UNIVERSITI PUTRA MALAYSIA

DEVELOPMENT OF A MULTI-OBJECTIVE OPTIMIZATION MODEL FOR TRANSPORT AND ENVIRONMENT IN A CLOSED-LOOP AUTOMOTIVE SUPPLY CHAIN

ABDOLHOSSEIN SADRNIA

FK 2014 25

DEVELOPMENT OF A MULTI-OBJECTIVE OPTIMIZATION MODEL FOR TRANSPORT AND ENVIRONMENT IN A CLOSED-LOOP AUTOMOTIVE SUPPLY CHAIN

By

ABDOLHOSSEIN SADRNIA

Thesis Submitted to the School of Graduate Studies, Universiti Putra Malaysia, in Fulfillment of the Requirements for the Degree of Doctor of Philosophy

July 2014

With love and gratitude to my Parents , my wife, Marzieh and my children and.

Abstract of thesis to be presented to the Senate of Universiti Putra Malaysia in fulfillment of the requirements for the degree of Doctor of Philosophy

DEVELOPMENT OF A MULTI-OBJECTIVE OPTIMIZATION MODEL FOR TRANSPORT AND ENVIRONMENT IN A CLOSED-LOOP AUTOMOTIVE SUPPLY CHAIN

By

ABDOLHOSSEIN SADRNIA

July 2014

Chairman: Professor Datin Napsiah Ismail, PhD
Faculty: Engineering

Due to increasing severity of the environment such as limited raw materials, increasing pollutions, global warming and greenhouse gas (GHG) pollution, manufacturers have to design their supply chains to be green. For example, greening the automotive supply chain has become a major concern and car manufacturers have been obliged to recover at least 95% End-Of-Life vehicle (ELV) by 2015. Since closed-loop network make an infrastructure to collect and recover used products, developing an effective closed-loop network as a major greening tool in supply chains has been growing increasingly by researchers.

Most researchers have tried to minimize the total cost in logistics network and neglects environmental while the most important question in green supply chain is how to identify preferred solutions balancing environmental and business concerns. Since the logistics networks are known as complex models, exact methods could not find the optimum solution. Therefore, various meta-heuristic algorithms have been tried by researchers.

In this research, a new Multi-Objective Logistics Network Model for Automotive Closed-Loop Supply Chain (MOACLSC) for recovering ELVs was developed. After that a Meta-heuristic method is used for finding the global optimum solution. The methodology of this research includes three stages. The variable (such as truck type for transportation and the amount of material that should be transshipped between facilities) and parameters (such as transportation cost, facilities' capacity) are identified and then the conceptual model for MOACLSC was developed. In the second stage, the MOACLSC mathematical model was developed for recovering ELVs. In the last stage, an extended Gravitational Search Algorithm (GSA) as a parallel search algorithm and high convergence rate into high quality final solutions is used to solve the proposed mathematical model and to achieve the Pareto set of solution. The Multi-objective GSA (MOGSA) algorithm is adopted and then programmed using MATLAB software particularly to the MOACLSC.

To verify the model, four examples from literature were considered and compared the MOGSA's optimum solutions result by Genetic Algorithm's (GA) result. The results obtained from problem were analyzed based on the objective function (cost), and the design parameters of the network. Analysis of results expressed the acceptable

performance of MOACLSC and MOGSA compared to the proposed mathematical model in the example and GA. Comparing the total cost of the networks, revealed that the total closed-loop logistics network's cost for ELV recovering were reduced by 1.7%, 2.4%, 3.3% and 3.9% in four problems respectively. Finally to present the model validity of a real case study in automotive industrial was studied. The result shows if the proposed model implement to redesign forward logistics, 12.36% of the total cost can be decreased. Indeed, a Pareto set of solutions including, 15 solutions were found which they can be selected a preferred solution balancing environmental and business concerns. To know the proposed model's sensitivity, after model validation, sensitivity analysis has been done and the result has been interpreted to provide some interesting managerial insights.

