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Supply Chain Modeling and Green Supply Chain: Literature Revue

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Abstract

A green supply chain should be rethought towards the term greening, whereas greening concerns in particular the environment, a lot of research works has been carried out jointly on the supply chain and the environmental dimension, exclusively supply chain modeling. This article is intended to present, first of all a summarized literature review of supply chain, green supply chain, and its modeling. Many researchers have proposed different models of green supply chain, except that each model is specific to the studied supply chain. Tending to meet this challenge the contribution of this paper is to propose a general framework of the green supply chains modeling.

Keywords: Environmental impacts; green supply chain; supply chain; modelling.

1. Introduction

Today, man is supposed to be able to cope with the environment, He is the only one in charge of any harmful contribution to the environment, in particular the significant impacts of supply chains (SC). A green supply chain (GSC) requires using factors according to environmental imperatives, and also adopting sustainable development strategies[1].

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Coherent efforts are being made by global manufacturers in order to implement innovative and friendly environment technologies both in the SC process design [2]. In the literature, the concept of SC is treated in a different and varied way according to the structure, the classification and other factors, proposed by researchers as well as industrialists. Research in SC modeling has experienced a rapid evolution in recent years, as much as possible at the economic, social, technological, or environmental level, along with its modeling became an inseparable axis of its development. On the other hand the methods of modeling SC were improved in parallel dependence with the pace of tools and approaches' development imposed by research, and technological growth with the change in constraints resulting from the environment of the SC. A more simple, this evolution is muddled with innumerable problems, in particular those related to the environmental impacts of the "Green Supply Chain" which subsequently led to the massive use of researchers SC model carrying out to environmental constraint [3;4;5;6;2]. The majority of the research's work treats this topic taking into account only carbon emission [7;4,8;9;10] or greenhouse gas [11;12] and also renewable and sustainable energy[13;14] there is no overall work that gathers all environment dimensions.

This research aims to answer the following questions:

1) What's the difference between classical and GSC?

2) What are the types of modeling a SC?

3) How to model GSC, carry out all existents constraints?

Our contribution in this paper, is a systematic review of existing literature, that gathers all terminologies and definitions of SC, GSC, and identifies the difference between their modeling, Hence, the main objective of this paper is to build a standard model of GSC to be used henceforth, and which takes into account all the environmental constraints, and also to demonstrate its feasibility through an application of a case study.

The next section consists of an overview of a set of SC's definition and classification, followed by a general framework of the GSC. In Section 3, a literature review of SC modeling is presented in order to reflect current changes of research in this field. Section 4 presents the GSC modeling depending on some criteria., and we conclude by some perspectives that we have drawn.

2. Basic terminology and concept

Before starting the literature review, it turns out useful to define, and give a summary review of some key words to facilitate the understanding of the rest of the paper.

2.1. Supply Chain

The SC has evolved over time owing to the effort of some researchers who have focused their work on the study and resolution of problems related to the design, modeling and management of SCs, in particular to its diverse components. At first, the research mainly considered physical flows to manage a SC [15], thereafter economic

and technological evolution and many factors were taken into account, such as production and transport costs, customer-supplier relationship management ....Thus imposing the introduction of two other flows, informational and financial, "A supply chain is made up of two or more independent organizations, linked by physical, informational and financial flows "[16].

According to [17], SC can be defined as "a network of facilities that provides the functions of supplying raw materials, transforming these raw materials into components and then into final products, and the distribution of these final products to the customer ", and in terms of process approach, the SC of a final product for [18]" is defined as the set of companies involved in the processes of component sourcing, manufacturing, distribution and sales of the product from the first supplier to the ultimate customer ".

