World Academy of Science, Engineering and Technology
International Journal of Industrial and Manufacturing Engineering
Vol:12, No:10, 2018

Multi-Criteria Decision Making Network Optimization for Green Supply Chains

Authors : Bandar A. Alkhayyal

Abstract : Modern supply chains are typically linear, transforming virgin raw materials into products for end consumers, who then discard them after use to landfills or incinerators. Nowadays, there are major efforts underway to create a circular economy to reduce non-renewable resource use and waste. One important aspect of these efforts is the development of Green Supply Chain (GSC) systems which enables a reverse flow of used products from consumers back to manufacturers, where they can be refurbished or remanufactured, to both economic and environmental benefit. This paper develops novel multi-objective optimization models to inform GSC system design at multiple levels: (1) strategic planning of facility location and transportation logistics; (2) tactical planning of optimal pricing; and (3) policy planning to account for potential valuation of GSC emissions. First, physical linear programming was applied to evaluate GSC facility placement by determining the quantities of end-of-life products for transport from candidate collection centers to remanufacturing facilities while satisfying cost and capacity criteria. Second, disassembly and remanufacturing processes have received little attention in industrial engineering and process cost modeling literature. The increasing scale of remanufacturing operations, worth nearly $50 billion annually in the United States alone, have made GSC pricing an important subject of research. A non-linear physical programming model for optimization of pricing policy for remanufactured products that maximizes total profit and minimizes product recovery costs were examined and solved. Finally, a deterministic equilibrium model was used to determine the effects of internalizing a cost of GSC greenhouse gas (GHG) emissions into optimization models. Changes in optimal facility use, transportation logistics, and pricing/profit margins were all investigated against a variable cost of carbon, using case study system created based on actual data from sites in the Boston area. As carbon costs increase, the optimal GSC system undergoes several distinct shifts in topology as it seeks new cost-minimal configurations. A comprehensive study of quantitative evaluation and performance of the model has been done using orthogonal arrays. Results were compared to top-down estimates from economic input-output life cycle assessment (EIO-LCA) models, to contrast remanufacturing GHG emission quantities with those from original equipment manufacturing operations. Introducing a carbon cost of $40/t CO2e increases modeled remanufacturing costs by 2.7% but also increases original equipment costs by 2.3%. The assembled work advances the theoretical modeling of optimal GSC systems and presents a rare case study of remanufactured appliances.

Keywords : circular economy, extended producer responsibility, greenhouse gas emissions, industrial ecology, low carbon logistics, green supply chains
Conference Title : ICRSM 2018 : International Conference on Remanufacturing and Sustainable Manufacturing
Conference Location : Osaka, Japan
Conference Dates : October 11-12, 2018