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Design of Mathematical Modeling in a Green Supply Chain Network by Collection Centers in the Environment

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Abstract
Nowadays, Economic systems play an important role in environment's field. Along with the rapid change in global manufacturing scenario, environmental and social issues are becoming more important in managing any business. Increasing pressures and challenges to improve economic and environmental performance have been caused developing countries in generally in particular to consider and to start implementing green supply chain management. Green Supply Chain Network Design and Management are an approach to improve performance of the process and products according to the requirements of the environmental regulations. It is emerging as an important approach which not only reduces environmental issues but also brings economic benefit to manufacturers. Green Supply Chain Management (GSCM) has a significant influence to reduce environment's risks. Choosing the suitable supplier is a key strategic decision for productions and logistics management on the supply chain management. The purpose of this study is to describe the GSCM, to determine the allocation of products between plants, collection centers as well as effect of GSCM to the system's cost is investigated. In this paper, GSCM with multiple and conflicting objectives such as reducing costs, increasing customer's level of service and increased flexibility (accountability), respectively by providing mathematical model for optimal allocation of manufacturing products to market demand. In the event of a problem return them to factory pays the collection centers. Also, Green Supply Chain Network Design that includes several manufacturing plants, collection centers, and production with the aim of minimizing the total cost of the chain to be considered.

Keywords: Mathematical model, supply chain network design, level of customer service, Reduce costs, Green Supply Chain Management

Introduction

Supply chain management has traditionally been viewed as a process where in raw materials are converted into final products, and then delivered to the end-consumer. This process involves extraction and exploitation of the natural resources. It is important to note however that we live in a decade where environmental sustainability has been an important issue to business practice (Kumar and Chandrakar, 2012). On the other hand, the economic growth increases the level of energy and material consumption, which contribute to the environmental issues and resource depletion problems. The waste and emissions caused by the supply chain have become one of

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the main sources of serious environmental problems including global warming and acid rain (Kumar and Chandrakar, 2012).The manufacturing firm has increasingly faced the environmental protection issues that force firm to the environment in their market competition (Wu et al., 2011). It has become increasingly significant for organizations facing competitive, regulatory, and community pressures to balance economic and environmental performance. Nowadays, most organizations are starting to go green in their business as concern to environmental sustainability. This requires with green technical capabilities in electronic industry (Wu et al., 2011). They have realized the greater benefit of the green technology adoption in business operation, which also affected supplier**s** and customers. Environmental issues under legislation and directives from customer in developed countries become an important concern for manufacturers. As a result, Green Supply Chain Management (GSCM) emerges as a new systematic environmental approach in supply chain management. All of business activities related to green supply chain management (GSCM) have played as an important role to environmental management factors applied for the purpose of business manufacturer (Wu et al., 2011). GSCM is strongly consisted of inter-organizational environmental topics as industrial eco-system, industrial ecology, product life cycle analysis, extend producer responsibility and product stewardship. In a broader sense, GSCM also falls within the purview of the burgeoning literature of this and sustainability which incorporates other social and economics influences. GSCM's definition has ranged from green purchasing to integrated supply chains flowing from supplier, to manufacturer, to customers and reverse logistics, which is "closing the loop" as defined by supply chain management literature. Similar to the concept of supply chain management, the boundary of GSCM is dependent on the goal of the investigator (Rajabzadeh Ghatari et al., 2012). The growing importance of GSCM is driven mainly by the escalating deterioration of environment, e.g. diminishing raw material resources, overflowing waste sites and increasing level of pollution. However, it is not just about being environment friendly; it is about good business sense and higher profit. The supply chain "system" includes Purchasing and In-bound Logistics (materials management), Production, Outbound Logistics (physical distribution & Marketing), and Reverse Logistics. Greening supply chains aims to balance marketing performance with environmental issues. To meet with challenges such as energy conservation and pollution abatement, enterprises have tried to green their supply chains, that is, to create networks of suppliers to purchase environmentally superior products or to build common approaches to waste reduction and operational efficiencies. Greening the supply chain is increasingly a concern for many business enterprises and a challenge for logistics management in the present century (Kumar and Chandrakar, 2012).