The structure of SC had developed in keeping with the types of manufacturing, and the perimeters of chain, and oriented in line with the modeling framework[19] ,it divided according to [20] to SC: Series, Divergent, Dyadic, Convergent and Network. Another classification: sequential or linear, divergent or distribution, convergent or assembly and network [21], these various classifications lead us to formulate a summary for each proposed category:

- Convergent SC: this type of structure is applied in the companies whose SC is based on the assembly process, in this case divers suppliers feed (e.g : automotive industry) ;

-Divergent SC: unlike the convergent SC, this type of structure is characterized by a diversification of customers and suppliers, which feed between them, it allows the modeling of the distribution network (e.g: the electronics industry) ;

- Network SC: It is the combination of the two convergent and divergent structures;

- Series / Linear SC: where the manufacturing process is linear and vertical, or an entity is feeded solely by another pole or entity.

- Dyadic SC: it consists of a single client (prime contractor), and a single supplier (subcontractor), it is a series-type but two-stage SC.

In addition to these classifications, the work of [22], divides the SC into three categories according to the type of flows. We summarize them below, under the diagram of figure 1:

CSC: continuous SC [22] defines this type of SC as "consisting of a set of continuous processes of production".

DSC: discrete SC, made up of a set of discrete processes ",

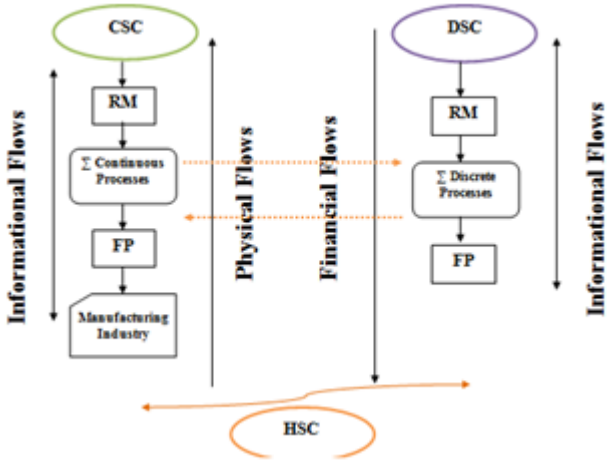

Figure 1: Example of supply chain classification

Except that" the transformation of raw materials into final products, is based on the “by lots” or “to unit" logics.

HSC: Hybrid SC, combines discrete and continuous processes", by exchanging information between the two processes.

We can conclude that the SC is a dynamic relationship linking at least three organizations through three types of flows: physical, information, and financial, and its management ensures the satisfying progression of the three main activities of organizations namely procurement, production, and distribution.

2.2. Green Supply Chain

Sustainable logistics has contributed, implicitly, to the advent of the term "green supply chain", "As for sustainable development, sustainable logistics is a discipline that takes into account economic, ecological and social constraints simultaneously, when drawing up logistics decisions " [23].The concept of green SC has entered the world of research since the 90s, due to the global climate change, pushing the state and other organizations to regulate industrial activities in terms of environmental protection, which in particular requires special attention to the harmful effects of environmental impacts, exclusively the decreasing of greenhouse gas emissions.

The GSC can be defined as a SC that integrates environmental axes in the logistics specifications, then ensures the respect of these axes throughout its activities (ecological activities), which among other things determines its relations with the suppliers in common agreement regarding environmental requirements. Its development is based on a set of factors including product lifecycle assessment, which requires the implementation of environmental impact assessment means on all members of the chain and ecosystems. In addition, reverse logistics approaches the study of a green SC in another way, considering a closed loop, and taking into account the environmental dimension during all the activities, including the product design, the choice of material sources, the production process, and delivering the final product to customer, up to and after the end of the product's life.

We present below a simplified diagram, defining the green SC.

