



Using Multi Agent Systems in Green Supply Chain

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Abstract: *the Green Supply Chain Management (GSCM) is one of the key concepts that organizations need to implement in order to reduce the environmental impact of their activities due to the increase of environmental awareness. However, its implementation is full of constraints in terms of the coordination and collaboration between all stakeholders. Therefore, many GSCM models and frameworks, like the multi agent systems (MAS) are proposed to reduce the complexity level in the Supply Chain. The main objective of this paper is to study the multi agent systems usage for GSCM modelling. The used research methodology is based on a literature review of 50 articles published between 2012 and 2019 in 10 different journals. 5 articles are selected out of 50 because of their accordance with the research subject. The contribution of this paper is to show the benefits of using multi agents systems for GSCM modelling problems.*

Keywords : Supply Chain Management, Green Supply Chain Management, Multi agent systems.

I. INTRODUCTION

In order to increase their competitiveness in global markets, organizations search for enlarging their supply chain around the world, this situation lead to an increase demand of natural resources. Moreover, the increasing attention from customers, stakeholders, governments and environmental organizations push companies to consider environmental impact of their activities. [1] For this reason, companies started to integrate new concepts like GSCM in order to improve their environmental responsibility and make the use of natural resources more rationalized.

Several research works propose dozens of practices of GSCM that can be adopted to improve the Supply Chain performance, but their implementation is full of constraints. As a result, several implementation models such as Multi agent system for GSCM are proposed to facilitate this transition. This research paper intent to answer the following research questions which provides a better understanding of

multi agent system usage in GSCM.

Q1 : to which extent the multi agent systems are used to address GSCM topics ?

Q2 : which methodologies are used to design a MAS architecture in GSCM field ?

The organization of the paper is the following. Section 1 presents the theoretical framework, which consists of GSCM and MAS definition. Next, section 2 discusses the adopted methodology to establish this literature review. Section 3 presents the findings of this review. A discussion of the found results is the subject of Section 4. Finally, the paper summarizes the main ideas, precises the contributions and provide a recommendation for future researches.

II. THEORITICAL FRAMEWORK

A. Green Supply Chain Management

Many definitions of the GSCM are provided in the literature, the most used ones define this concept as the consideration and the integration of environmental thinking in the Supply Chain, which include product design, raw materials sourcing, manufacturing process, delivery process to customers and product management after its lifetime [2]. Many GSCM definitions address both economic and environmental considerations, they also highlight the key role of coordination between partners and flows to implement the GSCM successfully. In addition, researchers distinguish between a pure reactive environmental practices and proactive program management. [3]. Therefore, the GSCM is a concept that has evolved a lot in recent years.

The GSCM covers many practices and activities like green design, green procurement, green manufacturing, green distribution and reverse logistics [2].

These activities encompass all processes in the supply chain, from green procurement (supplier selection, raw material selection, etc.) to green manufacturing (green design, waste reduction, energy reduction, etc.) up to the ecological logistics, recycling and waste management products. Green procurement can be defined as an environmental purchasing, consisting of activities like recycling and reuse of materials in the purchasing process. Green manufacturing is a production process with low environmental impacts and with less waste or pollution. Green distribution covers green packaging and green logistics. Quality packaging and loading models will significantly reduce the use of materials and space in the warehouse. [4]

B. Multi agent systems

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Multi agent system is a system composed of many agents, which take some specific and dedicated roles. They can interact with each other to solve problems, which exceed the capabilities and the knowledge of an individual agent [5].

These interactions can be simple information exchanges, but also demand for particular actions, cooperation, coordination and negotiation to manage interdependent activities [6]. Many researches advise that agent based models are the most appropriate ones for domains and systems characterized by high degree of location, distribution and dominated by discrete decision [7]. The Supply Chain network has the same characteristics as a multi agent system. In fact, the Supply Chain is composed of several autonomous participants who play specific roles. [8]

Each Supply Chain participant should have its own resources, skills and abilities to perform certain tasks and roles to make products conform to the customers' requirements [9].

Participants in the Supply Chain have basic skills and each of them can neither perform all the activities of the chain nor solve all the problems. Multi-agent systems are identified as a modelling methodology for supply chain management, which aims to deal with bullwhip effects, poor communication results, and poor coordination between members of the supply chain [10].

