An Overview of Supply Chain Management and its Network Structure

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ABSTRACT: Facility placement choices are important in the strategic design of supply chain networks since they influence the overall efficiency of the network. The purpose of this article is to provide a review of the literature on facility placement models in the context of supply chain management. We highlight the fundamental characteristics that models of strategic supply chain planning must contain in order to provide decision-support for those engaged in the process. The integration of location choices with other decisions that are important to the design of a supply chain network is specifically addressed in this paper. Furthermore, issues pertaining to the structure of the supply chain network, as well as those pertaining to reverse logistics, are discussed. Consideration is given to significant contributions to the present state-of-the-art, taking into consideration a variety of criteria. Performance measurements and optimization methods for the supply chain are also discussed in detail. There are many applications of facility placement models to supply chain network design that span a wide range of sectors, which are discussed in this paper. At the conclusion, a list of problems that need additional investigation is presented.

KEYWORDS: Consumer, Facility Location, Supply Chain Management, Supply Chain Network, Unconstrained Facility Location Problem (UFLP).

1. INTRODUCTION

In the field of Operations Research (OR), facility location is and has long been a well-established research topic. Numerous papers and publications bear testimony to this reality, as do other sources. The American Mathematical Society (AMS) has even developed special codes for locating issues in its research publications. Despite this, the issue of whether or not location models are applicable has long been a source of debate and contention. The actual utility of logistics, on the other hand, was never a point of contention. Supply Chain Management (SCM) is one of the areas of logistics that has received a great deal of attention recently. In reality, the development of SCM began independently of OR, and it was only gradually that OR was integrated into SCM. Facility location models have progressively been presented in the context of the supply chain as a result, opening the door to an incredibly fascinating and profitable application area. In the course of such a development, it is inevitable that many issues will emerge, including: I What characteristics must a facility placement model possess in order to be acceptable in the context of the supply chain; and (ii) How can a facility location model be improved? Existing facility location models that are already compatible with the supply chain context? (ii) Is there a market for new facility location models that are already compatible with the supply chain context? (iii) Is it necessary to have facility location models in SCM at all?

Because the number of papers on this topic has increased dramatically in recent years, and because the Association of European Operational Research Societies (EURO) has recently dedicated a Winter institute to this topic, we felt that the time had come to publish a review paper that specifically addressed the role of facility location models within supply chain management. Before we begin the study, we need to quickly identify our two primary subjects of inquiry, which are the location of the facility and the SCM[1].

Generally speaking, a facility placement issue includes a collection of geographically dispersed consumers and a set of facilities to meet the needs of those customers. Furthermore, a specific metric is used to quantify the distances, durations, and prices that consumers must travel between facilities. The following are examples of questions that may be answered: Which facilities should be used (opened)? To keep overall expenses as low as possible, which clients should be served from which location (or facilities)? Along with this general configuration, there are a number of restrictions that are imposed by the particular application domain as well.

Supply chain management (SCM) is the process of efficiently planning, executing, and managing the activities of the supply chain. All movements and storage of raw materials, work-in-process inventories, and completed products, from the point of origination to the point of consumption, are included under supply chain management (SCM). In supply chain management, one of the goals of the planning procedures is to determine the optimal supply chain design. In addition to the general facility site layout, additional areas such as procurement, manufacturing, inventory, distribution, and routing must be taken into consideration, among other things. Historically, academics have concentrated their efforts very early on the design of distribution networks, without taking the supply chain as a whole into consideration[2].

1.1 Location of SCM:

If you are faced with a discrete facility placement issue, your options for locating additional facilities are limited to a small number of potential places from which to choose. The most straightforward formulation of such a challenge is the one in which p facilities are to be chosen in order to reduce the overall distances or costs associated with meeting client requests. This is referred to as the p-median issue, and it has received a great deal of attention in the literature. This option implies that all potential locations are equal in terms of the cost of setting up a new facility when a new facility is being built. Alternatively, if this is not the case, the objective function may be modified to include a term for fixed facility location costs, and as a consequence, the number of facilities to be created is usually determined by an endogenous decision process. The incapacitated facility placement issue is a term used in the literature to describe this unique situation (UFLP). There are many references to the UFLP to be discovered. In both the p-median problem and the UFLP, each customer is assigned to the available facility that has the lowest assignment cost for him. In the capacitated facility location problem (CFLP), which is one of the most significant expansions of the unconstrained facility location problem (UFLP), exogenous values are evaluated for the maximum demand that may be provided from each prospective site. It is no longer possible to use the closest-assignment property in this situation[3].