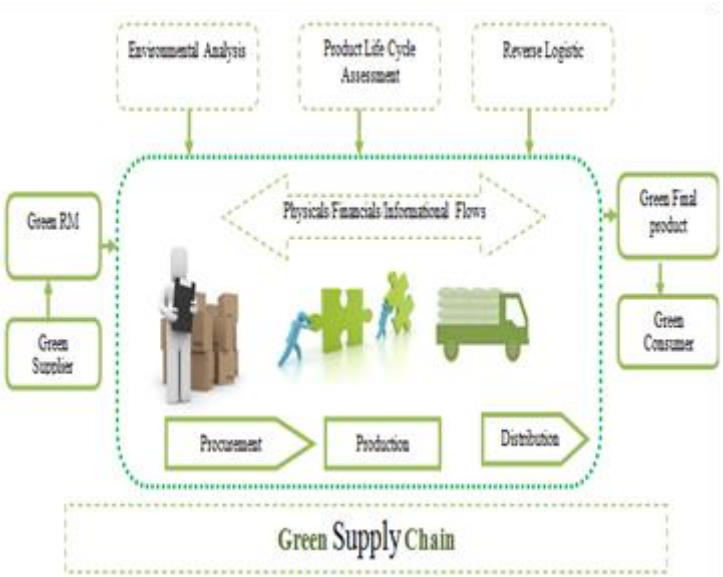

Figure 2: Example of green supply chain

3. Research method

This paper starts with terminologies and the different definition of the keywords of this work namely:

-Supply chain(SC)

-The green supply chain(GSC)

Then a literature review on SC and GSC modeling according to the type of modeling and the environmental aspect taken into account in the modeling, including a new approach of modeling a SC, in the framework of integrating the environmental constraints. An illustration of this approach is also presented as an industry case study, generally addressed to demonstrate the feasibility of the proposed approach this work is intended to show

The structure of our work is shown in the following flowchart.

The research material was selected from the two kinds of literature: professional and scientific, we utilized the professional literature to make a relevant review, because the extensive review in modeling SC and GSC, based on the scientific literature is very limited, we selected works from conference paper, thesis, records, and textbooks obtained from professional organizations like “The Technology Press of MIT”, “Center for Electronic Commerce Final Report”. On the other hand, for the scientific literature we used the most popular web search “Science Direct”, and also “Google Scholar”, the mainly chosen key words are: “Supply chain”, “Supply chain modeling”, Green Supply chain modeling”. The table below (table1) shows the list of utilized scientific journals in this literature review.

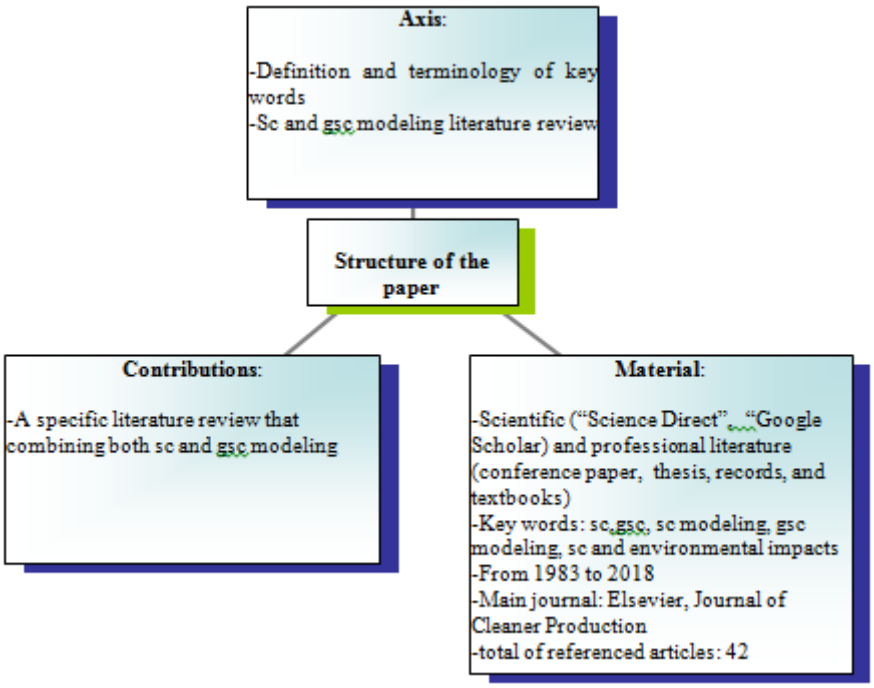

Figure 3: Flowchart of the structure of the paper

We have proceeded to an iterative process, choosing terms related to the SC and its modeling, as well as the GSC, by using Boolean operators such as (AND & OR). In parallel we have used inclusion and exclusion criteria to cover all the literature offered since 1983:

Table 1: List Of Scientific Journals And Related Articles (1989–2018).

