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Integrate subcontracting into Supply chain configuration and diffusion of new Product

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***Abstract*— Outsourcing is one of the most replicated forms of collaboration today, as it represents a strategy for the organization internally to focus on the mainly process and create a network of external suppliers for the secondary activities**

This paper introduces a mathematical model supply chain configuration of a new product. Which integrates the outsourcing constraint in both product life cycle phases, production and diffusion. Knowing that is uncommon, the studies that consider the outsourcing constraint in the product life cycle configuration .The proposed model is applied in practical case to with several scenarios to identify the optimal plan which define the correct quantities to be produced or distributed with company resources and those to be outsourced to maximize the company's net revenue.

***Keywords*— Supply chain configuration, new product diffusion, outsourcing**

I. Introduction

Outsourcing can be beneficial, but it is necessary to choose in which process the Supply Chain will be integrated. Despite the fact that there is a lack of models in the literature that considers the presence of outsourcing, we will be based on two main works to achieve our new model.

The Supply Chain Configuration is about preparing the decisions including selection of suppliers, production process, transportation modes and facilities to place the appropriate levels of safety stocks.

The aim of this paper is to define a model when and how much quantity must be outsourced during the production and delivery process. Our model can be considered as a decision support tool which provides a modeling framework, to design a supply chain, adaptive to the changing customer demand during new product lifetime's.

II. Related Literature

Y According to Haito and Keith [1], the company must configure its supply chain and make decisions before starting production. They provide a decision-making framework for the supply chain configuration and manufacturing by MTO (Make To Order). Their model is based on a combination of two MINLP programming (Mixed Integer Non Linear Programming) and « Contraint Programmation (CP) ». The purpose of work has shown that their model optimizes the total costs of the chain in connection with planning decisions. It takes into account various cost elements, including the cost of goods sold, the cost of security stock and the total cost of execution.

Lu,[2] investigated the problem of companies that manufacture multiple products in multiple periods of stochastic demands. In general, manufacturers have two alternative modes of production: one is to outsource the parts to external suppliers, then to assemble them, the other is to manufacture parts internally and then assemble them.

In 2013, Stritto and Falsini,[3] developed the supply chain model for the release of the new Product, while integrating warehouse location strategies, dynamics demand, and the product dissemination process. The problem is formulated as a stochastic program solved using a hierarchical heuristic solution approach, which is constituted by a Tabou procedure.

Kumar and Swaminathan[4] presented a distribution model of new NPD products . This model used to express the effect and interactions of

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supply constraints on fluctuations in customer demand for the release of the new product. They took into account supply constraints that neglected by the model Bass [5].

To prove their concept and model, Kumar and Swaminathan [4] have studied the case in which the firm can choose any level of production, even if the production capacity and convex growth. They show that setting production capacity before starting production gives optimal and relevant results.

After extensive study of the NDP model, Graves and Willems [6], found that this model focuses on the interactions between manufacturing and marketing / sales decisions in a firm assuming a fixed cost for each production unit. . Note that the NPD model does not consider other functions of the company's supply chain such as markets, supply, assembly and distribution. For this reason, they created their SCC model to optimize the supply chain configuration for new product release.

In this model, the company selects the options for each function (components, parts, or processes) in the supply chain to minimize the total cost of the entire supply chain system.

SCC also allows coordination between actors in the chain

by optimally determining their inbound and outbound service times, as well as inventory positioning in the supply chain.

Amini and Li [7], have been convinced that both the NPD and SCC approaches are extremely linked. For this reason, they presented their model named "Integred / Hybrid Supply Chain Configuration Model". The latter defined as the choice of a feasible production plan, and the configuration of the corresponding supply chain throughout the life of the product.

Since the variation in the requested trajectory was not addressed and addressed by the SCC model, they proposed a hybrid optimization model that takes into account the impact of customer demand dynamics when disseminating new products.

The development of an integrated optimization model that takes into account the configuration of the supply chain and the dissemination of products as a solution to optimize net profit during the product life cycle [7]. The authors emphasized the value of local production in increasing the benefits of society without considering other options or procedures that are capable of doing so. As a result, our work is moving in this direction from our mathematical model which deals with the integration of subcontracting constraints into production as well as distribution.

In order to concretize their model Amini and Li [7] proposed to test it on a practical case "construction of the pipelines". On our part, we will look at the same context of this application to obtain numerical values that will be comparable to those of Amini and Li. The application of our model to determine whether the use of outsourcing is interesting for company to express the concepts of reliability when integrating outsourcing within the configuration of a Supply Chain. Based on the results obtained, a comparative study will be conducted between our model and the integrated hybrid model of Amini and Li [7] in order to negotiate the consistency of the results, in order to deduce a good decision.

III. DESCRIPTION PROBLEM

The following table lists the different parameters used to solve this model. The application of the model developed allows testing several scenarios presented below.