Supply Chain Network Design (SCND) is one of the most important strategic decisions for researchers. A SCND problem involves the sum of facilities organized to gain and transfer raw materials to finished products, distribute these products and present the services after selling to fulfill the customer needs. This problem determines the number, location, capacity level and technology of the facilities to be considered. Because the tactical and operational activities are implemented after establishing the strategic decisions, the logistic network configuration will become a restriction for tactical and operational level decisions. Moreover, since opening and closing the facilities is a time-consuming and expensive act, the change of the network configuration is not possible easily. Hence, the supply chain configuration is a key strategic issue influencing tactical/operational activities and need to be optimized for the long-lasting efficient operation of entire supply chain. SCND can be divided into two parts, namely forward logistic (FL) and reverse logistic (RL). The first case only addresses the forward network. The reverse logistic itself comprises problems that fully focus on the backward network, known as recovery network, and those that the backward network is integrated with the forward network, known as closed-loop network. In general, in the forward logistic, as a conventional logistic, after purchasing from suppliers, raw materials are converted to finished products in manufacturing plants, and then these products are transferred to customers via distribution centers to satisfy their demands. In the reverse logistic, the flow of returned products is processed from the customers back to the collection centers for repair, remanufacturing or disposal. Due to the fact that designing the forward and reverse logistics separately results in sub-optimal designs with respect to objectives of supply chain, the design of forward and reverse logistics should be integrated. This type of integration can be considered as either horizontal or vertical integration. The first type includes the integration of activities in the same planning level (tactical, operational or strategic). For instance, integrating the supplier selection with network design and integrating the design of forward and reverse supply chain are two examples of horizontal integration in the strategic level. The latter type encompasses the integration of decision-making processes across planning level. For instance, locations of the facilities at the strategic level and the quantities of shipment transferred between facilities at the tactical/operational level can be considered simultaneously. An important issue in SCND is the establishment of appropriate performance measures to determine efficiency and/or effectiveness of the current system in comparison with alternative systems. Traditionally, the focus of SCND problems is usually on a single objective, namely minimizing the cost or maximizing the profit. The other measures considered in supply chain are as follows: maximization of the customer service level, minimization of the financial risk and maximization of the quality level. Many companies emphasize the customer responsiveness and quality. One measure to quantify the customer service level is fill rate that is the fraction or amount of customer demands satisfied within the promised delivery time (Ramezani et a. 2013).

Literature Review

Green supply chain management (GSCM) involves traditional supply chain management practices integrating environmental criteria or concerns into organizational purchasing decision and long term relationships with suppliers (Gilbert, 2000). Torres et al. (2004) presented that a green supply chains aims at confining the wastes within the industrial system in order to conserve energy and prevent the dissipation of dangerous materials into the environment. Olugu et al. (2010) presented that the disproportionate environmental impact of supply chain processes within an organization. GSCM is the summing up of green purchasing, green manufacturing, green packing, green distribution and marketing. GSCM is to eliminate or minimize waste in the form of energy, emission, hazardous, chemical and solid waste. Large and Thomsen, identified five potential drivers of green supply chain management performance: green supply management capabilities, the strategic level of purchasing department, the level of environmental commitment, the degree of green supplier assessment, and the degree of green collaboration with suppliers (Large and Thomsen, 2011). Chiou et al. (2011) concluded that greening the supplier through green innovation leads to significant benefits to the environmental performance and competitive advantage of the firm. Cohen and Lee (1988), analyze the integration of production and distribution systems in a supply chain network. Supply chain network consists of a subset or sub-parts. The output of each sub module was used as the input to other sub modules. These sub modules include material control, production control, and finished goods inventory and distribution system control. Martin et al developed an optimization model that included decision variables for production, inventory and distribution using a linear programming model (Martin et al., 1993). Alumur et al. (2012), proposed a mixed integer linear programming model that maximizes reverse logistics network profit. Salema et al. (2010), proposed a multi-period and multi-product network model for the simultaneous design and planning of supply chains with reverse flows. Mutha and Pokarel (2009), developed a mathematical model for reverse logistics network of product returns. The model makes decision on location, number, capacity of storing, reprocessing, remanufacturing facilities and allocation of material flows between them considering all network costs. Melkote and Daskin (2001), represent a single-period locating-network designing model considering capacity constraints. In this model, each vertex is a demand center and only one facility, which has a limited capacity, is permitted to be assigned to each vertex. The objective function minimizes the cost of transportation, locating the facilities, and allocations (Saffar et al., 2014). Pishvaee et al. (2011), introduce a linear model minimizing transportation costs. Pishvaee and Razmi (2012), provide a model considering both forward and backward flows, simultaneously. Pishvaee and Torabi (2010), propose a bi-objective mixed-integer linear programming model minimizing the total costs in a closed-loop logistics and maximizing the network responsiveness. A memetic algorithm is extended to solve the presented bi-objective MILP model (Pishvaee and Torabi, 2010).

The Production and Transportation Problem

This paper examines the company in the field of forest products (in relation to the hardwood) is active. The company aims to reduce the total cost of the resource allocation. The company will supply and customer demand with minimal cost and reduce customer waiting time to get his product. In this paper, mixed integer programming to optimize the allocation and transfer of goods to customers on a weekly orders. Each week, customers place orders with the central sales office, which then allocates these orders to various mills to be produced in the subsequent week. Depending on the consumers in one area, the transportation allocation is different. As soon as the products are manufactured, they are shipped to the customers, where access to rail lines are in the same order as they are sent. Most orders are made firm by rail. In regions where there is no access to rail lines, orders and carried by trucks. These machines have different capacities depending on the orders, are used. Sometimes on the basis of orders and the access to transport products may be used both by train and truck.

