SYSTEMATIC LITERATURE REVIEW FOR LOCATION-ALLOCATION PROBLEM UNDER ECONOMIC AND ENVIRONMENTAL SUSTAINABILITY

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ABSTRACT

Location-allocation problem is one of the vital strategic problems. It determines the locations of facilities that should be opened and the allocation links among them. In this study, systematic literature review is applied to guide the research. We review three main concepts which are: characteristics of location-allocation problem, economic and environmental sustainability in the scope of supply chain network design, and an optimization model with solution approach. The result suggests that future optimal solution development including mathematical model and solution approach is applied to configure network for specific product type and standard procedure of supply chain flow. Multi-objective functions are used to balance flexibility, reliability, and responsive network structure with standard raw material/product quality consideration in economic and environmental impact perspectives; whereas other impacts, beside pollution, are also taken into account. Moreover, component costs such as inventory holding cost, purchasing cost, production/operation cost and others should be included in the mathematical model. Additionally, new solution for heuristic scenario should be developed and upgraded for a more realistic application for sustainable supply chain network.

KEYWORDS: supply chain network, location-allocation problem, sustainability, environment, economics, optimization

1. Introduction

A successful business strategy is supported by strategic and tactical planning, and operational performance whereby supply chain management is of utmost vitality. Thus, supply chain network structure is prioritized to the benefit of stakeholders and the success of the whole supply chain of the business. Network structure is considered as an effective and efficient feedback to the whole supply chain where all nodes, whether externally or internally, are linked together to form real-time informational flow. Supply chain network design primarily aims to shape the structure of supply chain by strategically configuring the location and the number of facilities that should be set up, followed by defining raw material/product flow allocation in supply chain nodes—supplier, plant, and distribution center. Thus, location-allocation problem is the first prioritized task in defining the success of supply chain in term of cost reduction, profit earning, collaboration, and sustainability [1-4].

The first academic study on facility location problem was proposed by Weber [5] to determine the location of a single distribution and to optimize total transportation cost between distribution to customers. Fifty-five years later, a study of Hakimi [6] attempted to find the minimal location of multiple facilities by using the absolute centers and medians of a graph. Those two main works brought facility location problem to become a popular issue in operational research field where plenty of models and solution approaches attempted to deal with a number of complex problem characteristics [7, 8]. Quantitative location-allocation model begins from a single product, single echelon, simple linear, incapacitated, and deterministic model to a more complex network, comprising of multi-commodity, multiple echelons, capacitated facilities, nonlinear and probabilistic models where solution approach such as algorithms are also developed to ensure that desirable results [9]. According to 126 peer reviews of Mangiaracina's literature review from 1972 to 2013, there are 86 papers that proposed single objective functions attempted to minimize total cost, maximize profit and customer service level separately and then increasingly cropped into models with multi-objective functions which are in the scope of economic perspective [10].

Environmental perspective, one of the main components of sustainability [11], is popularized during the early 21st century [12], which also includes structuring problem of supply chain network design [13]. In recent years, network design problem studies is exponentially increased, adding environmental impact into the models and solutions approach in order to trade off the optimal results with economic benefits. To balance these two bottom lines of sustainability in supply chain network, location configuration is getting more complex in terms of determining number and location of facilities that also conform to size, type, capacity, the distance between each node, and environment impact as well [11, 14, 15]. For instance, specific activities coexist in both financial and environmental concerns are discussed in Amin and Zhang [16] & Bortolini, Galizia [17] where recycling, product return and so on are considered. Optimal solution is reached to deal with such a herculean problem.

Therefore, location-allocation problem, one of the main strategic supply chain management planning, is a decision-making task that determines the number and location of the whole or partial sites of network in the aspect of forward, reverse, and closed-loop network that commonly followed by allocating demand to those facilities [10, 18]. According to many operational researches, optimization approach is effectively applied to solve such issues. To achieve this task, mathematical model and solution method are technically processed in three main parts in term of: problem statement or assumption, mathematical model structure, and computational algorithm [9].

