

# Modeling the Adoption of Sustainable Practices in the Supply Chain: A Game Theory Approach

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**Abstract**—One goal of the 2030 Agenda for Sustainable Development of the United Nations is strengthening the means of implementing and revitalizing the Global Partnership for Sustainable Development. So, the adoption of sustainable practices into the management and operation of supply chains is a big challenge that companies need to face. However, the research in this area has mainly been qualitative and the developed models do not take into account the social pillar of sustainable development. The aim of this paper is to develop an agent-based model to analyze the factors that mainly influence the interactions among the functional companies of supply chains for the adoption of sustainable practices considering social aspects. First, we develop a conceptual model about the interactions among companies of supply chains based on the pair wise Prisoners Dilemma game and the game-dynamical replicator equations for multiple populations. Then, we implement the model using NetLogo™ software. We design some scenarios varying factors to analyze how the adoption of sustainable practices evolves in time. We prove that the interactions between companies that do not prefer to adopt sustainable practices with those who have already adopted the practices influence the decision to adopting such practices in a positive way. Our results provide a game theoretic model for sustainable supply chains.

**Index Terms**—supply chain, agent-based modeling, game theory approach, simulation, sustainability, 2030 agenda

## I. INTRODUCTION

The 2030 Agenda for Sustainable Development of the United Nations [1] is an action plan for people, planet and prosperity that consists of 17 Sustainable Development Goals, namely: no poverty, zero hunger, good health and well-being, inclusive and equitable quality education, gender equality, clean water and sanitation, affordable and clean energy, sustainable economic growth, full and productive employment and decent work for all, building resilient infrastructure, reducing inequality, making cities sustainable, ensuring sustainable consumption and production patterns, taking urgent action to combat climate change, conservation and sustainably use marine resources, protecting, restoring and encouraging the sustainable use of land ecosystems, promoting peace and inclusive societies for sustainable development, and, last but not least, strengthening the means of implementing and revitalizing the Global Partnership for Sustainable

Development. In the case of supply chains, the integration of sustainability issue in its operation and management is a big challenge in the new global business.

From the systemic perspective, the supply chain is a complex system made up by large numbers of adaptive companies at multiple scales that interact in parallel interchanging information, materials and capital. From such interactions arise global patterns of self-organization that let to companies be collaborative and cooperative. Collaboration as a requirement to implementing sustainable management approaches, may contribute to inter organizational dynamics by strengthening the knowledge absorption capacity, structuring solutions, and motivating activities around a commonly defined goal [2] such as the adoption of sustainable best practices in supply chains which are based on economic, environmental and social aspects. Complex systems are distinguished by the extensive use of computer simulation as a research tool. Several scholars have studied supply chain problems based on a complexity approach [3] - [6] but in the case of sustainable supply chain the existing models do not take into account the social aspects [7], [8]. The aim of this paper is to develop an agent-based model to analyze the factors that influence the interactions among companies of supply chains to adopting sustainable practices in their management and operation. The paper relies on standard game theoretic modeling techniques but we make a novel applications in the field of sustainable supply chains where researchers just integrate economic and environmental aspects using traditional theoretical tools.

This paper is prepared as follows: a conceptual model about the interactions among companies of supply chains based on the pair wise Prisoners Dilemma game and the game-dynamical replicator equations for multiple populations is developed in Section 2. An agent-based simulation model about the adoption of sustainable practices is implemented using NetLogo™ software and it is presented in Section 3. The simulation results are analyzed in Section 4. Concluding remarks are drawn in Section 5.

## II. CONCEPTUAL MODEL DEVELOPMENT

### B. Design Formulation

Companies of a supply chain are modeled as agents that interacts each other. The rules of interactions are

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