Abstrk tesis dikemukakan kepada Senat Universiti Putra Malaysia sebagai memenuhi keperluan untuk ijazah Doktor Falsafah

PEMBANGUNAN MODEL PENGOPTIMUMAN MULTI-OBJEKTIF UNTUK PENGANGKUTAN DAN PERSEKITARAN DALAM RANTAIAN TERTUTUP LOOP AUTOMOTIF BEKALAN

Oleh

ABDOLHOSSEEIN SADRNIA

Julai 2014

Pengerusi: Professor Datin Napsiah Ismail, PhD
Fakulti: Kejuruteraan

Oleh kerana tahap peningkatan alam sekitar seperti bahan-bahan mentah dan sumber, meningkatkan pencemaran dan pelupusan yang melimpah, pemanasan global dan pencemaran gas rumah hijau (GHG), penghijauan rantaian bekalan automotif telah menjadi keperluaan utama supaya pengeluar kereta diwajibkan untuk mendapatkan semula sekurang-kurangnya 95% akhir hayat kenderaan (ELV) pada tahun 2015. Sejak infrastuktur suap-balik dan rangkaian logistik terbalik dalam memungut dan mendapat, menilai, mengilang semula dan mengitar semula produk yang digunakan untuk mencapai objektif, penyelidik dan pengamal pembangunkan suap-balik yang berkesan dan rangkaian logistik terbalik sebagai alat penghijauan utama dalam rantaian bekalan telah semakin berkembang. Kebanyakan kajian pada masa sekarang telah cuba untuk mengurangkan jumlah kos dalam rangkaian logistik dan ini bermakna model selalunya dianggap sebagai objektif tunggal dan mengabaikan persekitaran dan objektif sosial. Manakala "rekabentuk" dalam kes sebenar biasanya melibatkan percanggahan objektif yang memerlukan tolak ansur dan kesimbangan.

Rangkaian logistik dikenali sebagai model komplek, kaedah yang tepat tidak dapat mencari penyelesaian optimum, oleh itu masalah hijau begitu kompleks perlu pada pembangunan teknik-teknik moden dari pelbagai bidang saintifik. Salah satu kaedah pengoptimuman heuristik adalah *Gravity Search Algoritma (GSA)* yang dibina berdasarkan undang-undang graviti dan tanggapan interaksi massa.

Dalam kajian ini, model Multi-objektif Logistik Rangkaian baru telah dibangunkan untuk Rantaian Automotif Bekalan suap balik (MOACLSC) untuk pemulihan ELVs. Algoritma GSA multi-objektif (MOGSA) diterima pakai dan kemudian diprogramkan menggunakan perisian MATLAB untuk MOACLSC. Dalam perbandingan rangkaian jumlah kos, ia adalah jelas bahawa kos jumlah gelung tertutup rangkaian logistik untuk pemulihan ELV telah menurun sebanyak 1.7% , 2.4 %, 3.3 % dan 3.9 % dalam empat masalah masing-masing. Akhir sekali untuk menentukan kesahihan model, kajian kes sebenar dalam industri automotif telah dilakukan. Hasilnya menunjukkan jika model yang dicadangkan itu dilaksanakan bagi reka bentuk semula logistik ke hadapan, 12.36 % daripada jumlah kos boleh dikurangkan. Malah, satu set Pareto penyelesaian termasuk 15 penyelesaian ditemui. Set keputusan boleh digunakan oleh pembuat keputusan.

ACKNOWLEDGEMENT

I would like to thank GOD for the countless bounties he has granted me. I thank Him for giving me the ability to deal with my challenges during my research. I thank Him for letting me accomplish this thesis work.

I would like to express my deepest gratitude, appreciation and thanks to my research supervisor and the chairman of my supervisory committee Prof. Datin Dr. Napsiah Ismail, who is learned such academician ethics to me besides the value comments during my education. And also I am thankful to my supervisory committee members Assoc. Prof. Dr. Norzima Zulkifli and Assoc. Prof. Dr. Khairol for their complete support and advice on this research work. Without their guidance in these three years, I could not accomplish the thesis.