The Solution Approach

The company wanted to allocate customer orders to the various mills to minimize the resulting overall costs of both production and transportation. Owing to the complexities involved with the production process and the various modes of transport, as well as the large number of orders the company receives each week, determining an optimal assignment of customer orders to mills is not a simple task. A suitable decision procedure must consider factors such as unit production costs (which may differ from mill to mill), mill capabilities (as each mill can produce only a certain set of products), production capacities, rail and truck transportation costs, vehicle capacities and availabilities. For solving the problem, to solve this problem, a number of people came to the factory to be able to estimate these factors. The Information obtained from the research team provide mixed integer programming model. The unit production cost includes the cost of ingredients used in production such as wood, resin, wax, edge seal, stamp ink, etc. as well as fixed costs such as salaries, taxes, etc. The unit production capacity of a product in a mill is the production volume of the mill when only producing that specific product during a single shift. The transportation costs include the fuel costs as well as the loading and unloading costs at the mills, reload points, and customer sites.

Assumption

1) The sales price of products in the orders is set in advance, and the volume capacity of each transport vehicle is assumed to be fixed for any given customer order.
2) The company manufactures products primarily to fulfill customer orders, and it keeps only very limited amounts of inventory on hand that not be considered in the model.
3) In model, considered only the allocations for the orders scheduled to be produced in the following week and did not consider the possibility of producing an upcoming week's orders in advance of their scheduled shipment date and holding them in stock.
4) As the products are quite similar in composition and production requirements. The setup times required to change a production line from one product type to another were very short. Therefore, the setup times were assumed to be negligible in the model (Aydinel et al., 2008).

Network description

Closed-loop supply chain network which includes plants, collection centers, and demand markets. The plants can manufacture new products and remanufacture returned products. The products are sent to demand markets by plants. Then, the returned products are sent to collection centers. The objective is to know how many and which plants and collection centers should be open, and which products and in which quantities should be stock in them.

Problem assumptions

1) The model is designed for a single period.
2) All of the returned products from demand markets are collected in collection centers.
3) Locations of demand markets are fixed.
4) Locations and capacities of plants and collection centers are known in advance.

Mathematical modeling

This problem can be formulated by integer linear programming. Sets, parameters, and decision variables are defined as follows:

Sets

i = set of potential manufacturing and remanufacturing plants locations (i=1,2,…,I)
j = set of products (j=1,2,….,J)
k = set of demand markets locations (k=1,2,…,K)
l = set of potential collection centers locations (1=1,2,. . ., L)

Parameters

A_j = production cost of product j
B_j = transportation cost of product j per km between plants and demand markets
C_j = transportation cost of product j per km between demand markets and collection centers
D_j = transportation cost of product j per km between collection centers and plants
O_j = transportation cost of product j per km between collection centers and disposal center
E_i = fixed cost for opening plant i
F_l= fixed cost for opening collection center l
G_j = cost saving of product j (because of product recovery)

H_j = disposal cost of product j
P_{ij} = capacity of plant i for product j
Q_{lj} = capacity of collection center l for product j
t_{ik} = the distance between location i and k generated based on the Euclidean method (t_{kl} and t_{li} are defined in the same).
t_l= is the distance between collection center l and disposal center
d_{kj} = demand of customer k for product j
r_{kj} = return of customer k for product j
$\propto_j$ = minimum disposal fraction of product j

Variables

X_{ikj}= quantity of product j produced by plant i for demand market k
Y_{klj} = quantity of returned product j from demand market k to collection centre l
S_{lij} = quantity of returned product j from collection centre l to plant i
T_{lj} = quantity of returned product j from collection center l to disposal center
Z_i = 1, if a plant is located and set up at potential site i, 0, otherwise
W_l= 1, if a collection centre is located and set up at potential site l, 0, otherwise

Objective Function

$$\text{Min} \quad Z_1 = \sum_i E_i Z_i + \sum_l F_l W_l + \sum_i \sum_k \sum_j (A_j + B_j\, t_{ik}) X_{ikj} + \sum_k \sum_l \sum_j C_j\, t_{kl}\, Y_{klj} + \sum_l \sum_i \sum_j \left(-G_j + D_j t_{li} \right) S_{lij} + \sum_l \sum_j \left(H_j + O_j + t_l \right) T_{lj}$$

S.t.

