

Simulation Model for Optimizing Energy in Supply Chain Management

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Abstract—In today's world, with increasing environmental awareness, firms are facing severe pressure from various stakeholders, including the government and customers, to reduce their harmful effects on the environment. Over the past few decades, the increasing effects of global warming, climate change, waste, and air pollution have increased the global attention of experts to the issue of the green supply chain and led them to the optimal solution for greenery. Green supply chain management (GSCM) plays an important role in motivating the sustainability of the organization. With increasing environmental concerns, the main objective of the research is to use system thinking methodology and Vensim software for designing a dynamic system model for green supply chain and observing behaviors. Using this methodology, we look for the effects of a green supply chain structure on the behavioral dynamics of output variables. We try to simulate the complexity of GSCM in a period of 30 months and observe the complexity of behaviors of variables including sustainability, providing green products, and reducing energy consumption, and consequently reducing sample pollution.

Keywords—Supply chain management, green supply chain management, system dynamics, energy consumption.

I. INTRODUCTION

THE term sustainable supply chain or green refers to the integration of sustainable environmental processes into a traditional supply chain. This can include processes such as material selection and purchase, product preparation, product design, product production and assembly, product distribution, and end-of-life management [7]. Undoubtedly, air and water pollution reduction and waste management is the main goal of the green supply chain. Green operations examine companies' performance in terms of less waste generation, reuse and recycling of products, and reduction of production costs [4], [5]. Green supply chain can reduce environmental pollution and production costs, and can also lead to economic growth, create a competitive advantage in terms of greater customer satisfaction, a positive image and business reputation, and a better opportunity to export our products to pro-environment countries. The idea of green includes innovations and new techniques to protect environmental sustainability that can be achieved through corporate social responsibility, green production, waste reduction, recycling and rebuilding an environmentally friendly supply chain [14].

The rapid growth of industry and industrial development endanger the natural environment of the country. Also, the use of inappropriate and outdated technologies as well as

inefficient management in industries has led to excessive consumption of primary resources. The severity of environmental pollution caused by waste materials in cities and industrial centers is such that it has attracted scientific and executive attention for proper disposal, or principled recycling of these materials. Today, ensuring the sustainable development of any country depends on the conservation and optimal use of limited and irreplaceable resources in that country. Various measures and decisions have been taken in this field, including green laws and principles, such as the use of environmentally friendly raw materials in production and industrial centers, reducing the use of fossil and oil energy resources, recycling paper and reusing waste. The pressure of government regulations to adopt environmental standards and the growing consumer demand for natural (green) products has led to the emergence of a new concept of GSCM, which includes product life cycle stages from design to recycling in a way that is compatible with the environment [17].

The importance of GSCM goes beyond preventing the use of toxic chemicals or reducing the release of pollutants into the environment. GSCM principles can be applied to all parts of an organization and all tangible and intangible areas.

The benefits of complying with the GSCM can be divided into three categories: 1- material benefits, 2- intangible benefits, and 3- emotional benefits. 1) Material benefits: Reducing the environmental burden on the environment, reducing the costs of suppliers, producers and customers and reducing energy consumption and resources in society are considered material resources. 2) Intangible benefits: Among the intangible benefits of GSCM are ease of access for producers, customer satisfaction and better satisfaction of social needs. 3) Emotional benefits: Better image for suppliers and manufacturers, better feeling and improved quality of life for customers, and forcing different industries to accept responsibility towards society, are among the emotional benefits of GSCM.

A. The Role of Success Factors in GSCM

There is no doubt that green supply chain is a relatively new idea, which gains its popularity when it improves environmental performance throughout the chain. Here are six key success factors for achieving GSCM to achieve better environmental sustainability [2], [3]. We have identified these dimensions: 1- Ethical leadership/internal management, 2- Customer management, 3- Supplier management, 4- Competitiveness, 5- Monitoring, 6- Social responsibility [24].

Ethical Leadership/Internal Management

Internal management includes the support and

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encouragement of senior executives. Internal management is a very important factor in the success of companies to adopt green processes. Employee pressure creates, encourages and supports environmental protection that motivates senior managers. At the same time, understanding the environmental risks involved can make a positive difference in green practices.

Customer Management

In the green supply chain, customers play an important and effective role. In fact, firms in developing countries are under heavy pressure to adopt green practices in their supply chain activities in order to be present in a competitive market in order to meet customer demand under the heading of demand-driven demand [8], [9]. Working with customers is very useful for achieving fruitful benefits in GSCM [17], [18].

