Literal framework of Green supply chain Modeling

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Abstract: Background: Supply chain covers a set of logistics components (procurement, storage, production, distribution...). In addition to the classical logistics components, the green supply chain integrates the environmental dimension in all these components.

Nowadays modeling a supply chain by integrating environmental constraints has become an important metrics, in the logistic field for scientists, and also for industrialist in order to meet the customer needs, that has become more and more demanding in terms of respecting environment.

This article aims to summarize some literature studies of the green supply chain and its modeling; afterwards we will expose an overview trough a comparative study about the used methods and approaches in the green supply chains modeling.

Key words: *Inser green supply chain, environmenta limpacts*

INTRODUCTION

Action on climate change has never been more necessary. Year after year, we remark increasingly hot temperatures recorded impacting our ecosystems and our environment. In this context, the Paris agreement of COP21 entered into force. This decisive statement of intent, born of an unprecedented global consensus, marks a step genuinely meaningful toward a future to low carbon content (CDP Supply Chain Report 2016/2017).

Today, the green supply chain (SC) is one of the well-known topics of current interest and debate in numerous research projects, but also, for companies whatever their field of application.

To meet the challenge of climate change, companies are thinking about good practices and actions to reduce environmental impacts, such as supply chain modeling (SC) by integrating environmental constraints. The word green supply chain (SC), has become a trend, and a customer expectation [1]. Herein, the customer has also become aware of the importance of protecting environment from products or services impact's offered by companies.

1 The Green Supply Chain

At the end of the 1990s, a new topic of research has been appeared: the green SC. Moving from classical SC to the green SC emerged strongly in the early 2000s as a result of climate change, which increasingly requires responsible corporate involvement. The objective is to develop economic and environmental performance by promoting a broad client-supplier relationship [2]. This passage has indeed made it possible to integrate the environment imperatives and to adopt strategies in the sense of sustainable development [3]. The effort focuses exclusively on reducing greenhouse gas emissions, with special attention being given to carbon dioxide CO_2, which is the most liberated gas.

A green SC can be defined as a SC that is based on the concept of sustainable development, and all its activities are mostly ecological, from procurement to distribution of green products, or services that respect the environment, thus the customer-supplier relationship must be based on a common agreement on environmental requirements. Among the factors of development of green SC, the product life cycle, operational life cycle, performance measures, and elements of environmental policy [4]. For instance, life-cycle assessment helps in decision-making by providing means of assessing impacts on human health, ecosystems and natural resources [5].

Green SC management differs from an ordinary SC by adapting decision-making levels to environmental constraints, and a piloting that takes into account environmental risk (i.e. waste management), from

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diverse activities: from procurement, to production, till distribution. Moreover, reverse logistics approaches facilitate the study of a green SC in a different way, considering a closed loop. The green SC management integrates the environmental dimension throughout its management [6] including product design, selection of material sources, production process, and delivery of the finished product to the customer, up to and after the end of the product's life.

2 Green Supply Chain Modeling

Modeling a supply chain means presenting one or all its entities, in procurement phase, production, distribution or three phases using a method or approach (mathematics, by simulation, or organizational) according to several criteria that depend both on the field of application, the decision levels and also the feasibility of the used approach, in order to detect malfunctions and needs.

The modeling of a classical SC, focuses on economic optimization objectives, although the emergence of recent research that attempts to link SC to the environmental aspect, paved the way for the integration of environmental constraints in the SC modeling that are not always oriented towards economic objectives.

Also linking remanufacturing strategies and greening supply chain [7]. In the following paragraphs, we suggest a summarized bibliographic study and specific to SC modeling integrating environmental constraints. In this literature review we are particularly interested in two main industrial fields; the chemical industry and the canning industry.

3.1 Green Agro-food (SC) modelling

The cost of logistics is about 15% to 30% of the export or distribution price of agricultural products [8], the agro-food sector, is among the most demanding, in terms of SC management, in particular and more recently to environmental impacts. A significant number of researchers are interested in developing methods for modeling agro-food SC, including environmental constraints.

The article [9] deals with green SC modeling in the agro-food sector, namely, the case of orange juice production SC's, by evaluating the life cycle and multi-objective optimization by genetic algorithms and multi-criterion decision-making tools (TOPSIS), taking into account three echelons: supplier, manufacturing and market segments. This study was carried out in order to show the utility of eco-labeling, by integrating environmental constraints into the established model. Taking in consideration the global warming potential expressed in kg, as an example of constraints. On the other hand, this study contributed to the achievement of sustainable agro-food SCs.

Article [10] introduced a new ALADIN simulation environment in a case study of food SC modeling; it proposed an integrated approach to logistical sustainability and food quality analysis. Indeed, this work has integrated sustainability indicators into the simulation models.

As for article [11], it presented the mathematical modeling of an oil Palm SC, with an emphasis on the reverse logistic flow. This paper has dealt with the case of closed loop SC, where the upstream and downstream product flows are simultaneous. The environmental aspect has been taken into account relatively to an objective that integrates energy consumption. After analyzing the results, it appears that the upstream and downstream flows have a positive impact on agro-food SC in economic and environmental terms.