Due to increasing interest of economic and environmental sustainability, deep understanding of economic benefits and environmental concerns are of vitality where the aforementioned dimensions should be studied in order to gain an understanding of what kind of performance standard that is currently reached and what suggested areas should be studied in future researches. Besides this, optimization approach is used as a supported tool for seeking optimal or trade-off solution is also assisted to make decision that can be undeniable. Thus, reviewing the previous optimization approaches helps lighten up the roadmap for developing more effective and realistic solution approaches for sustainable supply chain network designs.

This paper aims to respond to the essential increases of interest, especially by identify the gap and intentionally suggest components which should be presented in mathematical models and the key ideas for future framework related to the aforementioned situation where location-allocation problems and optimization approach related to modeling (decision, relevant cost components) and solution method (e.g. algorithm), are included and reviewed from previous works. First of all, characteristics of problem is described to bright spotlight of every single problem statement occurring in recent years. Second, two main sustainable dimensions will be identified and observed as to what those literatures focus and what main fields of economic and environmental dimensions are considered from the works of Chardine-

Baumann and Botta-Genoulaz [19] where social dimension is excluded in this research. Then, the next part is a summary of mathematical model and solution used. The last part is a conclusion of those works to define the current state of problem and to identify the gap of future search based on peer reviews for the purpose of contributing in developing model, and a solution approach for network design problem as a whole. To gain a fruitful result, systematic review methodology of Denyer and Tranfield [20] is applied to smooth the process of reviewing academic articles in our work. The main objectives of the paper are described as following:

- To define the current relevant work of location-allocation problems.
- To identify the research gap of network problem which considers economic and environmental sustainability in supply chain network.
- To determine the developing model and solution approach.

This study is organized in the following manner. Research Methodology is introduced in section 2. Then, a brief of characteristics of location-allocation problem description is presented in section 3. In section 4, sustainability concern consists of economic and environment dimension is presented respectively. Optimization solution is followed in section 5. Finally, conclusion and recommendation are in section 6.

2. Methodology

In this section, we describe our research methodology where research procedure will be followed Denyer and Tranfield [20]. The structure of systematic research methodology is formed by four main parts to complete this review task as the following:

2.1 Question formulation

Primary work is identifying the review scope as shown in Figure 1, and specially forming questions to build research the framework. To define the scope of review, our paper adopts CIMO (Context, Intervention, Mechanism, Outcome) proposed by Denyer and Tranfield [20] to construct questions that cover the whole review. This logic method breaks down the main context of our work which attempts to characterize location-allocation problem with lighting those works' aiming (C), under economic and environmental consideration (I), what are the models and solutions used to crack down problems under both conditions (M), and to summarize the current state and guide the future tending, notify the gap of such a hazardous problem and recommend optimization solution approaches for problem (O).