Supplier Management

Green supply chain practices are not possible without the active participation of customers and suppliers. Intense collaboration with suppliers strengthens incentive systems and leads to the adoption and development of innovative environmental ideas [10], [11]. Technologies, green partnership agreements may increase operational and environmental performance to achieve the economic goals of enterprises. The selection of these suppliers is of special importance [1], [4].

Competition

A number of published studies have shown that competence and related elements can play a role in implementing green methods in their supply chain. Competitiveness is considered one of the key points of organizations to support the sustainability of green environment [6].

Social Responsibility

A number of researchers recognize the importance of social factors in achieving the goals of environmental friendliness. As regulators grow and customers become more aware of the environment, companies are forced to provide final information about the impact of their supply chain operations on the local community and people's lives [22], [23]. In addition, NGOs, electronic and social media are more effective in pressuring firms to adopt green practices [19], [25].

Monitoring

The growing importance of environmental concerns has led regulators to tighten their environmental laws and policies. Government agencies have enacted strict environmental laws to control climate change, global warming and pollution. And companies have a responsibility to reduce the negative impact of their supply chain on environmental sustainability [26].

II. LITERATURE REVIEW

A significant part of studies on environmental issues in the supply chain represented that customers and partners tried to improve environmental performance. In an article, Zhou and

Sarkis examined the performance of companies and customer-centric management in green supply chain management. The results of this study show that green supply chain management improves the environmental performance of organizations [22], [21]. In fact, the basis of the green supply chain is the integration of internal and external actions to control environmental effects in the product life cycle through information sharing, coordination and collaboration with all members of the supply chain. Green supply chain management integrates supply chain management with environmental requirements in all stages [26].

Internal and external actions in the supply chain include product design, selection and supply of raw materials, production and manufacturing, distribution and transfer processes, delivery to the customer and finally after consumption, recycling and reuse management [10]. Green supply chain management can be defined as a subsystem of the sustainable supply chain combined with Inter-organizational supply chain management techniques [17], [25].

The purpose of green supply chain management is to manage the environment through environmental cooperation or through better analysis of bilateral issues and reduce environmental risks in supply chains [20]. Soring analyzed the concept of integrated supply chain management to reduce environmental requirements in the textile industry. In order to make progress in participation with business partners, transparency in organizational areas is needed. External participation refers to a higher level of supply chain management [12].

At GSCM, all suppliers are environmentally friendly. They help to use it with the right raw materials' adequate green plans and green measures. A green group can be members of a green chain from an environmental perspective and benefit the economy. Gao [5] indicates that organizations in Southeast Asia which have inbound/outbound logistics tend to use environmentally friendly raw materials. This process leads to green production and finally cleaner production and prevents waste of resources. Such motivations lead to improvements in environmental performance supply chain management.

Green has enhanced efficiency and coordination among business partners [9].

External green cooperation has a positive relationship with green performance in the organization. The only way for organizations to do serious research for sustainability to operate is to integrate the entire supply chain. In sustainable operations management for achieving economic, social and green goals, the concept of "Green supply chain management" is important [21].

Zhu proposed concepts of environmentally friendly management. Biology and their relationship with supply chain management practices such as vendor evaluation, participatory supply strategies, environmental policy development procurement were described [18].

Kumar conducted research entitled "Green Supply Chain Management" that employs green supply chain in manufacturing industries in India [16]. Execution methods of

GSCM of 14 factors consist of: eco-friendly accounting, logistics design environment, environmentally friendly product design, eco-friendly production, marketing and communications, economic performance, environmental performance, customer cooperation, human resources and technical, internal environmental management performance, operational performance, stakeholders, and vendor management [23].

Mangela also indicated that several rules for success are in environmental design; such as, not using toxic substances; minimizing the consumption of energy and resources in the production and transmission stages, increasing lifespan for products with significant environmental impacts and designing products that can be easily repaired [13].

Researchers also with decision making model and the complexity of green supply chain management for adopting an environmental technique have helped to study in this field [15]. Review of comprehensive articles approves the relationship between internal actions of the green aspects in the green supply chain management.

Generally, green supply chain management is defined as a subsystem of the sustainable supply chain that can be combined with environmental issues, inter-organizational supply chain management techniques, including reverse logistics [21], [22].