I would like to express my sincere thanks and gratitude to my wife Marzieh Tajvidi, my children Hannaneh and Mohammad, and my mother for her praying for me and my family for their great understanding, support and advice throughout the period of completing this research work.

Finally, the most acknowledgements go to my friends Omid, Mehrdad, Alireza, and Gholam Reza, who have given me moral support to complete my work within the period.

I certify that a Thesis Examination Committee has met on 16 July 2014 to conduct the final examination of Abdolhossein Sadrnia on his thesis entitled "Development of A Multi-Objective Optimization Model for Transport And Environment in a Closed-Loop Automotive Supply Chain" in accordance with the Universities and University Colleges Act 1971 and the Constitution of the Universiti Putra Malaysia [P.U. (A) 106] 15 March 1998. The Committee recommends that the student be awarded the Doctor of Philosophy.

Members of the Thesis Examination Committee were as follows:

Barkawi Bin Sahari, PhD
Professor
Faculty of Engineering
Universiti Putra Malaysia
(Chairman)

Shamsudin bin Sulaiman, PhD
Professor
Faculty of Engineering
Universiti Putra Malaysia
(Internal Examiner)

Tang Sai Hong, PhD
Associate Professor
Faculty of Engineering
Universiti Putra Malaysia
(Internal Examiner)

Ahad Ali, PhD
Professor
Name of Department and/or Faculty
Lawrence Technological University
United States
(External Examiner)

NORITAH OMAR, PhD
Associate Professor and Deputy Dean
School of Graduate Studies
Universiti Putra Malaysia

Date:

This thesis was submitted to the Senate of Universiti Putra Malaysia and has been accepted as fulfillment of the requirement for the Degree of Doctor of Philosophy. The members of the Supervisory Committee were as follows:

Datin Napsiah bt. Ismail, PhD
Professor
Faculty of Engineering
Universiti Putra Malaysia
(Chairman)

Mohd Khairol Anuar b. Mohd Ariffin, PhD
Associate Professor
Faculty of Engineering
Universiti Putra Malaysia
(Member)

Norzima bt. Zulkifli, PhD
Associate Professor
Faculty of Engineering
Universiti Putra Malaysia
(Member)

_____
BUJANG BIN KIM HUAT, PhD
Professor and Dean
School of Graduate Studies
Universiti Putra Malaysia

Date:

Declaration by Graduate Student

I hereby confirm that:

- This thesis is my original work;
- Quotations, illustrations and citations have been duly referenced;
- This thesis has not been submitted previously or concurrently for any other degree at any other institutions;
- Intellectual property from the thesis and copyright of thesis are fully-owned by Universiti Putra Malaysia, as according to the Universiti Putra Malaysia (Research) Rules 2012;
- Written permission must be obtained from supervisor and the office of Deputy Vice-Chancellor (Research and Innovation) before thesis is published (in the form of written, printed or in electronic form) including books, journals, modules, proceedings, popular writings, seminar papers, manuscripts, posters, reports, lecture notes, learning modules or any other materials as stated in the Universiti Putra Malaysia (Research) Rules 2012;
- There is no plagiarism or data falsification/fabrication in the thesis, and scholarly integrity is upheld as according to the Universiti Putra Malaysia (Graduate Studies) Rules 2003 (Revision 2012-2013) and the Universiti Putra Malaysia (Research) Rules 2012. The thesis has undergone plagiarism detection software.

Signature: _____ Date:

Name and Matric No.: Abdolhossein Sadrnia, GS28654

Declaration by Members of Supervisory Committee

This is to confirm that:

- The research conducted and the writing of this thesis was under our supervision;
- Supervision responsibilities as stated in the Universiti Putra Malaysia (Graduate Studies) Rules 2003 (Revision 2012-2013) are adhered to.

Signature:
Name of
Chairman of
Supervisory
Committee: Napsiah bt. Ismail, PhD

Signature:
Name of
Member of
Supervisory
Committee: Mohd Khairol A.M Ariffin, PhD

Signature:
Name of
Member of
Supervisory
Committee: Norzima bt. Zulkifli, PhD

TABLE OF CONTENTS