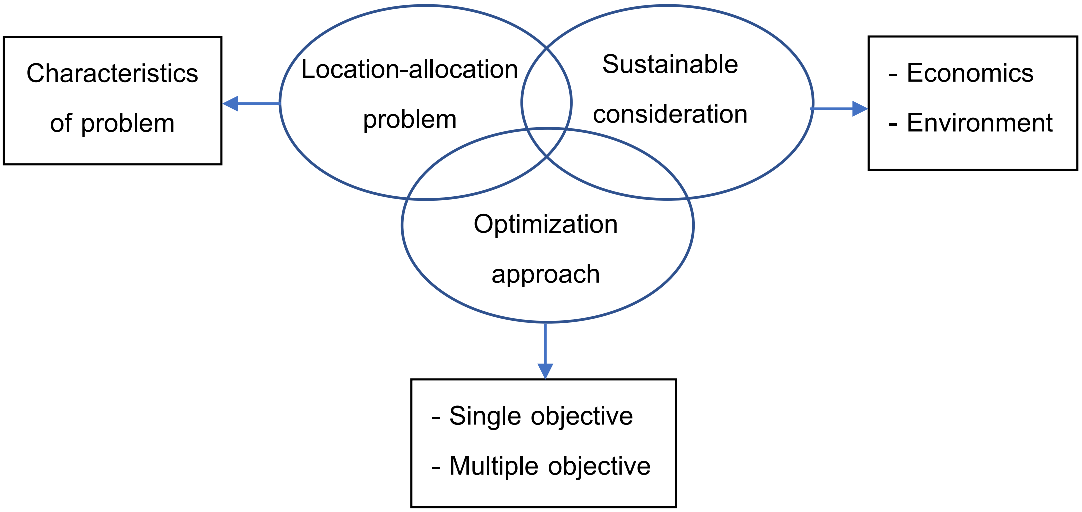

Figure 1 The literature review scope

2.2 Locating studies

This step is to determine keyword tools for reviewing relevant papers in database. Defining research keyword is a precise process to support review questions which are able to cover a wide range of available academic sources (article, books, journal, proceeding paper) related to the main topic in order to point out the missing parts which aren't solved, yet. Furthermore, future direction will be oriented to seek optimal solutions. Therefore, variety of published works related to location-allocation problem under economic and environmental consideration focusing on quantitative and conceptual model are found by using keywords as shown in Table 1.

Efficiency of review in database execution comes from constructing research sting. Hence, those keyworks in Table 1 are combined together into equations using simple operators and Boolean logic tools [20]. According Table 1, keywords are divided into three groups: (a) Location-allocation problem which can be searched independently to oversee in detail of the problem or can be combined with other two groups, (b) Sustainable consideration is used by economic and environmental keywords to dependently search by following group (a), and (c) optimization model and solution, it is potentially structured with both two mentionable groups. List of keyword construction using Boolean operators for searching in database is shown in Table 2.

Table 1 List of keyworks for searching in database

Location-allocation problem	Sustainable consideration	Optimization approaches
Sub keywords: - supply chain network - logistics network - facility location - allocation	Sub-keywords: - economics - environment - green	Sub-keywords: - mathematical modeling - solution approach - single objective - multiple objectives

Table 2 Keyword construction

Location-allocation problem	“And” sustainability		“And” Optimization Approach	
“Or” Network design Logistic network Facility location	“Or” Economics Cost	“Or” Environment Green	“Or” Mathematical Modeling	“Or” Solution approach

2.3 Study selection and evaluation

Our study searches relevant academic published papers based on some of major databases related to engineering, operation, production, and management areas. These includes Springer, Science Direct, Emerald Insight, Research Gate which provide high quality articles and peer-review journals accessed and broadly used by many academic organizations. In this step, selection criteria were defined, what are included and what are excluded in order to receive relevant papers which answer and meet the objective of this work. Criteria inclusion in this study was set: 1) Papers published in between 2010 to 2019 and authors come from Canada, United Kingdom, Turkey, Italy, Australia, Germany, India, United State of America, China, Japan, Thailand, Spain, and Iran 2) Papers described about characteristics and literature reviews of the main problem in this study are considered, 3) Both quantitative and theorical model are taken into account, 4) Articles dealing with proposing optimization framework and solution approach are considered into study included for forward, closed-loop and reverse supply chain. In contrast, exclusions are defined to take away from study such as 1) Location-routing and other problems in supply chain network are ignored, 2) Social dimension, one of sustainability component, is not taken into consideration. A total of 11 academic papers were selected resulting from constructing keyword equation that concern keyword domains, title, abstract, and finally, selection criteria (inclusion/exclusion).

2.4 Reporting results

The section of reporting review result is classified into (1) Location-allocation problem which were shown as objectives and characteristics of the problem. (2) List of journals which are relevant to economic and environmental indicators following Chardine-Baumann and Botta-Genoulaz [19] characteristics of sustainable performance, economic and environment respectively, as shows in Table 3. (3) Mathematical models and solution approach procedure is summarized in this paper and (4) Cost in each model will be analyzed in detail and finally (5) conclusion and recommendation will be illustrated in section 6.

Table 3 Characteristics of sustainable performance

Economic dimension	Environmental dimension
Fields	Fields
Reliability: - customer service - suppliers' service - reliability of stocks - reliability of forecasts	Environmental management: - environmental budget - environmental certification - environmental compliance - workers implications
Flexibility: - suppliers flexibility - supply flexibility - production flexibility - delivery flexibility	Pollution: - air pollution - water pollution - land pollution - other pollution