III. METHODOLOGY

Simulation of the model was conducted using Vensim PLE, a fully functional system dynamics software package from

Ventana Systems, inc. (Harvard, MA, USA). The unit time frame selected was a month, and the model was run over a period of 30 months, representing a medium-term security planning horizon. Attempting to simulate for longer periods would entail greater uncertainty and less meaningful results because longer term predictions are difficult to accurately make in distribution industry. The model was run under variety of conditions to understand the impact of different green supply chain investment policies in distribution industry. This was done to help managers make effective decisions concerning green supply chain platforms.

IV. SIMULATION MODEL

The model was run under variety of conditions to understand the effects of multiple variables in the supply chain. Many variables such as optimizing energy consumption, sustainability, providing green products, consequently reducing pollution variables were tested in the model. The behavior of the variables in the output graphs of the simulated model is depicted in Figs. 3-5.

Modern technology such as mobile application, social media, artificial intelligence, behavioral marketing leads to optimizing production time. Distributed warehouse, inventory adjustment, delivery time variables were tested in simulated model. In this simulated model we saw reduction rate in failure rate and lead time variables.

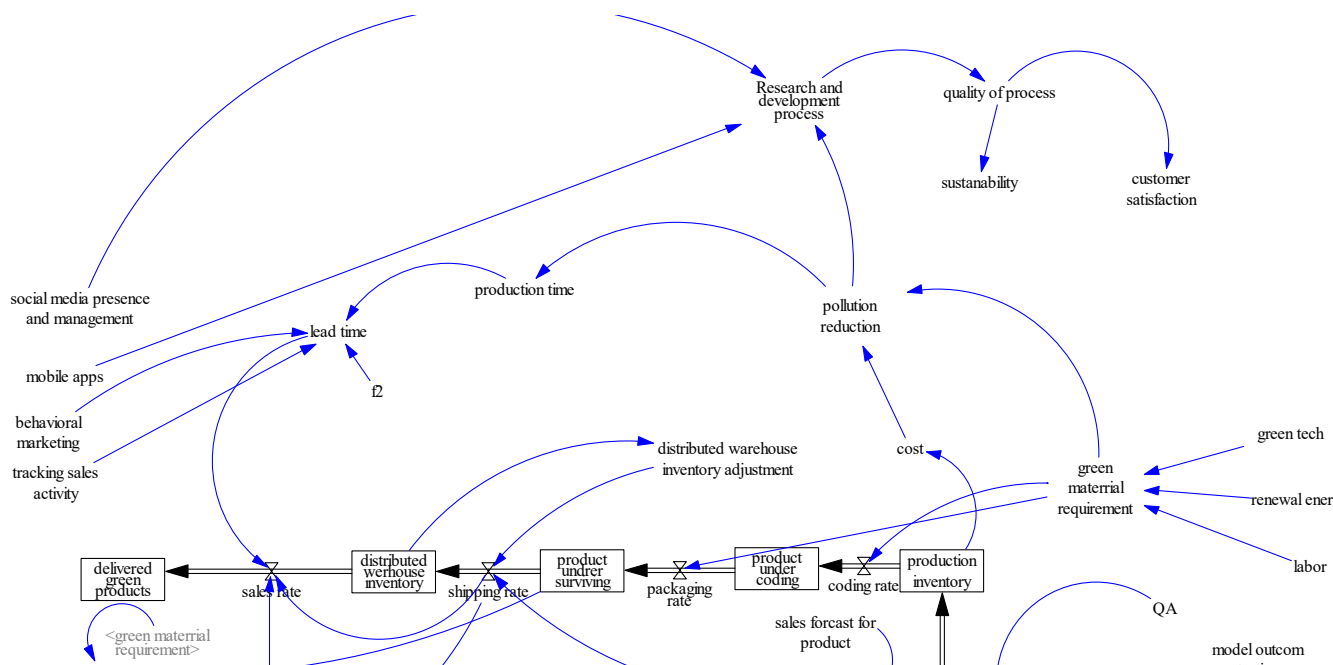


Fig. 1 Green supply simulation model

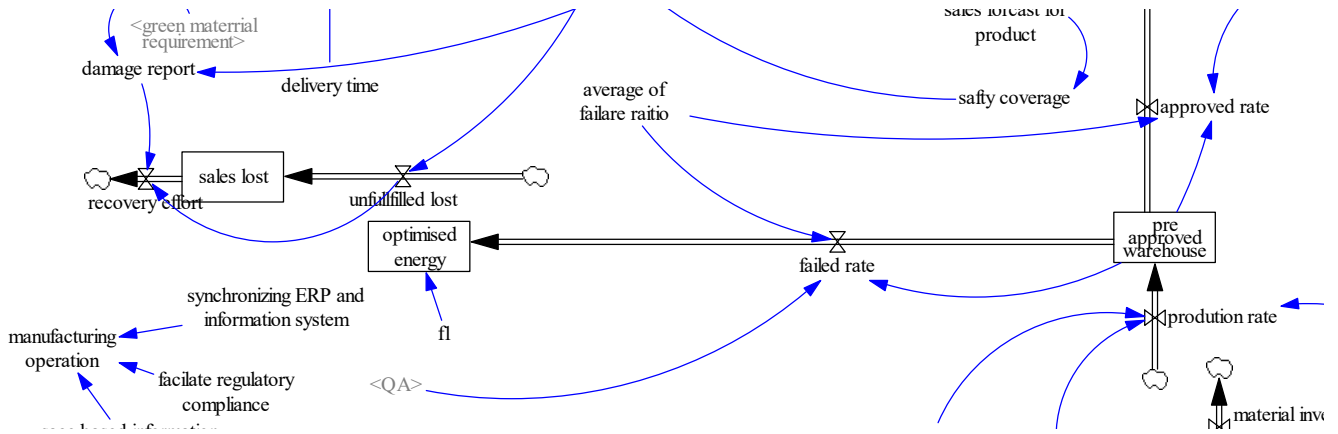


Fig. 2 GSCM inventory simulation

