A Multi-hierarchy Facility Location with time based considering under Demand Uncertainty by using Robust Optimization

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Humanitarian logistics have been indicated as significant issues in several terms of natural disaster operations and management. Indeed, a fluctuation demand as known as the demand uncertainty usually happens during a post disaster. Accordingly, time plays an important role in various real-life modeling applications. Therefore, an objective is to apply the uncertainty parameter model during post disaster considering the time based modeling. We analyze a few distinct network designs both single and double hierarchies of facility sites to find a most efficient network for a relief distribution under the demand uncertainty with time dependent. The parameter uncertainty is handled by robust counterpart in Robust Optimization (RO) which has the capability to operate under lack of full information on the nature of uncertainty and increasing the popularity. The Tohoku's Earthquakes in 2011, Japan is a case study. We focus on Miyagi prefecture which is the most affected area and huge number of evacuees. The unit of time is a day and one month is investigated. The expected results are the suitable network configurations and operation truck sizes with total delivery cost efficiency and their robustness which depend on the time. The uncertainty model is useful to help the planner to identify trade-offs between the inability to recover fully costs for excess link flow, and the need to manage transportation resource such as trucks, drivers and etc. to satisfy with the demand.

Key Words: *multi-hierarchy, uncertainty demand, facility locations, Robust Optimization*

1. INTRODUCTION

The post disaster logistics functions are defined for two significant issues as proving essentials to survived victims and recuing the victims. This study is considered the vital item distributions to relieve the large number of survived victims. There are sub three problems in logistics activities; location, routing and location-routing which are realized with a cost efficiency, a quick response, a satisfied demand and an environment issue. Moreover, the efficiency of planning and coordinating of logistic activities are necessary to treat them.

The location problem is one of the most important aspects in logistic activities. Some researchers have been done about the appropriate location of medical centers where the evacuees can be quickly accessed.

Not only the medical centers but also the location of shelters is conducted. Details of these researches are shown next part of the literature reviews. This study intends to design the depot locations by considering the cost efficiency and also the satisfaction with the demand. Lin *et al.*[3)] focused on logistics efficiency improvement. They said that the prioritized items for delivery and an extensive time period are importance of humanitarian logistics.

They presented the location of temporary depots around the disaster-effected area between the long travel distances of demand points and the central depots.

This model is to design principally the distribution network with multi-layer of facility locations by using the multi-source Capacitated Facility Location Problem (CFLP), or sometime is called the Capacitated Concentrator Location Problem (CCLP). The model is designed for single and double layers of depots to make the model more realistic and satisfied with the demand.

Furthermore, the real situations usually meet with the fluctuation of parameter uncertainty. Therefore, this study also stresses the importance of uncertainty of parameters; here is the supply and demand uncertainty. The methodology to handle with this demand fluctuation is Robust Optimization. The models that illustrate for uncertainty parameters are known as robust optimization model which are opposite with deterministic models.

In such background, this study attempts contributes to the previous research by considering the worst-case scenarios of the multi-facility location problems under uncertainty demand. Accordingly, main objective of the study is to tackle the facility locations problem and allocations with demand uncertainty function while considering the time. The objective of the study can be summarized are:

1. To manage the facility location problem in the context of both deterministic demand and uncertainty demand
2. To optimize the model with the important role in real life situation by considering the time based modelling.
3. To evaluate the total delivery cost efficiency on different networks. Accordingly, we analyze the model on three different networks by the structures and truck sizes.
4. To evaluate their robustness on different networks.

The expected results of facility location model with routing are defined as follows:

1. To search the appropriate locations of depots to distribution the relief items in Miyagi prefectures.
2. To allocate the transportation link flow at each network configurations.
3. To minimize the total delivery cost which includes the transportation cost, the opening facility cost and the transshipment cost.

2. BACKGROUND OF THE STUDY

As we know that there are enormous impacts as both a humanitarian crisis and a massive economic aftermath of the 2011 Tohoku earthquake and tsunami. The Japan's central bank said that the economic losses of Kobe quake in 1995 were 10 trillion yen for both immediate problems with industrial production suspended in many factories, and the longer term issue of the cost of rebuilding. However, the Japanese Government, BOJ Governor Masaaki Shirakawa had estimated that this cost is much higher than the cost of just the direct material damage could exceed 25 trillion yen. Moreover, the several costs are generated to recover the situations during disaster and post disaster period, for example reconstruction cost, rescue cost, logistics cost and etc. The logistic cost was present by Nagurney *et al.*[4] as approximately 80 percent from overall of operation responding cost. Therefore, the cost efficiency should be one of many aspects that must be considered. By this reason, this study would like to play on the logistic cost efficiency. An improved supply distribution cost can reduce the expenditure of the whole of operation cost during the amelioration period. A bottle of water is considered to be a requisite item for preliminary succor. Even the total delivery cost minimization is not only one to consider in humanitarian logistics however it is a good criterion to compare the results of distinct network systems.

This study considers robust counterpart in Robust Optimization (RO) which is provided by AIMMS software and more recently applied to handle under uncertainty of the parameters in the models. Robust optimization is designed to meet some major challenges associated with uncertainty-affected optimization problems as follows; to operate under lack of full information on the nature of uncertainty, to model the problem in a form that can be solved efficiently and to provide guarantees about the performance of the solutions. Robust Optimization is an uncertainty modeling approach suitable for a situation where the uncertainty ranges are known and not necessarily the distribution. Typically some inputs take an uncertain value anywhere between a fixed minimum and a maximum. This demand uncertainty can present how the worst case is when we consider the fluctuation of the demand. The Robust Optimization is very suitable for many problems as only simple inputs are required from the user about the data uncertainty because there are no scenarios or distribution functions need to be defined. The advantage of Robust Optimization models is that they grow only slightly when uncertainty is added. As the result, the model can be solved efficiently. Many fields of the academic study had discussed uncertainty parameter handling with robust optimization approaches, for an instance, a design and operations of chemical processes, an electrical capacity system, supply chain networks and transportation planning design.