Table 3 (Continued) Characteristics of sustainable performance

Economic dimension	Environmental dimension
Fields	Fields
Reliability: - customer service - suppliers' service - reliability of stocks - reliability of forecasts	Environmental management: - environmental budget - environmental certification - environmental compliance - workers implications
Responsiveness: - design responsiveness - purchase responsiveness - source responsiveness - production responsiveness - delivery responsiveness - sell responsiveness - return responsiveness - supply chain responsiveness	Use of resources: - renewable energy - recycled water - inputs stemming from the recycling, - recyclable outputs - recyclable wastes
Financial Performance: - design cost - purchase cost - source cost - production cost - delivery cost - return cost - supply chain cost	Dangerousness: - dangerous inputs - dangerous outputs - dangerous wastes
Quality - product/service quality - quality performance of suppliers - production quality	Natural environment - eco-systemic services - respect of biodiversity - land use - development of urban and rural areas

Adopted from Chardine-Baumann and Botta-Genoulaz [19]

3. Location-allocation problem

Objective of systematically selected papers are summarized in Table 4 and the general reviewed-based characteristics of supply chain network are shown in Table 5. Those works show the characteristics of supply chain network both in obvious and experimental manners which are generally comprised of five main components: objective, time horizon, echelon, product, raw material. Liu and Xu [21] deals with a random uncertainty of such a problem that a clearly defined network is taken into account for a single period of single-type product flow along three echelons (plant, DC, customer) for the singular purpose of optimizing total relevant costs. The same objectives, but more deferent and complex characteristics of Lekhavat's work [22] is proposed with two new heuristics: allocating demand from customer to DCs and to develop Particle Swarm Optimization with multiple social learning terms (GLNPSO) where network configuration consists of three-echelon supply chain network (supplier, firm, DC) are considered as bill of materials (BoM) to produce multiple commodities divided into separated groups, with its objective function set as a single total relevant cost optimization in a single period. Amin and Zhang [16] aims to maximize profit in a period of time horizon where the network is set up based on product life cycle and designed as closed-loop network categorizing into six levels for producing output from a group of materials which comprised of outsourced suppliers, manufacturers, customers, collection sites, repair sites, disassembly sites, and recycling sites. Ruiz-Femenia, Guillén-Gosálbez [23] developed a multi-scenario model to deal with configuring number, location and capacity of facility and products flow at each node of supply chain created by plants, warehouses, and blocks of customer markets where raw materials and technologies are considered to produce chemical products in a set of periods.

However, a robust optimization model for outbound logistic network under uncertainty of De Rosa, Gebhard [24] is transformed from a deterministic model where it consists of facility, depot and customer, and product which are defined as a single type in a series of time horizon under uncertainty. Additionally, Harris, Mumford [25] proposed a capacitated facility location plan (CFLP) solution approach to meet multiple objectives which are considered a single product type between depot and customer location to determine the number of facility and product allocation.

Furthermore, a conceptual model is developed by Dubey, Gunasekaran [26] based on a real air conditioner company case study where the network characterizes into supplier, manufacturer, DC, mixing center, repair center, dismantling center, remanufacturing center, decomposition center, customer market, and secondary customer market processing with bill of raw material to manufacture various models of air conditioner products in multiple periods, aiming to minimize cost and time. Sabegh, Mohammadi [27] developed a multi-objective mathematical model for pharmaceutical field where quality is important. Procurement of raw materials are made and produced by manufacturing centers and then products are undergone quality check again before being shipped to DC, and finally transported to disaster areas; whereas products that failed quality test will be sent to rework centers to be re-maintained and distributed to DC if no defective results are found. Bortolini, Galizia [17] deal with location-allocation problems by designing a supply chain network that are both multiple objectives and multi-period planning for perishable products which are carried by packaging containers from farms to DCs and then to grocery stores. Still, the process of reverse logistics for reusable and disposable condition to pooler and recycling center where DC and pooler locations, product allocation, and packaging containers are still being carried out at the same time.

Table 4 Objective of selected papers

N°	Author	Paper objective
1	Liu and Xu [21]	Introduces the concept of hybrid variable and propose a mixed-integer programming model for random fuzzy facility location–allocation problem.
2	Lekhavat [22]	Presents new allocation schemes which are "highest-total-demand customer to nearest DC" and "nearest all types of facilities" to solve multicommodity distribution network design problem (MDNP).
3	Amin and Zhang [16]	Designs and configures a general closed-loop supply chain network based on product life cycles which focus on maximizing profit in a period of time horizon.