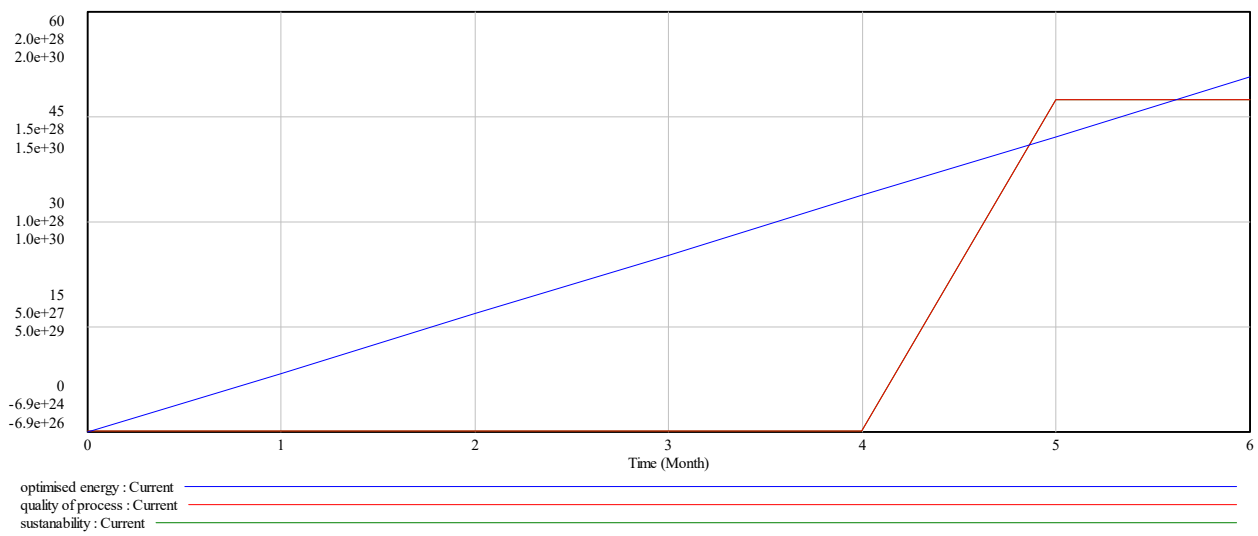


Fig. 3 Delivered green supply chain products, sustainability, lead time results

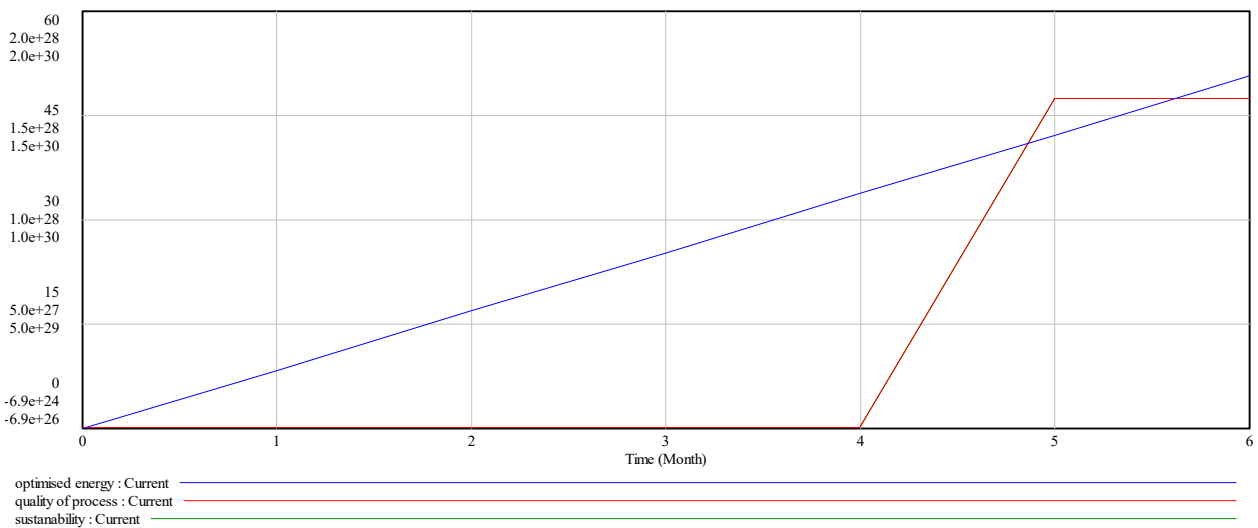


Fig. 4 Simulation result for production inventory, distributed warehouse inventory adjustment

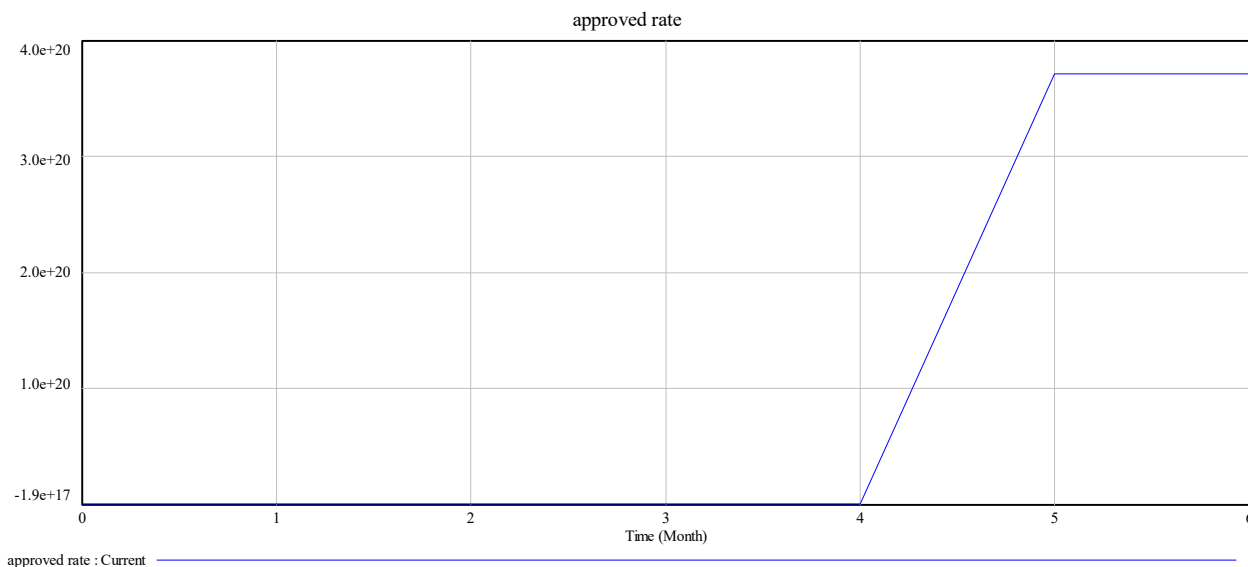


Fig. 5 Approved rate variable simulation result

V. CONCLUSION

In this paper we used the concepts of system thinking, the dynamics of some of those chain-related issues. Based on analysis of models in this paper we have seen steady growth in sustainability total production inventory holding cost, delivered green product and approved rate variable we saw sustainability and delivered green product and approved rate variable and decrease rate in wasted product time and lead time.

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