Date of articles	N° of journal	Name of the journal	N° of articles
2013-2015-2016-2017	1	ELSEVIER	10
2013-2015-2017-2018	2	Journal of Cleaner Production	5
1996-2017	3	European Journal of Operational Research	3
2002-2017	4	Computers and Industrial Engineering	3
2015-2017	5	Computers and Operations Research	2
2016	6	Journal of Production Economics	2
2017	7	Sustainable Production and Consumption	1
2017	8	Resources, Conservation and Recycling	1

2016	9	Environmental Science &Technology	1
2017	10	Renewable and Sustainable Energy Reviews	1
2017	11	Omega	1
2017	12	Computers and Chemical Engineering	1
2016	13	Journal Européen des Systèmes Automatisés	1
2016	14	Robotics and Computer Integrated Manufacturing	1
2015	15	Procedia Economics and Finance	1
2012	16	Global Journal of Flexible Systems Management	1
2003	17	International Journal of Production Research	1
2000	18	Maintenance & Entreprise	1
1998	19	International Journal of Production Economics	1
1993	20	Operation Research	1
1991	21	Journal of Manufacturing Systems	1
1990	22	Computers in Industry	1
1989	23	Production and Inventory Management Journal	1

The next section shortly discusses previous pertinent research, tackles in particular the topic of modeling SC. To do so, we classified the literature into two major groups SC modeling and GSC modelling.

4. Supply chain modeling

4.1. The Modeling

"Modeling is a representation process that allows obtaining an approximate image of the real system further to an abstraction phase. This process facilitates the study and the comprehension of systems "[24]. Indeed the Modeling of a system requires "the definition of many simplifying hypotheses". Quite simply, "Modeling is the action of representing by a language and/or an adequately formal method, a reality observed by the modeler, so

simple precise and understandable "[25]. Modeling, in summary, is to redefine a system by observation, schematizing it, using different approaches, and based on many assumptions conditioned by the real system.

4.2. Supply Chain Modeling

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

In logistics, Reference [26] has chosen to classify SC models into four categories: deterministic, stochastic, economic and simulation. There is also another classification proposed by [27]: analytical models (deterministic or stochastic), hybrid models (dynamic, often use simulation), IT models (optimization models, based on computational methods integrated in management software packages).

Notwithstanding, several researchers have agreed that SCs modeling can be divided into three main categories: organizational modeling, analytical modeling, and simulation modeling [24,28,29,30,31], adopting this classification, we propose a review in a detailed identification of the abovementioned type of modeling in the next section.

- Analytical Modeling

"Analytic models describe a system by a set of equations governing its operation; either deterministic (all parameters of the models are reputed known) or stochastic (some parameters are uncertain and follow a law of probability) »[15], a hierarchical vision, the work of [32] classify analytical models into two levels: operational, and strategic. In terms of information sharing in a SC [33], refers us to three different paths, either remedy mathematical theories or to validate the model with random data, and lastly to share information using game theory. A decomposition, of SCs analytical modeling approaches', adopted by [34] "The Control theory and the Operational Research". Otherwise [28] proposes two approaches of analytical modeling: "actor approach" and "control theory".In control theory, SC modeling is based on differential equations. Among other things, it relies on assumptions of linearization of behavior, which requires an adaptation of conditions of the real model [30]. Most of the works that used the control theory, are dedicated to tactical planning [35;15]. Elswhere operational research is a set of scientific methods of solving physical problems, translating them into mathematical problems, by maximizing or minimizing an objective function, specific to the problem to be solved, and thereafter interpretation of the results, helps decision making. Or else at first, it's "a scientific method intended to provide to the executive departments a quantitative basis for the decisions related to operations under their control" [36]. On the other hand [30] defined "Operational research" as it is based on optimization theories, game theory, statistics, algorithmics and it applies to linear and nonlinear systems. This method does not take in consideration time, which makes the dynamic behavior modeling of the entities difficult to express ".In the SCs analytical modeling context, we referred to a some works that used operation research especially transport problems [37;38]. Among the least used methods we cite the game theory, it is a decision support method, by