Table 4 (Continued) **Objective of selected papers**

N°	Author	Paper objective
4	Ruiz-Femenia, Guillén-Gosálbez [23]	Presents a stochastic multi-scenario mixed-integer linear program (MILP) with the unique feature of incorporating explicitly the demand uncertainty using scenarios with given probability of occurrence.
5	De Rosa, Gebhard [24]	Proposes a deterministic model for forward and reverse SC then extends to a robust capacitated facility location model under uncertainty.
6	Harris, Mumford [25]	Proposes a multi-objective optimization approach to the capacitated facility location–allocation problem (CFLP) for solving large instances that considers flexibility at the allocation level, where financial costs and CO_2 emissions are considered simultaneously.
7	Dubey, Gunasekaran [26]	Proposes a responsive sustainable SC model using three robust optimization and develops a question for answering environment and social dimensions.
8	Sabegh, Mohammadi [27]	Proposes a new multi-objective mathematical model for natural disaster response considering quality, green concepts.
9	Bortolini, Galizia [17]	Aims at designing a supply chain network, including the best packaging container, storage/handling node location and flow allocation.
10	Balaman, Matopoulos [28]	Presents a novel bi-level decision support system (DSS) to aid modelling and optimization of multi technology, multi product supply chains and co-modal transportation networks for biomass based (bio-based) production combining two multi-objective mathematical models.
11	Ratnayake, Kachitvichyanukul [29]	Presents a multi-objective model for solving location-allocation problem (LAP) which considers the greenhouse gas.

Otherwise, Balaman, Matopoulos [28] developed a decision supporting system for dealing with multiple objective network optimization network for bio-based products in a single-period time horizon. There are five echelons that consist of biomass source site, demand node, energy plant, pre-processing facility and storage facility. Ratnayake, Kachitvichyanukul [29] attempted to developed a multiple objective model for a single-period of time horizon network planning which considers a green gas impact and multiple product types produced from bill of materials and flow in four echelons: Supplier, Plant, DC and Customer.

4. Sustainability Consideration

According to Chardine-Baumann and Botta-Genoulaz [19], sustainability performance is based on three main indicators. They are economic, environmental and social dimension, and in this work, we picked only economic and environment sustainability to discuss in detail. Economic dimension is categorized into five fields: financial performance, flexibility, quality, responsiveness, and reliability, where environmental dimension consists of: environmental management, resource usage, pollution, dangerousness, and natural environment. Table 5 looks into characteristics of location allocation problem, whereas table 6 discusses economic and environmental sustainability. Below sub-section will discuss eleven papers in both economic and environmental aspects.

4.1 Economic Dimension

All eleven papers in this work are similarly and differently considered in economic area. Many papers attempted to minimize cost and some focused on maximizing profit or net present value. Like, Liu and Xu [21] attempted to minimize a total supply chain total cost under randomness and fuzziness condition. Lekhavat [22] developed a model and allocation heuristic in order to optimize and near optimize total relevant costs for multicommodity distribution network where opening and transportation costs are considered. Amin and Zhang [16] presented a closed-loop network for sustainability in supply chain which focuses on minimizing costs and maximizing profit by using mathematical model and sensitive analysis to support decision making.

However, Ruiz-Femenia, Guillén-Gosálbez [23] optimized multiple different objectives. The first objective is to simultaneously analyze economic/finance performance in an attempt to maximize total net present value (NPV) where demand is uncertain and final product price, cost of raw material, investment budget and operating cost are taken into account. Bortolini, Galizia [17] specifically presented a fresh food supply chain network design by additionally considering packaging containers problem into perishable product supply chain where reversion of its packages has been considered. Their work firstly deals with minimizing relevant costs such as opened DC and pooler cost, transportation cost, package purchasing cost, storage cost, package re-maintaining cost, incineration/recycling cost.