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Parameter	Level
π	1.1
h	0.001
w	0.005
m	3000
p	0.03
q	0.4
K	100
T	30

- The hybrid-integrated model solved by the solver GAMS DICOPT. The objective function presented as follows:

Total revenue - product life cycle

$$= \sum_{t=0}^{T} \overline{c}_N \left[\pi y_t - r_t - w l_t - h I_t \right]$$

The table below presents the obtained results:

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	Min	Max

Case 1 : $\alpha = 1$; $\beta = 1$	Solution1 : Max Z (1, 1)= 111,82DT
Case 2 : $\alpha = 1$; $\beta = 0$	Solution 2 : Max Z (1, 0)= 97,65 DT
Case 3 : $\alpha = 0$; $\beta = 0$	Solution 3 : Max Z (0, 0)=109,48 DT
Case 4 : $\alpha = 0$; $\beta = 1$	Solution 4 : Max Z (0,1)=86.58 DT
Case 5 : $0 < (\alpha, \beta) < 1$	Solution 5 : Max Z (0,0.45)= 87.77 DT

hybrid integrated model	38.82	**123.65**

SCC Costs = Cost of Pipeline Stock + Cost of Pipeline

	Hybrid integrated model	Proposed Model
Selling price	374.61	372.70
Production capacity per period	Local 100	Local + outsourced 66 local ; 34 outsourced
Production rate	100%	66% local ; 34% outsourced
Unit delivery cost	Locale (Pas de livraison dans ce modèle)	Local + outsourced 35D

Security Stock

$$= \sum_{i=1}^{N} h(\overline{C_i} - \frac{C_i}{2})\, P_i \mu_i \quad + \quad \sum_{i=1}^{N} h\, \overline{C}_i \sigma_i \sqrt{s_i^{in} + p_i - S_i^{out}}$$

With:

	Min	Max
hybrid integrated model	0.42	**15.54**

Also Amini and Li [7] have tried to calculate the net profit using the general or basic formula (net = selling price - cost) and they found the following results:

Maximize total profit Net = selling price – cost
= 374,72 - 287,89
= 86,72

According to their integrated model the net profit will be equal to:

Maximize Total Profit Net = Total Revenue - Product Lifecycle - Costs SCC
= 123.65 – 15.54 = 108.11

So, we notice that the hybrid integrated model gives more effective results than the base model with a 25% increase.

Following the approach of our model, the Amini model presented in the following situation (local production and local delivery):

IV. RESULTS AND DISCUSSION

In this part, we will focus on applying our parameters and our collected data to the same context of this "pipeline construction" application in order to arrive at numerical values and results that will be comparable to the Amini and Li model. The following table presents a comparative study between the integrated hybrid model of Amini and Li [7] and our model.

TABLE 1: RESULTS PER CASES

TABLE 2: RECAPITULATIVE TABLE

Our approach will be applied while varying the quantities of products manufactured and delivered either internally (own means of the company), externally (subcontracting) or internally and

Cas1 : $\alpha = 1$; $\beta = 1$	Solution1 : Max Z (1, 1) = 108.11

externally. Since the model of Amini and Li [7] deals only with the configuration of the supply chain without giving importance to the subcontracting. We tried to calculate the results by subcontracting part of the pipeline production, we outsourced the process of casting the mold and the formwork. Regarding delivery, we have tried to calculate the results and conclude the effect of the outsourcing of delivery in this pipeline sector.

Our objective function is as follows:

$$Max\ Z(\alpha,\beta)(r,c)=\left[\sum_{t=0}^{T}\ \pi_t y_t-\sum_{t=0}^{T}\overline{C_N}\left(\alpha r_{t\ \mathrm{loc}}+\left(1-\alpha\right)r_{t\ \mathrm{sout}}\right)\right]$$
$$-\left[\sum_{i=1}^{N}h(\overline{C_i}\ \ \frac{C_i}{2})\ \mathrm{P}_i\mu_i+\sum_{i=1}^{N}h\ \overline{C}_i k\sigma_i\sqrt{s_i^{in}+p_i-S_i^{out}}\right]$$
$$-\left[\beta C_{livloc}+\left(1-\beta\right)C_{livsout}\right]$$

After all calculations, the table below presents the results obtained when applying our model on the "pipeline construction" case study.

- Case 1: Presents the case where is to say that the production and the delivery are carried out locally by the own means of the society. This case leads to a net profit Max Z (1, 1) = 111.82DT. Comparing this result with the Amini model (Max Z (1, 1) = 108.11), we see an increase of 4%, hence our objective function gives a more profitable result than that of the hybrid model.
- Case 2: The production process is applied within the parent company such as, while the delivery process is delegated to a service provider from where. This combination resulted in Max Z (1, 0) = 97.65 DT. This solution does not present the best solution compared to the previous case and the case of Amini but it is more effective than the general case which is equal to 86.72.

Case 3: Presents a complete outsourcing of production and delivery processes. The profit Max Z (0, 0) = 109.48 DT, which is as even more efficient as 108.11 found by the hybrid model.

Case 4: In this case, we have. This combination results in Max Z (0, 1) = 86.58 DT.

Case 5: Presents a random variation of the two variables and between 0 and 1, in order to identify the best combination between production and local and outsourced delivery.

V. Conclusions

From where we find that the application of our model gives a more efficient and cost-effective solution than the integrated hybrid model of Amini even if the increase is 4% compared to the hybrid integrated model.

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