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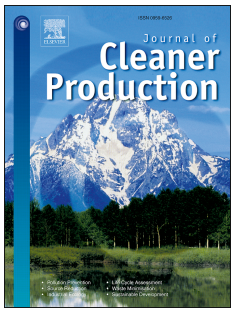

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PII: S0959-6526(16)30247-5

DOI: 10.1016/j.jclepro.2016.04.006

Reference: JCLP 7011

To appear in: *Journal of Cleaner Production*

Received Date: 6 April 2015

Revised Date: 14 March 2016

Accepted Date: 3 April 2016

Please cite this article as: Wang Z, Soleimani H, Kannan D, Xu L, Advanced Cross-Entropy in Closed-Loop Supply Chain Planning, *Journal of Cleaner Production* (2016), doi: 10.1016/j.jclepro.2016.04.006.

Advanced Cross-Entropy in Closed-Loop Supply Chain Planning

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Abstract

Developing new methodologies for nondeterministic polynomial (NP-hard) problems such as supply chain network design is always a major consideration for academia and practitioners. In this paper a cross-entropy (CE) based solution methodology is developed in order to cope with complex combinatorial problems. The NP-hard problem of designing and planning a closed-loop supply chain (CLSC) is considered. Furthermore, a multi-product multi-period CLSC network in a mixed-integer programming structure is regarded. On the other side, cross-entropy is one of the newly developed and successful metaheuristic algorithms. Thus, in order to achieve better solutions in comparison with current solution methodologies, a cross-entropy algorithm is developed for the first time in CLSC design and planning. Then, the capabilities of the cross-entropy algorithm are elevated, in order to achieve solutions that are more robust. Therefore, an algorithm, which is called "advanced cross-entropy" (ACE) is proposed. Finally, two presented CE-based algorithms are compared with a developed genetic algorithm (GA) for the same problem. GA is the most well-known metaheuristic algorithm, which has been abundantly developed in CLSC. Results prove that both of proposed CE-based algorithms dominate current methodologies. Both can find acceptable solutions in comparison with GA. Furthermore, the proposed advanced cross-entropy performs even better than CE in the quality of solutions and time.

Keywords: Cross-entropy; Advanced cross-entropy; Genetic algorithm; Closed-loop supply chain.

1. Introduction

In order to cope with complex combinatorial problems, traditional exact methods like the branch and bound or branch and cut, and some approximation methods, are reliable but are generally better suited for small-size problem instances (Kannan, Govindan, & Soleimani, 2014). Indeed, they are inefficient techniques when we deal with real-world instances. On the other hand, in metaheuristic issues (Govindan, Jafarian, & Nourbakhsh, 2015), exploiting and elevating new approaches instead of older and conventional ones (as genetic algorithm (Chen, Govindan, & Golias, 2013; Chen, Govindan, Yang, Choi, & Jiang, 2013; Kannan, Noorul Haq, & Devika, 2009), tabu search (Caballero et al., 2007), simulated annealing (Khan & Govindan, 2011; Raj Mohan, Shahabudeen, & Kannan, 2009), etc.) will be an important step to the future. Cross-entropy is one of the recently developed metaheuristics that has been utilized successfully in NP-hard problems such as the Knapsack problem (Caserta et al., 2008), max cut, traveling salesman problem (Rubinstein and Kroese, 2004), vehicle routing problem (Chepuri and Homem-de-