Computers & Industrial Engineering 99 (2016) 432–447

Contents lists available at ScienceDirect

Computers & Industrial Engineering

journal homepage: www.elsevier.com/locate/caie

A Hybrid Territory Defined evolutionary algorithm approach for closed loop green supply chain network design

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ARTICLE INFO

Article history:
Available online 18 May 2016

Keywords:
SCM
GCLSP
EDA
NSGAII
EDATDEA

ABSTRACT

The Closed loop Supply chain network distribution is one of the most important problems with much real world application in supply chain management area. Presently climate change problem is one of the major concerns for Researchers. Closed loop green supply chain (GCLSC) problem is the extension of closed loop supply chain problem. Semiconductor industries are one of the major industries and a number of waste products in semiconductor industries are quite high. We have considered reducing the waste in semiconductor by recycling the useful waste electronic equipment. In GCLSC, we consider to maximize the profit in forward supply chain whereas we attempt to minimize the Carbon footprints at the same time. In this paper we used a hybrid of Estimation of distribution algorithm (EDA) and Territory Defined multi-objective algorithm to select the optimum number of facilities in the closed loop supply chain network. To examine the effectiveness of our Hybrid Territory Defined algorithm (EDATDEA), we compare the results with those obtained by NSGA II on a same GCLSC problem with different problem sizes and the same data sets.

1. Introduction

Climate change problem have become one of the major threats on earth. Many toxic gases such as Carbon dioxide, carbon mono oxide and many greenhouse gases are one of the biggest contributors to the threats. Dumb products are another major contribution to environment pollution. Today people, government, and business organization are more concerned about the climate change and reducing pollution and global warming.

In today's competitive and global market, the success of an industry is reliant upon the management of its supply chains. Supply chain network design includes all the internal and external components of supply chain management (SCM). Nowadays, customers want the products at the minimum possible cost, whereas firm has many objectives such as maximization of profit, reducing the carbon footprint and recycling the products. So it is important that a firm organizes the plants; retailer, supplier, distribution center and customer zone in such a manner that customer obtains the product at minimum cost and the firm should maintain their profit and minimize carbon footprint. Under these competitive missions, firms are using different ways for environment protection. Few firms are considering satisfying the customer by development of green product which can be environmental friendly. Another way is to reduce the raw material by recycling the product. To reduce the environment damage, waste products, use the green raw material and reduce the carbon dioxide emission and push the firm to adopt the Green Supply chain. From this perspective, green supply chain can help companies to reach a more competitive position, higher profitability, and better performance by satisfying their customers more effectively Sarkis (2003). The reverse supply chain has been continually developed not only as a result of the associated economic profit but also because of the ecological motivation, Georgiadis and Vlachos (2004). Nakamura and Kondo (2006) proposed a waste input–output life-cycle cost analysis of the recycling of end-of-life electrical home appliances. Pohlen and Farris (1992) have investigated the reverse distribution channel structure in plastic recycling and analyzed the compaction and routing issues related to transportation in the RL process. The most important objectives of green supply chain management were reducing cost, increasing profit as well as protecting the environment by recycling, reusing, reworking, remanufacturing, refurbishing, reclaiming, and reducing to design reverse logistics by using closed loop supply chain management (Srivastava, 2007). Mutha and Pokharel (2009) proposed a Strategic network design for reverse

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http://dx.doi.org/10.1016/j.cie.2016.05.018
0360-8352/

logistics and remanufacturing using new and old product modules. Closed-loop supply chain (CLSC) focuses on recycling the products by taking them back from the customers. Faccio, Persona, Sgarbossa, and Zanin (2011) apply different supply chain (SC) design approaches in the presence of reverse flows, analyzing the network structure where they considered flows are forward flow exclusively, or forward and reverse flows, or integral closed-loop flows. Last few years closed loop supply chain gained considerable attention of researchers as well as many companies. The definition of closed loop supply chain is the design, control, and operation of a system to maximize value creation over the entire life cycle of a product, with dynamic recovery of value from different types and volumes of returns over time Guide and Van (2009). Koh, Hwang, Sohn, and Ko (2002) proposed an optimal ordering and recovery policy for reusable items. The remanufacturing poses an interesting question with respect to the design and management of closed loop supply chain, Canan, Bhattacharya, Luk, and Wassenhove (2004). Traditional supply chains have been designed in single direction network, called forward logistic with the need of recycling products and decrease the waste products at the end of cycle. However, reverse and closed loop supply chain become as a most important tools for companies which is based on environmental concerns and regulations. The main application of reverse supply chain is to improve reclamation of the products at the end of their life cycle, Meade and Sarkis (2007). Past few years, the closed loop supply chain problem gains more attention. Many researchers have been proposed different closed loop supply chain models in different conditions. Abdolhossein et al. (2012) proposed an overview about closed loop supply chain, and authors discuss different aspects of closed loop supply chain and how it can help to protect the environment. Most of the researchers' concerns are about use of the few raw materials by using the recovery products. To collect the end-of-cycle product from the customers is a big problem. Canan et al. (2004) developed a closed loop supply chain model with product remanufacturing and proposed an idea about collecting recycle product in three different ways. They suggested that firms can collect product by themselves, or firms can provide a suitable incentives to an existing retailer, or firms can subcontract the collection activity to a third party. Lee and Lee (2013) proposed a modeling and optimization of closed-loop supply chain considering order or next arrival of goods.