The models discussed above have many features, including a one-period planning horizon, deterministic parameters, a single product, a single kind of facility, and choices on where to locate and how to allocate resources. These models, on the other hand, are obviously inadequate for dealing with a wide range of actual facility placement scenarios. As a result, many expansions to the fundamental issues have been proposed and thoroughly researched. When dealing with circumstances whose parameters vary over time in a predictable manner, multi-period location issues have been suggested as a strategy. The aim is to match the configuration of the facilities to the parameters that have been identified. As a result, it is common to consider a planning horizon that is split into multiple time periods.

In addition, the incorporation of stochastic components in facility placement models is a significant advancement. Due to the uncertainty that may frequently be linked with certain factors, such as future consumer needs and expenses, this is being done in order to mitigate risk. Researchers give an overview of research on facility placement that, via the consideration of time and uncertainty, has resulted in more realistic models of facility location being developed.

A critical element of many practical location issues is the presence of several kinds of facilities, each of which serves a particular function, as well as a natural flow of materials between them. It is customary to designate a layer or an echelon for each group of facilities that are the same kind and perform the same function, thus establishing a level in the hierarchy of facilities. There is a plethora of articles in the literature that discuss this subject. When it comes to the study of core location, intra-layer material fluxes have received just a small amount of attention. Furthermore, the potential of direct flows from higher levels to consumers has received just a passing mention in the scientific literature.

Another element pushed by real-world applications, and one that has received a great deal of attention, is the need to deal with multi-commodity issues in order to be successful. A conclusion that can be made from the literature dedicated to the UFLP and its expansions is that this study area has developed in a way that does not take the SCM environment into consideration. Features such as various facility levels and capacities have been incorporated in the models in a fairly generic manner, and particular features that are critical to SCM have been ignored or omitted from the models. In reality, it seems that the majority of expansions were driven by problem-solving techniques. For example, in multi-layer models, intra-layer flows are often not taken into account since this characteristic breaks the structure of the constraint matrix, making it impossible to utilize decomposition techniques on the resulting matrix.

Figure 1 illustrates a basic supply chain network that comprises operations that occur both forward and backward in the supply chain. Additionally, the image depicts the potential flow of material in addition to the various kinds of infrastructure. A common occurrence in many supply chains, in contrast to traditional location issues, is the movement of goods between facilities within the same tier. The majority of the time, these flows are required for material balance or inventory consolidation purposes[4].

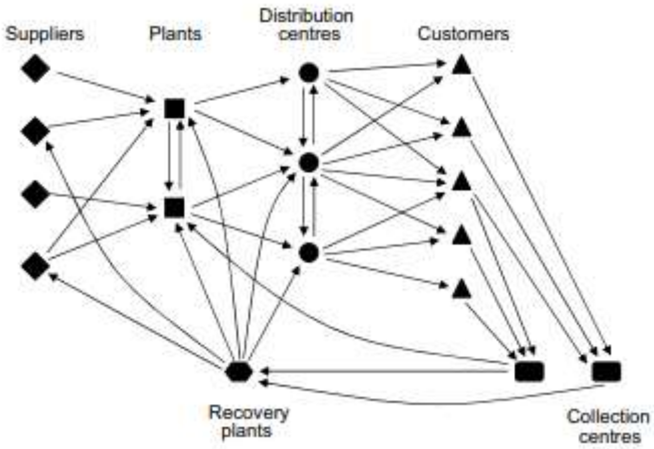

Figure 1: Illustrates a basic supply chain network [5]**.**

1.2 Strategic Levels of Supply Chain Management:

As part of the decision-supporting process in SCM, we provide a synthesis of the current literature in terms of the key elements and choices that should be included in facility placement models to aid in the decision-making process.

