respect of a certain threshold of some qualitative criteria such as traceability, the technology used ..., other constraints imposed to avoid the monopoly of a single LSP for the outsourcing of all services ...

So, we tested the scenario we chose according to the accessibility to the data tested with CPLEX. The model developed has certain limitations. Apart from the difficulties of resolution in some cases where the data are important, the model developed has certain limitations, in the event that some information is not available or rather is not accessible given its confidentiality for some LSP. In addition, the information concerning the sharing of service between several LSPs in the multi-sourcing strategy pushed us to limit ourselves to a very specific scenario.

 This is why it would be interesting, in perspective, to develop another scenario by taking the case of service sharing between several LSP and the fact that a LSP can provide more than a service or the taking into account of the cost associated with the different types of risks, are all possible study situations.

References

[1] - McGinnis, M.A., Kohn, J.W. (2002), Logistics strategy-revisited. Journal of Business Logistics 23 (2), 1–17

[2] Lieb, R., Butner, K., (2007.a.). "The North American Third Party Logistics Industry in 2006: the Provider CEO Perspective." Transportation Journal, 46(3), 40- 52.

[3] Lieb, R., Butner, K., (2007.b.). "The year 2006 Survey: CEO Perspectives on the Current Status and Future Prospects of the European Third Party Logistics Industry." Supply Chain Forum : An International Journal, 8(1).

[4] NAJI Marouane and MOUNIR Younes, « De la mesure de performance des chaines logistiques – Revue de littérature et taxonomie », Revue Internationale des Sciences de Gestion, vol 4, N° 2, pp1187 :1214.

[5] Horvath. L, (2001), "Collaboration: the key to value creation in supply chain management", Supply Chain Management: An International Journal, Vol.6 n°: 5, pp.205-207.

[6] Philipp, B. (2007), Supply chains durables : changement de paradigme, modèle ou mode ?, in Paché G., Spalanzani A. (Eds), La gestion des chaînes logistiques multi-acteurs: perspectives stratégiques, Presses Universitaires de Grenoble, Grenoble, pp. 85-100.

[7] MARC-ANDRÉ CARLE, « LA MÉTAHEURISTIQUE CAT POUR LE DESIGN DE RÉSEAUX LOGISTIQUES DÉ TERMINISTES ET STOCHASTIQUES »,Thèse,la Faculté des études supérieures et postdoctorales de l'Université Laval, QUÉBEC 2012

[8] Roy, B. (1996). Multicriteria methodology for decision aiding. In Nonconvex optimization and its applications. Dordrecht: Kluwer Academic Publishers.

[9] Lhoussine ABOUDRAR, Jamal el Baz and Hassan Batrich, « Impact de l'externalisation du transport/logistique sur le triptyque coût-qualite-delai: cas des entreprises marocaines»,

Dossiers de Recherches en Economie et Gestion : Numéro spécial : Décembre 2014, pp464-484.

[10] Paché, G. 2009. « Quels impacts de la crise sur la logistique ?» Revue Française de Gestion 35 : 51–57. doi:10.3166/rfg.193.51-57.

[11] Akgün, M., & Gürünlü, M. (2010). Cash to Cash Cycle as an Integral Performance Metric in Supply Chain Management: A Theoretical Review. IUP Journal of Supply Chain Management, 7(1/2), 7-20.

[12] Ko, H.J., Ko, C.S. and Kim, T., 2006, "A hybrid optimization/simulation approach for a distribution network design of 3PLs", Computers & Industrial Engineering, 50, 4, 440-449.

[13] Chen, F.Y., Hum, S.H. and Sun, J., 2001, "Analysis of third-party warehousing contracts with commitments",European Journal of Operational Research, 131, 3, 603-610.

[14] Kumar, M., Vrat, P. and Shankar, R., 2006, "A multi-objective 3PL allocation problem for fish distribution",International Journal of Physical Distribution & Logistics Management, 36, 9, 702-715

[15] Liao and Rittscher, (2007),"Integration of supplier selection, procurement lot sizing and carrier selection under dynamic demand conditions". International Journal of Production Economics 107,p.502-51

[16] Lin, Y.K. and Yeh, C.T.,(2010),"A Decision Method for Disruption Management Problems in Intermodal Freight Transport ". International Journal of Production Economics, vol.128,p.510-51

[17] Ahmadi, R.H. and C.S. Tang, 1994. Production allocation whith dual provising, European Journal Of Operational Research, 75, p. 186-199.

[18] Degraeve, Z. and F. Roodhooft, 1999. Improving the efficiency of purchasing process using total cost of ownership information : the case of heating electrodes at at cockerill Sambre S.A, European Journal of Operational Research, 112, p. 42-53, 1999

[19] Weber et Current,1993] Weber C.A, Current J.R. A Multiobjective Approach to Vendor Selection. European Journal of Operational Research 68, pp 173-184, 1993

[20] Anupindi, R., & R. Akella (1993). Diversification under supply uncertainty. Management Science, 39 (8), 944-963.

[21] M.E.BOUNIF , Optimisation à base de simulation pour le développement des systèmes décisionnels, Doctorat, Msila, 2015

[22] Parunak et al., 1999] Parunak, H.V.D, Savit, R., Riolo, R.L, Steven, J.C, 1999. DASCh: Dynamic analysis of supply chains. Center of Electronic Commerce Final Report.

[23] Abdelkader Hammami, « Modélisation technico-économique d'une chaîne logistique dans une entreprise réseau », thèse de doctorat à L'Ecole Nationale Supérieure des Mines de Saint-Etienne (Université Jean Monnet, Saint-Etienne, France), 3Mars 2013

[24] [Pan, 89] A.C. Pan, "Allocation of order quantity among suppliers", Journal of Purchasing and Materials Management, pp 36-39, (1989).

[25] [Buffa et Jackson, 83] F.P. Buffa et W. M. Jackson, "A goal programming model for purchasing planning", Journal of Purchasing and Materials Management, pp 27-34, (1993)

[26] MacCormack et al., 94] A. D MacCormack, L.J. Newman III et D.B Rosenfield, "The new dynamics of global manufacturing site location", Sloan management review , pp 69-80, Summer (1994).

[27] Azzouz khaoula, Arif jabir et Benboubker Mohamed Badr, « Exploratory Study of the Role of Logistics Service Providers in Terms of Traceability in the Process of Outsourcing of Logistics' Activities: Case of Moroccan LSP », International Journal of Engineering Research in Africa, Vol 54, 187-208.