Time plays an important role in various real-life modeling applications. Typical examples are found in the areas of planning, scheduling, and control. The time scale in control models is typically seconds and minutes. Scheduling models typically refer to hours and days, while the associated time unit in planning models is usually expressed in terms of weeks, months, or even years.

3. CONCEPTUAL FRAMEWORK

The problem is designed for three different network structures of relief distribution. In addition, the study concern about the model reality by considering time. The framework of the study is shown in figure 1. We categorized the three networks based on the network configurations and the dispatched truck sizes. Two types of the network configurations are single layer and double layers of facility site candidates, defined as central depots and depots.

This study focuses on the multi-source and multi-layer of facility location problem with uncertainty demand by considering the ellipsoidal uncertainty set in robust optimization approach. The robust counterpart in Robust Optimization (RO) is provided by AIMMS software which is more recently applied to handle under uncertainty of the parameters.

4. EXPECTED RESULTS

The expected results are to define the appropriate distribution network by searching for the facility locations for both context deterministic demand and uncertainty demand. Therefore, the main result is the facility locations which offer the minimum total deliver cost. Consequently, the transportation amount link flow is optimized. According to the time based, the study expects to find the best network and how the network responds during the time.

5. CONCLUSION AND FUTURE WORKS

We discuss the interrelated aspects to improve the future work as follows: (1) we have not considered the other parameters that can be possible to fluctuate

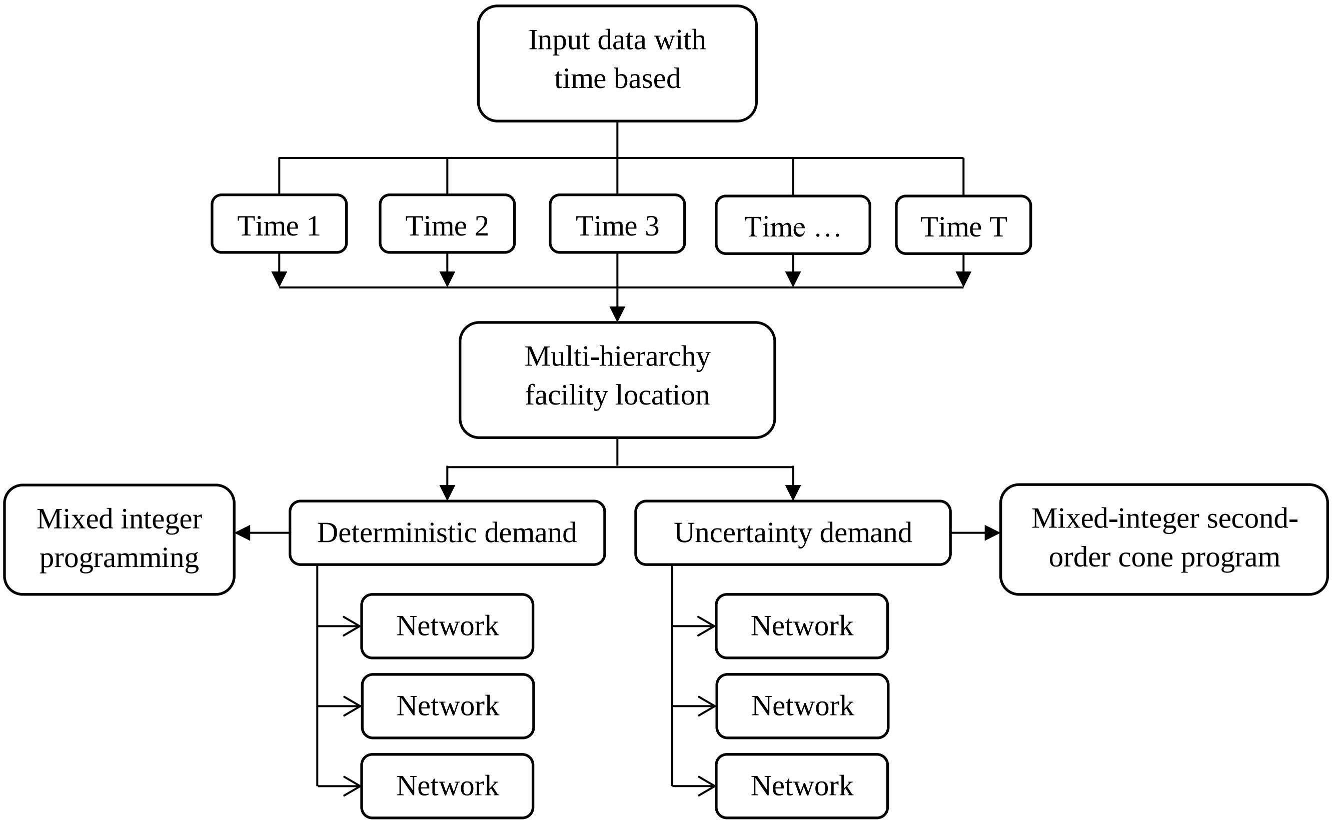

Fig. 1 The conceptual framework of the study

during humanitarian logistics, for example the supply amount, the unit transportation cost, the opening facility cost and etc. Therefore, not only the uncertainty demand but also such kind of parameters should be considered simultaneously. (2) The future work can also consider the multi-objective facility location routing problem. The model should be more reasonable by investigation both cost and time indicators simultaneously. After that the uncertainty of the demand is assigned to use with the model and then evaluates their model robustness.

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