analyzing elements behavior, related to the decision-making process, we differentiate between two types of games. Cooperatives are based on the cooperation value, by creating a cooperation between the players, without identifying the specific actions to be undertaken, which allows to analyze the interactions and the contribution of inter-company cooperation at the strategic level. While non-cooperative games are used to model the effects of decentralized decisions on the chain's performance at the tactical and operational levels [33].

Henceforth, the analytical modeling is mostly limited, since it requires on the one hand a simulation, to well visualize the system behavior. This simulation is sometimes impossible to implement, on account of the difficulty of finding equations between variables of the studied system. Simulation models are generally used when it is difficult to come across a relationship between different variables and therefore it's inappropriate to transform them to an analytical model [15].

- Simulation Modeling

SC simulation modeling emerged since the 1990s as an effective approach of analysis and detailed evaluation of SC design and management problems [39]. For [40] simulation modeling is divided into dynamic and static models, it could be achieved using four approaches: Spreadsheet simulation which has appeared in logistics field, with the aim of strengthening MRP calculators for logistics management [41], models using spreadsheet are now very poorly suited to complex systems, such as SCs [42]. , then the systems dynamics approach which allows solving and analyzing complex problems in industrial control and management, in particular it permits to treat the problems related to the interactions between information flows, money, orders, materials, personnel and equipments in a company, industry or national economy. But it does not grant the consideration of stochastic aspects, so it is inadequate to analyze the impact of hazards on the system (eg failures, random arrival of orders, etc.) [43], thirdly the discrete events approach, discrete event simulation models relies on two approaches: agent and object [44], lastly the business games whose model is represented in a form of interaction between players who represent companies and their contestants in terms of competition. In the sense of information sharing [33] has presented a list of methods and tools used, by the simulation approach, namely: the flows discrete event simulation, multi-agents, Systems Dynamics, Matlab, Simulink, Genetic Algorithm, C ++ Oriented Object Language.

Matlab and CPLEX are among the most used software [45;46;47;48] the multi-agent system based on the discrete event approach is also frequentely used [49].

- Organisational modeling

"Organizational models offer a representation that do not allow obtaining a behavioral evaluation of the system over time, facing the environmental stimuli"[15] a definition given by [30]. "Modeling approaches, derived from business organization theory, represent the organization from its entities, activities, processes, functions, structure, and it behavior."[50]. And [51], have proposed a decomposition into two approaches of this type of modeling namely: Hierarchical approach (Cartesian approaches[52])., Systemic approaches[53]), and Heterarchic Approach Heterarchic View [54]., The Process Approach [55], The Holonic Approach [56],

Emerging Approaches [57], the multi-agent approach). Among commonly used methods and tools in this field of modeling, we cite the multi-agent approach and the agent-oriented approach are [30;28;58;59], "ArchMDE" methodology [60;61], the UML language [62].

Recently a simple conceptual model KSA (knowledge skills attitudes) model is applied in a SC, in order to show the importance of collaboration between partners in a SC [63].

5. The green supply chain modeling

The green SC modeling is none other than the SC modeling by integrating the environmental constraints, regardless of the type of modeling (analytical, by simulation or organizational), it can be applied at all decision-making levels, in addition the level of complexity of creation or resolution of the models increases, on the one hand the environmental constraints can be treated qualitatively, or quantitatively, and on the other hand the modeling must be based on concrete results of the environmental analysis of the aforementioned SC. A summary bibliographic study specific to green SCs modeling, or to SC modeling integrating constraints in environmental order, is proposed in the next section.