A green SC model is also proposed by the article [12] and specifically the case of a French agro-food SC, using firstly the AHP method and the aggregation method (the ordered weighted method) to develop a multi-objective mathematical model. This model allows taking into account the three dimensions, in particular the sustainability including the carbon and water footprint. These numerical results, which provide an idea about environmental impact of the studied SC, also provide information on its design.

The article [13] has chosen to model an agro-food SC, using total interactive structural modeling, it is a food waste SC, to derive practical information, in order to improve effectiveness and to take in consideration the protection and conservation of environmental resources.

3.2 Chemical and automotive industry Green supply chain Modeling

Logistics costs are about 25% of the added value for manufacturing sectors [8]. In this case of industry, taking environment into account in SC management includes not only sustainable development, but also mutual economic benefits between customer and company. We propose hereafter several works about methods and tools of modeling such a SC type.

To optimize raw material procurement, article [14] proposed a green SC model by treating the case of a unit of bioethanol in France, from agricultural residues, and annual and perennial crop. By integrating the environmental impacts into the model. After testing several scenarios, this article deduced three types of biomass that generate critical and diversified percentages of GHG (Greenhouse Gas) emissions. It has also shown that GHG emissions can be reduced by up to 60%.

Gao,& al [15] proposed a hydrocarbon-based biofuels SC modeling in Illinois USA, by optimizing the life cycle of the product using a stochastic approach, more precisely a stochastic model of mixed linear fractional programming, taking as objective function a function minimizing the environmental impact relative to the acquisition, raw material processing, manufacturing, transportation and distribution of the product.

The cement industry is dealt with in article [16] in Brazil, in order to analyze the interaction between two strategies, one to reduce CO_2 emissions in the atmosphere (the imposition of a price policy on CO_2 emissions) and the second one the network infrastructure for CO_2 capture and storage, in particular the uncertainty of storage capacity. By using a stochastic model of linear mixed-integer optimization, which allows minimizing the costs of capture, transport and storage of CO_2.

Among the sectors most sensitive to environment, the automotive sector. Article [17] presented a modeling of an automotive SC for decision-making, identification of best practices of ecological and lean SC management in order to improve their eco-efficiency, using a mathematical model that minimizes the negative environmental and economic impacts of the SC.

More generally, article [18] modeled an industrial SC trough a mathematical model of multi-objective optimization, using the Tcgebycheffand weighted sum method, and as objective function, a function minimizing the total cost of CO_2 throughout the SC. The model is solved via CPLEX v12.4 Solver for Microsoft Excel, which helps to determine the model's ability to cope with the trade-offs between costs and environmental problems and to identify its limitation in the case of real size problems.

The article [19] highlighted the need to explicitly evaluate the environmental impact in a closed-loop SC, by treating the case of an electronics manufacturing company; the modeling is performed using the ToBLooM (Triple Bottom Line Optimization Modeling) method. It is a decision-making tool that consists of a multi-objective, mixed integer linear programming model, integrating several decisions, in particular the environmental impact through the life cycle analysis methodology.

To illustrate their model of optimization, Zhao R,& al [20] took the case of sanitary products SC in China. It is a multi-objective model that minimizes the inherent risk of handling hazardous materials and carbon emissions by proposing three scenarios that generally minimize the costs of carbon emissions. The model parameters are implemented via Big Data analysis using the SPSS19.0 software. These authors [20] have deduced that the best solution for reducing carbon emissions, as well as improving green SC, is optimization.

3.3   Green SC modeling other domaines
Sunil Kumar Jauhar,& al [21] proposed a linear mathematical model solved by the DEA (Data Envelopment) method and a fractional mathematical model solved by the DE (Differential Evolution) method, for an educational SC in India, by adopting an objective function that maximizes the overall efficiency of sustainable SC, taking in consideration environmental aspects.

Article [22] focused on reverse green SC, proposing a linear mixed integer programming (MILP) model, to model a reverse SC of electronic waste recycling, with uncertainty about the collection rate, the exchange rate, and the cost of shipping under carbon constraints.

A goal programming model to design a green SC of in-store product sales, is proposed in article [23] by integrating consumer segmentation, which is divided into three categories, green consumers, inconsistent consumers, red consumer, and proposed a resolution of the model by ILOG CPLEX Solver, in order to clearly demonstrate the value and applicability of the proposed model by studying a set of scenarios.

To evaluate the strategies of reduction of the carbon coming from SC in the UK, using an alternative port combination, and multimodal strategies, V.Sanchez Rodriques,& al [24] presented a simulation model, in five alternative scenarios, aimed to minimize CO_2 emissions, as well as their cost, generated by road freight transport.

In terms of energy saving, article [25] presented a study of the effects of various governmental regulation policies on competition of green supply chains, by formulating twelve mathematical programming models using Stackelberg game between government and supply chains.