Table 5 Characteristics of location-allocation problem

N	Author	Type of network	Objective	Period	Echelon	Product	Raw material
1	Liu and Xu [21]	Closed loop	S	S	3	S	-
2	Lekhavat [22]	Forward	S	S	4	M	M
3	Amin&Zhang, [16]	Forward	S	S	7	S	M
4	Ruiz-Femenia [23]	Forward	M	M	3	M	M
5	De Rosa, [24]	Closed loop	S	M	3	S	-
6	Harris, Mumford [25]	Forward	M	S	2	S	-
7	Dubey, [26]	Forward	M	M	8	S	M
8	Sabegh, [27]	Forward	M	S	4	M	M
9	Bortolini, Galizia [17]	Closed loop	M	M	4	M	-
10	Balaman, [28]	Forward	M	S	5	M	M
11	Ratnayake, [29]	Forward	M	S	4	M	M

S = Single Objective/Period/Echelon/Product/Raw material; M = Multiple Objective/Period/Echelon/Product/Raw material; “ - ” = Not specified

Otherwise, Balaman, Matopoulos [28] deal with network design to trade-off between economic and environmental value where financial performance in their mathematical model is considered total supply chain profit which includes total revenue, discounted investment cost, operational cost, transportation cost, biomass purchasing cost, and auxiliary material cost are taken into consideration. Ratnayake, Kachitvichyanukul [29] considers minimizing total supply chain cost where establishing/opening and transportation cost are taken into account for mathematical model.

Flexibility is one of the main consideration of supply chain like a work of De Rosa, Gebhard [24] where network design is focuses on flexible facility capacity adjustments in a set of periods in time horizon for the purpose of combating uncertainty and improve sustainability in supply chain network that seeks to optimize cost of investment and operation cost of transportation cost, investment of opening facility, cost of change facility, fixed cost to change capacity of facility, maintenance cost, operation cost both forward and reverse. Harris, Mumford [25] concerns the network design where allocation is flexible and capacitated in a picture of cost minimization associated to fixed of operating open facilities and transportation cost trade-off with environmental matter that will discuss in next sub-section.

Another research dealing with responsive supply chain design is Dubey, Gunasekaran [26], whose model is used for dealing with three main objectives whereby one of them is economic performance that mainly responds to uncertainty problem, aiming for profit maximization where setting cost, capacity expansion cost, transportation cost, processing cost and delivery and collection time are included.

Supply chain network design which considers quality concept is proposed by Sabegh, Mohammadi [27]. Their work focus on analyzing cost of poor quality which includes appraisal and prevention costs for designing supply chain network in the purpose of minimizing total manufacturing cost of which production cost, purchasing cost, opening cost, opening facility cost and transportation cost are included to optimal model.

Reliability still remains an important aspect in designing supply chain network. Work of Balaman, Matopoulos [28] does not only attempt to cover financial performance but also reliability of network that service level is considered by optimizing simultaneously transportation distance between each node in supply chain network.

4.2 Environment Dimension

Environmental issue becomes a common concept to consider for designing supply chain or logistics network in the last decade where it is combined together with economic concept to enhance sustainability. As shown in Ruiz-Femenia, Guillén-Gosálbez [23], a model seeking for Net Present Value (NPV) maximization includes global warning issue. In their work, there are three main actions of pollution related to raw material consumption rate, transportation, and energy utilizing of Emission. Harris, Mumford [25] concerned reduction of CO_2 emission by using a life cycle analysis called IMPACT2002+ in terms of transportation and daily operation of facilities. Furthermore, in Sabegh, Mohammadi [27]'s contributions made to minimize the pollution impact from travelling distance and production operation that produced CO_2, hazardous gases and liquids. [28]'s work was concerned pollution matter that relates to GHG emission in term of production performance. Ratnayake, Kachitvichyanukul [29] attempted to sole supply chain network problem by both considering economic and environment where GHG minimization is taken into account to trade-off with total cost optimization. There are main sources of emission that are considered opening and operation activities of suppliers, plants, DCs in their work.

Table 6 Economic and environmental sustainability in selected peer reviews

N	Author	Economic	Environment
1	Liu and Xu [21]	Financial Performance	-
2	Lekhavat [22]	Financial Performance	-
3	Amin &Zhang, [16]	Financial Performance	-
4	De Rosa, [24]	Flexibility	-
5	Ratnayake, [29]	Financial Performance	Pollution
6	Ruiz-Femenia [23]	Financial Performance	Pollution
7	Sabegh, [27]	Quality	Pollution
8	Harris, Mumford [25]	Flexibility	Pollution
9	Balaman, Matopoulos [28]	Reliability &Financial Performance	Pollution
10	Dubey, [26]	Responsiveness &Flexibility	Use of resource
11	Bortolini, Galizia [17]	Financial Performance	Use of resource

Dubey, Gunasekaran [26] developed a supply chain network that corelates with responsiveness and also attempts to reduce the environment impact by designing a closed-loop supply chain network with remanufacturing and recycling in mind. Bortolini, Galizia [17] attempted to design supply chain network that does not only facility determination and product allocation but also reverse packaging container to increase the efficiency and effectiveness of resource utilization.