5.1. The environmental impact of CO2 emission

CO2 emission has become a major factor to be taken into consideration in sc modeling [64], towards the imposition of CO2 emission price policy [65] because it generates very significant costs compared to the size of the studied sc [8] on the one hand and according to its type in particular the case of closed loop SC [4]. In addition activities related to transport in a SC was the subject of a panoply of research works, in terms of CO2 emission reduction, in the port area [9], a specific example of cement industry [38] CO2 emission is also evaluated with emphasis on cost of CO2 and CO2 emission, in order to identify its impact on the total costs of the SC [66].

5.2. The Environmental Sustainability of Supply Chain

A sustainable SC requires the validation of the criteria related to the respect of the environment, in one side and to ensure the concept of sustainability, whether in relation with the customer or supplier [64]. Life cycle assessment is one of the methods to evaluate the sustainability of the SC [11;67;68,69], trough the assessment of environmental impacts, as an example of impacts to be identified, the potential of global warming [70]. By the same token, the improvement of the sustainable SC performance is a perspective and an ultimate goal for Practitioners, and academicians [71]. Indeed a recent work [72] have proposed a sustainable SC performance model in a theoretical framework. Much less, the evaluation of the competitiveness of a SC is based on the following elements: quality, costs, financial results, while the competitiveness of sustainable SC must imperatively be based on the reinforcement of environmental sustainability [68].

5.3. Green Quality of Product

A product is obtained from a sequence of steps of SC, and it must obey the customer’s expectations, so that it’s

sold. Currently the concept of green quality of product is important criterion throughout the product manufacturing process, as it becomes a sale force variable decision [5]. More and more, consumer consciousness has become a key element for measuring economic and environmental benefits [6], it is considered then, as a constraint of recently proposed models, in terms of green quality of product, the example of [3] who chose to segment it into three categories green consumers, inconsistent consumers, red consumers,

The table below summarizes all environmental dimensions, mentioned in this paper according to the field of application with references.

Table 2: Set of relevant research works, that takes environmental constraints according to the field of application

Field of application	**Environmental dimension**			**Reference**
	CO2 & GHG	**Sustainability**	**Green product**	
Industry	✓			- Ernesto D.R. and his colleagues (2017) ;Kartina Puji Nurjanni and his colleagues (2016) ;
	✓	✓		- Gao, Jiyao., & You, Fengqi. (2017); Yue and his colleagues (2016)
		✓		-Bruna Mota and his colleagues (2017) ; Leone Peter Correia da Silva Andrade, (2016) ; Shibin, K.T. and his colleagues (2017)
			✓	-Zahra Basiri, Jafar Heydari, (2017) ; Dai R and his colleagues (2017)
Agri-food	✓			-Validi and his colleagues (2012) ([73]).
		✓		-Miranda-Ackerman, and his colleagues (2017); M. Balaji, K. Arshinder (2016).
		✓		
Other field	✓			-V.Sanchez Rodriques and his colleagues (2015) ; Malek Abu Alhaj, (2015) ; Abderaouf Benghalia, (2016)([74])
			✓	- Coskun S and his colleagues (2015)

Figure 4: Geographical distribution of articles

6. Conclusion

Through this paper a general academic literature framework of SC, and an introduction to GSC topics are presented, in addition to a literature revue including a set of example of SC and GSC modeling, which again emphasizes gaps in this field of research, in particularly, in terms of integrating environmental constraints in SC models, and carrying out new resolution approaches and methods. Indeed this approach contributes to find out a general framework of GSC modeling. Therefore, the proposed framework could serve as a starting point for academics to support research on GSC modeling .Our perspective is to perform an example of a model of GSC, or else to deal with an approach for GSC model and resolution. And we propose to link this model to lean SC as it has been proposed in some research works, to more sophisticate the model of GSC [75;76].

7. Recommendations

The mathematical modeling is highly recommended for modeling industrial supply chain in combination with MCDM method, in the case of complex supply chain.

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