SCs modeling have implicitly contributed to the rise of climate change; moreover if the first SC models considered so far environmental constraints, perhaps the climate change could be likely mitigated from current events. In view of the models presented above, it's noted that the CEPLEX solver is the most used as a model resolution, and that CO_2 emissions is the most treated as an indicator or model environmental constraint, thus it's observed that most of works do not take into account simultaneously the three constraints: economic, environmental, and social, besides they have proved a certain willingness to promote the models of SC, or to propose new models, with a consciousness of environmental challenge.

On the other hand, the proposed models testify and approve the lack of a common model of SC modeling, whatever the tools and approaches, each researcher works on his own model, or improve another from a perspective; however, the environmental component will further complicate this lack.

3.4   Comparative Study
We summarize the methods and approaches of the above presented models proposed in this paper, depending on the field of application, in the below summary table (Table 1).

Tableau 1: Comparative table of the proposedmodels

Research works	Modeling		Environmental Constraints	Indicators	Resolution
	Type	Model			
	Agri-food				
Miranda-Ackerman, et al [8]	Analytic	Non-linear integer multi-objective model -Genetic algorithm and multi-criterion decision making tools	Eco-labeling Global warming potential	Global warming potential	M-TOPSIS
Hamid Allaoui et al, [11]	- Analytic -Simulation	AHP method and the agregation method (the ordred weighted method) MILP	Sustainability including carbon and waterfootprint	Economic environmental socials	LP Solver CPLEX Pareto
M. Balaji, K. Arshinder, [12]	Organizational	Total interactive structural modeling MICMAC (cross-multiplication impact matrix to a ranking)	Protection and conservation of environmental resources	-	-
Edgar H.et al, [10]	Analytic	Mathematical modeling	Objective integrating energy consumption	-	Genral Algebric Modeling System(GAMS)
J.G.A.J.van der Vorst D.et al, [9]	Simulation	A novel simulation environment	Logistic sustainability	-	ALADIN
	Automotive and chemical industry				

Gao, Jiyao., & You, Fengqi. [14]	Analytic	Stochastic model of mixed linear fractional programming	A function minimizing the environmental impact related to acquisition	GHG Emission	BARON 15
Bruna Mota et al, [18]	Analytic	ToBLooM (*Triple Bottom Line Optimization Modeling*) method, composed of a mixed integer linear multi-objective programming	Environmental impact assessment using the life cycle analysis method.	environmental Impact Social indicator based on GDP Economic	GAM 23.6 CPLEX 12.0
Ernesto D.R. et al, [15]	Analytic	Linear mixed-integer optimization stochastic model SMILP	Minimize CO2 storage	-	GAMS CPLEX
Helena Carvalho et al, [16]	Analytic	Mathematical modeling (maximize / minimize)	Minimize the negative environmental impacts of SC	-	-
Kartin a Puji Nurjanni et al, [17]	Analytic	A mathematical model of multi-objective optimization, MO the weighted sum method Tcgebycheffan d,	Minimize the total cost of CO2	Total Emission of CO2 Total cost of financial expenses	CPLEX v12.4 Solver for Microsoft Excel
Karine Dufoss et al, [13]	By simulation	GCM model (General circulation model)	Reduction of GHG emissions	GHG Emission (CO2/N2O) kg	GERES-EGC
Zhao R, et al, [19]	Analytic	multi-objectif Model MO	Minimize the inherent risk in handling hazardous materials, and the	Carbon Emission Inherent risk	Big Data analysis using SPSS19.0 softwar

			carbon emission		
	other fields				
V.Sanchez Rodriques et al [23]	By simulation	simulation Model , in five alternative scenarios	Minimize CO2 emission	-	EXCEL Solver
Zhitao Xu, et al. [21]	Analytic	Integrated linear mixed programming model (MILP)	Carbon Emission	-	GAMS CPLEX 12.5
Sunil Kumar Jauhar et al, [20]	Analytic	Linear mathematical model Fractional mathematical model	Maximize the global effectivness of sustainable chain	-	DEA method (*Data Envelopment*) ED method (*Differential Evolution*)
Coskun Set al. [22]	Analytic	Goal programming Model	Consumers segmentation, (green consumers, inconsistent consumers, red consumers)	-	ILOG CPLEX Solver

4. Conclusion

Considering examples cited in this paper, we can conclude that the reduction of costs is inseparable from the reduction of environmental impacts. Green SC management is attempting to increase economic returns by reducing the environmental impact. Indeed, several companies worldwide are increasingly moving towards action plans to protect the environment, through the adoption of the best standards, and environmental standards, including the modeling of green SC. In this paper we have focused on modeling green SC, by presenting a brief literature review, and in a second step we proposed models of green SC according to the fields of application. In perspectives we propose as future research works:

- Most models only take into account CO2 emissions, hence the need to generalize the

modeling by integrating all the environmental constraints arising from the supply chain.

- Establish a standard green SC modeling procedure, taking into account environmental analysis, regardless of the used approach or tool.

- Then we aim to propose to integrate social sustainability in the green supply chain modeling, taking as a starting point the research work of Tamara Popovic, & al, [26].

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