5. Optimization solution

5.1 Mathematical model and solution approach

According to systematic reviewing, the aforementioned literatures show increasing interests in multiple objective functions in optimization models for sustainable supply chain network designs. Among eleven papers, there are only four models which solve an economic objective function like Liu and Xu [21], Lekhavat [22], Amin and Zhang [16], De Rosa, Gebhard [24]. Seven papers are considered both economic and environmental objective functions such as Ruiz-Femenia, Guillén-Gosálbez [23], Harris, Mumford [25], Dubey, Gunasekaran [26], Sabegh, Mohammadi [27], Bortolini, Galizia [17], Balaman, Matopoulos [28], Ratnayake, Kachitvichyanukul [29].

For single objective function, Liu and Xu [21] and Lekhavat [22] both proposed a model relevant to forward supply chain network problems where facility configuration problems consider the selection facilities from a set of potential facility, and how to allocate customer demands to opened facility respective to facility capacities. Then, both models are computed in Priority-based genetic algorithms and particle swarm optimization with multiple social learning terms (GLNPSO) which proposed by Liu and Xu [21] and Lekhavat [22] respectively. Looking more into complex closed loop supply chain network, Amin and Zhang [16] proposed a model to determine quantity of products and components in an entire network as well as defining number of facility locations (recycling, disassembly, and repair sit separately) in a reverse logistics part of the supply chain network. In the same direction, De Rosa, Gebhard [24] aim to define the network where location configuration (opening or closing), capacity adjustment, facility type and size modification and determination of product quantity are considered in design optimization.

Multiple objectives are proposed and developed in terms of quantitative and theorical model and optimization solution approach, including decision support system. Ruiz-Femenia, Guillén-Gosálbez [23] proposed a stochastic model where net present value maximization is taken into account by following different scenarios and GHG emission is transferred into mathematical model following life cycle assessment (LCA) by standard algebraic equations.

Harris, Mumford [25] developed an optimization framework where the model separately minimizes economic and environmental objective functions and then both equations are integrated into SEAMO2 in order to compute facility configuration and customer demand allocation. Dubey, Gunasekaran [26] presents a theoretical model that minimizes total cost (economic) and time (environment) which is then reformulated into a more robust model. Sabegh, Mohammadi [27]'s model primarily optimizes total cost then minimized environmental effect of production and transportation actions and is finally maximized for human labors. This three-in-one model is separately computed in different algorithms: artificial neural network, Genetic algorithm, and Particle swarm optimization. Bortolini, Galizia [17] developed a model that deals with both economic and environmental dimension associated with cost optimization and CO_2 emission minimization, where the framework is then applied to trade-off those two objective functions by using normalized normal constraint method (NNCM) in the process of getting the Pareto frontier. Balaman, Matopoulos [28] proposed multiple mathematical model for both total profit and GHG emission trade-off and deeply focus on developing decision support system for objective optimization by integrating fuzzy set theory and e-constraint method together. Ratnayake, Kachitvichyanukul [29] also proposed a mathematic model for minimizing total supply chain network cost and the total green house. This model uses a constraint with slack approach in order to obtain a Pareto optimal solution and computed by CPLEX optimization solver.

5.2 Decision and cost consideration

Our literature review reveals that facility costs and transportation costs are commonly considered in those previous works. Facility costs normally refers to opening or establishment or set up cost that is categorized into fixed cost where transportation costs are sometimes even categorized into fixed cost or variable cost [16, 17, 21, 22, 25-29]. Facility cost extensively includes facility capacity adjusting cost, location changing cost (building/closing) [23, 24, 26].