1.2.1 Network Structure:

A supply chain network is expected to remain in operation for an extended period of time, during which time numerous factors may shift and alter. If the unknown parameters have a probabilistic behaviour connected with them, then a stochastic model may be the best suitable model for the scenario in question. The occurrence of certain characteristics changing over time in a predictable manner opens the door to another modelling option. In this instance, if predictions for the unknown parameters are available, they may be included into the model in order to produce a network design that is capable of dealing with these changes in the future. For example, a one period facility placement model may be sufficient to identify a "robust network architecture" as well as a "robust set of tactical/operational choices." A compromise may also be feasible, in which the strategic placement choices are adopted at the beginning of the planning horizon, but other decisions, such as the allocation of customer needs to facilities, may alter over time as new information becomes available.

Strategic choices should, by their very nature, be implemented over an extended period of time. In fact, given the significant financial expenditures that are often involved with these types of choices, stability in terms of the design of the supply chain network is a very desired characteristic. It may still be necessary in some cases to consider the possibility of making future adjustments to the network configuration to allow for gradual changes in the supply chain structure and/or the capacities of the facilities, which may necessitate taking into account the possibility of making future adjustments. In this scenario, a planning horizon split into multiple time periods is usually considered, with strategic choices to be made for each period of the planning horizon as it is developed. Such a scenario may arise, for example, when major facility investments are constrained by the money available in each fiscal year or fiscal quarter. Naturally, significant modifications in the design of facilities, such as warehouses, make more sense when compared to facilities needing relatively modest expenditures. Furthermore, it is feasible to integrate multi-period planning with stochasticity in a single model. This is the scenario in which the probabilistic behaviour of the unknown parameters varies over time as a result of the uncertainty[6].

1.2.2 Reverse Logistics:

The literature on reverse logistics may be split into two categories: planning issues where the reverse network is connected with the forward network, and planning problems where the reverse network is completely focused on recovery operations. In the first instance, we refer to a supply chain as a closed-loop network, and in the second case, we refer to a recovery network as a closed-loop network.

It is proposed by the researchers that a layer of disposal facilities be established to accept returned goods that cannot be salvaged. The reverse flows are sent straight to facilities for re-use in the manufacturing process. In a similar vein, return goods are handled in the same facilities that enable direct operations in the model described above. Only facilities supporting ‘forward operations' are considered when deciding where to locate them. The collection centers serve as fact-checking sites for consumers who want to return goods if they are dissatisfied with them and wish to get a refund. This article discusses the peculiarities that E-commerce has brought into supply chain management in general, and reverse logistics in particular, and how they may be addressed. The significance of reverse flows in the light of the increasing importance of post-sale services is emphasized in particular here[7].

1.2.3 Additional Features:

By selling their goods and providing their services to customers all over the globe, economic globalization has opened up new possibilities for firms to expand their operations and increase their profits. Consequently, models for the strategic design of multinational supply chains have grown in significance as a result of these developments. Models of this kind handle global characteristics that are common to an international situation in which a company's commercial operations are geographically spread over a number of different nations.

Financial considerations are only a few of the problems that have a significant effect on the design of international supply chains. It is possible to split these elements into three groups. Taxes, levies, tariffs, exchange rates, transfer costs, and local content requirements are all examples of international variables, which fall under the first of these categories. The second category consists of financial and fiscal incentives provided by governments in order to encourage facility investments in certain nations or areas. The last category includes expenditures for capital improvements, which are often limited by the overall amount of available funds. Budget restrictions for the opening and closure of facilities serve as a model for this element. Whenever there are many periods in a planning horizon, financial constraints change from one period to the next, placing constraints on not just the placement of facilities, but also on other key supply chain choices[8].

1.3 Optimization of The Supply Chain:

Additional information about the articles is included in order to complete our assessment of the literature on facility placement models in a supply chain management (SCM) context. We look at the types of supply chain performance metrics that were utilized, the technique that was used to address the issues, and the applicability of facility placement models to strategic supply chain planning in this paper. The bulk of the articles have as their primary goal the reduction of costs. Furthermore, this goal is usually represented as a single objective via the sum of different cost components that are dependent on the set of choices that have been modelled in order to achieve it. As a result, the bulk of the papers reviewed had as their goal determining the network design that would result in the lowest overall cost.