III. RESEARCH METHODOLOGY

The adopted research methodology is to build a literature review to bring knowledge on this topic based on already existing literature [11]. The objective is to show to which extent multi agent systems can be used in the GSCM modelling. 13 per reviewed journals are analyzed within a time frame of six years (2012 – 2019) and the search was done using keywords on Green Supply Chain, Sustainable Supply Chain and Multi Agent Systems. The result of the initial research give a total of 50 articles and 15 articles were selected based on their title. From these 15 articles, 5 articles were selected because of their accordance with the focus and objective of the study. To the best of our knowledge, these articles are the only ones, which used a multi agent approach

in the context of Green Supply Chain Management within the pre-defined period. A literature review was done on these 5 articles to address research questions.

IV. FINDINGS

The overview of the five analyzed articles with their respective methodologies and findings are given in table I.

V. DISCUSSION

The Supply Chain network has the same characteristics as a multi agent system. In fact, a supply chain is composed of several autonomous participants who play specific roles along the chain [8]. However, very few studies are used multi agent systems to address GSCM topics [12]. To the best of our knowledge, the above-mentioned researches are the only ones, which considers applicability and suitability of multi agent systems in GSCM field. In addition, only 2 studies out of 5 which developed an integrated framework for the whole Supply Chain, and one of them considers only the context of Small and Medium Enterprises (SMEs). The result of the analyzed articles shows that MAS is able to solve communication and complexity problems in the GSCM field and it helps to introduce sustainability parameters such as the environmental concern into the closed-loop Supply Chain processes.

Concerning the MAS design methodologies, the most used one is the Foundation for Intelligent Physical Agent (FIPA), which consists of definition of the agent architecture and then use of FIPA protocols for the communication and interaction between agents. Multi Agent Logic Language for Encoding Teamwork (MALLET) is an agent language framework, which facilitates and manage agent activities via the proactive exchange of information [17]. ANEMONA is a MAS methodology for holonic manufacturing systems (HMS) design and analysis based on agent notion and HMS requirements [18].

Table- I: Overview of the articles in the literature review.

Authors	Year	GSCM process	Paper type	Description	MAS methodology & communication channel	Findings
Mishra, Kumar and Chan [12]	2012	Reverse logistics	Case study with empirical analysis	Solve the complexity of including waste management and recycling in the GSCM	MALLET	Decision framework from waste collection to the distribution of the recycled components to manufacturing



Fu-Shiung Hsieh [13]	2015	All processes	Case study with empirical analysis	Propose a framework to configure sustainable Supply Chain network quickly and efficiently.	FIPA	MAS helps to solve scheduling problem for sustainable supply chain.
Giret and Salido [14]	2017	Green manufacturing	Case study with empirical analysis	Develop Sustainable manufacturing system platform supported by intelligent software agents	ANEMONA	MAS help to include sustainability in manufacturing systems
Ghadimi, Toosi and Heavey [15]	2018	Green procurement	Case study with empirical analysis	Structured information exchange processes to make better sustainable procurement decisions by maintaining a long term partnership between the manufacturer and its suppliers.	FIPA	MAS is able to reduce communication and information exchange problems in the sustainable suppliers selection process
A, Ben Mekki, J. Tounsi, L. Ben Said [16]	2019	All processes	Research paper with conceptual model	Intelligent dynamic system based on agents interaction to study sustainability in the context of SMEs	FIPA	MAS helps to highlight the sustainability assessment process in SME context

VI. CONCLUSION

In this paper, we present a literature review on recent studies using multi-agent systems in the field of GSCM. The work proposed in this paper attempts to establish a literature review within a period from 2012 to 2019. 5 articles were selected out of 50 and help us to show the benefits of using multi agent systems in GSCM. It was also noticed most of the existing works do not integrate all the GSCM processes and focus only on some dedicated ones. In conclusion, the proposed work can provide a good methodological basis for solving the GSCM modelling and collaboration problem based on the multi agent approach. The proposal of other frameworks based on the multi-agent approach can be proposed as a perspective for future research.

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