Purchasing cost are included into models by Amin and Zhang [16], Ruiz-Femenia, Guillén-Gosálbez [23], Balaman, Matopoulos [28], Sabegh, Mohammadi [27], and Bortolini, Galizia [17] whose developed supply chain network designs are considered purchasing cost of packaging containers suitable for perishable products like food, fruit, vegetable.

Holding costs of inventory in warehouse for production, in DCs/depots for shipping to customer, or storing reverse products are discussed in work of Balaman, Matopoulos [28], Amin and Zhang [16], Ruiz-Femenia, Guillén-Gosálbez [23], Bortolini, Galizia [17], and Balaman, Matopoulos [28].

Operating costs in facilities are included in both operation activities at other facilities beside firm or production site and also in production activities as well like Amin and Zhang [16] that consisted of operating cost in collection sites. However, De Rosa, Gebhard [24] mentioned about maintaining cost of handling product at sites and production at forwarded or collected flow. Similarly, Ruiz-Femenia, Guillén-Gosálbez [23] and Balaman, Matopoulos [28] added this factor into their minimization model. Furthermore, Dubey, Gunasekaran [26] mentioned processing cost, representing operating cost into optimization model. Sabegh, Mohammadi [27] proposed adding production cost into their model as well.

Other costs are included into model and each of them is dependent on the aspects of network design that the authors in this review used. Amin and Zhang [16] considered recycling cost, disassembly cost, disposing cost for their closed loop supply chain network and Bortolini, Galizia [17] included re-maintaining and recycling costs into account in order to deal with supply chain network that prioritizes quality of raw materials and finished products. Sabegh, Mohammadi [27], however, considers some other important costs such as appraisal cost, rework cost, promoting safety cost, prevention cost, and cost of services to be theorized into the model.

6. Conclusion and recommendation

In our systematic literature review, eleven academic papers reveal the growth of facility location and allocation problem with various scenarios, new concepts, multiple performance measures, and more specific components for particular products and its supply chain of which sustainability is taken into account to enhance economic and environmental aspects of supply chain.

The papers show two main categories, general and specific. A group of papers aimed to design for a general or novel supply chain network and other works structured a network for a specific purpose and specific field or product. However, most of papers are designed for the forward supply chain and only a few are configured network for closed-loop supply chain. Although network configuration and raw material/component/product allocation purpose have different types of supply chain network manner, their characteristics are totally in the same manner such as: clear objective function, time horizon planning, deterministic echelons, type of product/raw material. Moreover, specific product types and standard procedures of supply chain flow and network with multiple objectives are starting to get more attention. Additionally, technology investment starts to include network design problems because of the growth of automation and cyber-physical systems based on societal development and technological advances.

Sustainability is tending to network design problems but not all of it work traditionally and classically by dealing with economic field, especially with financial performance in terms of cost minimization and profit maximization and other economic fields like flexibility, responsiveness, reliability, and quality fields of which are still limited. Another major matter, environmental sustainability, mostly considers pollution sources like gas, $CO_{2,}$ carbon emission from vehicle traveling and production/operation activities in an entire transportation network. Use of resources such as recycling, reusable activities are made in the view of reverse supply chain. Therefore, relevant matters in environment dimension such as environmental management, dangerousness, and natural environment.

Reviewing papers clearly reveals the decrease of single objective function and exponential tend of multi-objective functions of building mathematical models to combine economic and environmental performance measures into location-allocation decision-making. According to observation, not only strategic single location-allocation problem that have been solved, but also tactical level and operational level such as routing problem, inventory level, and so on, are included into model and solution approach for the purpose of deep, detail and realistic solution application for supply chain network problem. Moreover, relevant costs in modeling are also more detailed whereby previous models have considered only facilities opening cost and transportation cost. Any costs such as cost of environmental impact trade-off, purchasing cost of raw materials/products, inventory holding cost in warehouse/DC, operating/production cost at facilities and other cost are included in some of our peer reviews, and those should be considered in developing mathematical model and optimization solution approach for the future works. Moreover, solution methods like algorithm and CPLEX optimization solver, are considered more feasible, acceptable and reliable tools to optimize the solution.

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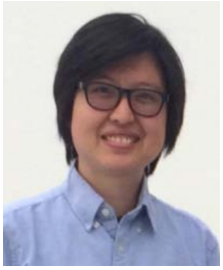

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