$$\sum_i X_{ikj} \geq d_{kj} \qquad (1)$$

$$\sum_l \sum_j S_{lij} + \sum_k \sum_j X_{ikj} \leq Z_i \sum_j P_{ij} \qquad (2)$$

$$\sum_l Y_{klj} \leq \sum_i X_{ikj} \qquad (3)$$

$$\propto_j \sum_k Y_{klj} \leq T_{lj} \qquad (4)$$

$$\sum_k \sum_j Y_{klj} \leq W_l \sum_j Q_{lj} \qquad (5)$$

$$\sum_k Y_{klj} = \sum_i S_{lij} + T_{lj} \qquad (6)$$

$$\sum_l Y_{klj} = r_{kj} \qquad (7)$$

$$Z_i, W_l \in \{0, 1\} \qquad (8)$$

$$X_{ikj}, Y_{klj}, S_{lij}, T_{lj} \geq 0 \qquad (9)$$

The purpose of design green supply chain network is to minimize the total cost. The first and second parts show the fixed costs of opening plants, collection centers and waste disposal. The third part represents the production and transportation costs of new products. The forth part is related to product recovery and transportation costs of returned products. Besides, the fifth part represents the total recovery and transportation costs of returned products from collection centers to plants. Besides, the sixth part calculates disposal and transportation costs. The constraint (1) ensures that the total number of each manufactured product for each demand market is equal or greater than the demand. Constraint (2) is a capacity constraint of plants. Constraint (3) represents that forward flow is greater than reverse flow. Constraint (4) enforces a minimum disposal fraction for each product. Constraint (5) is capacity constraint of collection centers. Constraint (6) shows that the quantity of returned products from demand market is equal to the quantity of returned products to plants and quantity of products in disposal center for each collection center and each product. Constraint (7) shows the returned products. Constraint (8) ensures the binary nature of decision variables while Constraint (9) preserves the non-negativity restriction on the decision variables (Hassanzadeh Amin and Zhang, 2013).

Computational Result

Table 1 shows the values. Problems have been solved by LINGO 12. All computational work was performed on a personal computer (32-bit operating system, Intel Core i3.
The model statistics are 69 non-zero elements and other variables are equal to zero. Model is iterations 17 times. The objective value (total cost), in the problem is **765,541,500,000**. Optimum results of the problem is presented in Table 2.

Table 1. The number of index

Index	*i*	*J*	*k*	*l*
Number of index	3	2	3	3

The result shows that between three factories, only factory 1 and 2 are open. Also, between three collections centers, only collection center 1 and 3 for receive returned product are selected. $X_{211} = 50000$, indicates that product type 1 from plant number 2 will be send to the customer. $Y_{111} = 200$, indicates that returned product type 1 from customer type 1 is sent to collection center type 1. $S_{222} = 324$, its means that returned product type 2 from collection center type 2 will be sent to plant 2. $T_{22} = 216$, represents that product type 2 is related to collection center type 2.

Conclusion

Green supply Chain Management (GSCM) has been identified as an approach for improving performance of the processes and products according to the requirements of environmental regulations. The fast growth of automobile manufacturing industry worldwide has created business opportunities but concurrently increased substantial environmental burdens (Rao, 2002). These burdens such as air emissions, scrap/waste, scarce resources occur at all stages of a product's life cycle from extraction for manufacture, use and reuse, recycle or disposal (Zhu et al., 2007). Over the past few decades, there has been a gradual progression in the environmental performance of industrial firms.

Table 2. Computational results

Variable	Value	Variable	Value
Z_2	1.000000	Y_{211}	580.0000
Z_3	1.000000	Y_{222}	540.0000
W_1	1.000000	Y_{312}	650.0000
W_3	1.000000	Y_{331}	390.0000
X_{211}	50000.00	S_{121}	390.0000
X_{221}	5000.000	S_{222}	324.0000
X_{222}	49000.00	S_{322}	1128.000
X_{231}	59000.00	T_{11}	390.0000
X_{232}	100000.0	T_{12}	650.0000
X_{312}	45000.00	T_{22}	216.0000
X_{321}	75000.00	T_{31}	390.0000
Y_{111}	200.0000	T_{32}	752.0000
Y_{132}	1880.000		

This trend has culminated in the concept of "Eco-efficiency," which involves minimization of waste, conservation of scarce resources, and avoidance of persistent, toxic by-products. Experiences demonstrate that reducing pollution at the source and designing products and processes in ways that enhance environmental quality will generally result in higher productivity and reduced operating costs, and may also increase market share.

Obviously, implementation of these strategies will require fundamental changes in core business processes such as product development, marketing and sales, manufacturing, supply chain management, and customer service. In each case, environmental accounting methods are useful for systematically identifying and assessing opportunities to increase shareholder value. In this paper, model designed for different factory, demand markets, distribution centers and productions. In this paper, we have tried to minimize the total cost of the chain so that the transportation cost and the storage cost of products are reduced and also the amount of distribution optimal, quantity of returned product reduced and amount of satisfaction customers are increased.

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