Presently semiconductor manufacturing industries are one of the major industries. In 2010 Semiconductor market exceeded more than 300 billion USD worldwide. Semiconductor industries are one of the most energy intensive. Therefore it needs to be more environmental friendly and energy efficient. In Semiconductor Company the most important challenge is the complexity of the manufacture of integrated circuits and the role of globalization in their production. Due to the globalization and new inventions, industries need to manufacture the new products and replace their old products, which increase the number of dumb electronic products. In this paper we have considered the recycling the electronic waste equipments, which can minimize the total cost of closed loop supply chain as well as reduce the dumb electronic equipment. Author proposed a model that integrates forward and reverse logistic to satisfy the demand in case of limited recovery electronic materials. Özkır and Baslıgil (2013) proposed a multi-objective optimization of closed-loop supply chain in uncertain environment. Author examined the problem through product recovery chain regarding the consumer sourced returns, end-of-use products and end-of-life products. A multi-objective model for a closed loop supply chain network design with uncertain parameters, such as cost coefficient and customer demands was proposed by Fallah, Sahraeian, Tavakkoli, and Moeinipour (2012). Author proposed an interactive possibilities approach to solve the multi-objective mixed integer linear programming model. Kannan, Sasikumar, and Devika (2010) proposed a genetic algorithm approach for solving a closed loop supply chain a case study of battery recycling. The Closed loop green supply chain is the extension of closed loop supply chain. Last few year researchers concern more on Green supply chain. Yang, Lu, Haider, and Marlow (2013) proposed the effect of green supply chain management on green performance and firm competitiveness in the context of container shipping in Taiwan. Sustainable SC through the complete reprocessing of end-of-life products by manufacturers: A traditional versus social responsibility company perspective proposed by Faccio, Persona, Sgarbossa, and Zanin (2014). In this study, author introduced a linear programming model to minimize the total cost in forward supply chain with Environmental sustainability by the complete reprocessing of the re-use of components, an end-of life product, the disposal of unusable parts sent directly from the manufacturers, with a closed loop transportation system that maximizes transportation efficiency. Kannan and Popiuc (2014) proposed reverse supply chain coordination by revenue sharing contract; author discussed a case study of personal computer industry. Brandenburga, Kannan, Sarkis, and Seuring (2014) proposed quantitative models for sustainable supply chain management: Developments and directions. Lu, Qi, and Liu (2014) addressed about two important issues of recycling; they proposed that the industry contains small-scale and inefficient recycling firms and the output from recycling a multi-components wasted product has multiple recycling products that cannot be recycled efficiently by a single firm. Giovanni (2014) proposed Environmental collaboration in a closed-loop supply chain with a reverse revenue sharing contract. Author considered a closed-loop supply chain (CLSC) with a single manufacturer and a single retailer who invest in green advertising to build up the goodwill dynamic. To address these issue author proposed on the cooperation of recycling operation. In this paper we have proposed a new model for closed loop green supply chain in semiconductor industries, and we used nine echelons, five are in forward direction and four in reverse direction for carrying back used products and extracting value from it. We used a new approach EDATDEA to solve the 9 different closed loop green supply chain problems. EDA is a probabilistic based know evolutionary approach. Initial population generation is based on the EDA, which provides better chromosome from the starting of the procedure. After generating the initial population we have used territory defined evolutionary approach (TDEA) to solve the proposed model. Territory defined evolutionary approach selects the best solution during the non-dominated sorting. We compared our result with the well know multi-objective algorithm NSGA II.

The paper is organized as follows: In Section 2 we have proposed the model and its mathematical formulation. Solution methodology is described in Section 3. Computation results are described in Section 4. Conclusion is described in Section 5.

2. Model descriptions

We have considered a closed loop supply chain with nine echelons, five are in forward direction and four in reverse direction for carrying back used products and extracting value from it (see Fig. 1). Case of coordinate supply chain was considered as it minimizes the supply chain cost. The costs that are considered in our analysis are, cost of raw material supplied by Supplier, cost of production by Manufacturer, repairing and recycling cost at Repairing Center, cost of disposing at Disposal Center, returns cost given by the Return Center to the customer as perk for returning the pro-