Profit maximization, on the other hand, has gotten much less attention. This is rather unexpected given the fact that the majority of company operations are geared toward making a profit. Two distinct types of profit maximization may be discovered in the literature: (1) maximization of revenues minus expenses, and (2) after-tax profit maximization. (1) maximizing of revenues minus costs Furthermore, in the context of profit maximization, it may not always be advantageous for a business to meet all of its customers' needs. This happens when providing services to certain consumers results in extra expenses that are more than the income generated by those customers. Furthermore, when the expenses of sustaining a client base become too expensive, a business may choose to deliberately lose consumers[9]–[11].

2. DISCUSSION

When the number of discrete variables is large, as is frequently the case when strategic location decisions relate to more than one equipment layer in the supply chain network, the resulting models are comparatively more complex, and problems of realistic size can only be solved using a heuristic approach. Many of today's most prominent methods include relaxation, linear programming-based heuristics, and metaheuristics, to name a few. Problems with multiple goals are addressed using a particular approach, which does not necessarily result in the discovery of optimum solutions to the problem at hand. This is the situation when a weighted total of the criteria is used to convert several goals into a single target, or when goal programming is employed to achieve the transformation. It has also been tried to use the -constraint approach, which similarly merges the many goals into a single goal.

At the end of this section, we offer many articles that specifically address the use of facility placement models to strategic supply chain planning. The articles are divided into two categories based on two criteria: the kind of industry from which the application originates and the context in which it is used. Case studies, for example, relate to a real-life situation that has not been implemented in reality, while industrial context refers to a research that uses randomly produced data for a particular industry, as defined by the category Industrial context. In the table, it can be observed that each cell is devoted to a certain industry and that each cell contains a more or less equal number of papers. As an additional point of interest, 68% of the papers report on case studies, with the remaining 32% using randomly generated data in an industrial setting. This significant disparity may be explained by the fact that, after sufficient information and data on strategic supply chain planning has been accumulated, it becomes more lucrative to concentrate on a case study. The relationship between site planning and Geographic Information Systems is discussed in the previous work. It is also debated whether or not location models should be included into the optimization suite mySAP Supply Chain Management created by the software firm SAP (Germany). An application-oriented modelling framework for strategic planning in supply chain management (SCM) is given, and a heuristic method for addressing a complete model is suggested.

3. CONCLUSION

Within the context of supply chain management, we examined the most current literature on facility location analysis and addressed the overall relationship between facility location models and strategic supply chain planning. Furthermore, we highlighted the features that a facility placement model should have in order to effectively meet the requirements of SCM planning efforts. Separate parts were devoted to the relationship between facility location and supply chain management, facility location models within supply chain management, solution techniques, and applications. It is still far from being possible to combine many tactical and operational choices in SCM, such as those involving procurement, routing, and the selection of transportation modes with those pertaining to location decisions. There are still a few articles available that cover these topics. The structure of the supply chain network, on the other hand, is significantly simplified in the majority of them. Further consideration should be given to the complete integration of forward and backward operations in supply chain management (SCM). As a result of the literature review, we can infer that just a few publications attempt this integration, and that, once again, substantial simplifications are implemented.

The approach that has been established to handle SCND issues has produced a large and diverse collection of possible solution methods. Because of this factor, as well as the constant development of greater computer power, it is now feasible to handle complex models. Although the inclusion of different characteristics mentioned above would inevitably raise the complexity of the models produced as a consequence, the prospect of addressing real-world issues seems to be very promising.

We may conclude from this study that there is a growing body of research that is aimed at the integration of strategic and tactical/operational choices in supply chain planning, which is the primary conclusion. Furthermore, the function of facility placement is critical in supply chain network design, and this role is becoming increasingly essential as the need for more complete models that capture many factors relevant to real-world issues concurrently grows. Nonetheless, much more study is required in order to include into current models a number of problems that have not gotten sufficient consideration in the literature too far. It follows that considerably more space exists for the creation of new models to assist in the decision-making process associated with integrated supply chain planning than there is now.

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