A BI-OBJECTIVE STOCHASTIC SINGLE FACILITY LOCATION MODEL FOR A SUPERMARKET

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This thesis is dedicated to my parents
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ABSTRACT

One of the important strategic challenges in today's competitive environment is to select the best location for new facilities. Selecting a new location is vital for retail stores such as chain supermarkets and can be considered as a huge competitive advantage which may result in their failure or success. Location models are hard to implement in the real world problems, firstly because of the uncertainty of the input parameters and secondly, due to the intensive computations involved when the solution space is large such as a city. In this study, a stochastic bi-objective model is developed for points and area destinations with the purpose of finding a single new location for a chain supermarket that aims to be close to more customers and also have the minimum number of competitors near to the new location. Customer locations are considered to be regional with uniform probability distribution. A reduced gradient solution procedure is used as an algorithm for solving the model. The problem is solved with the help of Matlab software due to the high computations involved. The result of this study shows that more firms and companies can be drawn to actually implementing these models that are closer to reality to increase their profit and minimize their cost which is the aim of all business firms.

ABSTRAK

Salah satu cabaran strategik yang penting dalam persekitaran yang kompetitif pada hari ini adalah untuk memilih lokasi terbaik untuk kemudahan baru. Memilih lokasi baru adalah penting untuk kedai runcit seperti pasar raya rantaian dan boleh dianggap sebagai kelebihan persaingan yang besar yang boleh mengakibatkan kegagalan atau kejayaan mereka. Model lokasi adalah sukar untuk dilaksanakan dalam masalah dunia sebenar, pertamanya kerana ketidaktentuan parameter input dan kedua, disebabkan pengiraan intensif yang terlibat apabila ruang penyelesaian adalah besar seperti sebuah bandaraya. Dalam kajian ini, model stokastik bi-objektif dibangunkan untuk titik dan destinasi kawasan dengan tujuan mencari lokasi tunggal baru untuk rantaian pasar raya yang bertujuan untuk menjadi dekat kepada lebih ramai pelanggan dan juga mempunyai bilangan minimum pesaing berhampiran lokasi baru. Lokasi pelanggan dianggap sebagai daerah dengan taburan kebarangkalian seragam. Prosedur pengurangan kecerunan digunakan sebagai algoritma untuk menyelesaikan model. Masalah itu diselesaikan dengan bantuan perisian Matlab kerana pengiraan yang tinggi yang terlibat. Hasil kajian ini menunjukkan bahawa lebih banyak firma-firma dan syarikat-syarikat boleh diambil untuk benar-benar melaksanakan model-model yang lebih dekat kepada realiti untuk meningkatkan keuntungan mereka dan mengurangkan kos mereka yang merupakan matlamat semua firma-firma perniagaan.

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CHAPTER 1

INTRODUCTION

1.1 Introduction

Facility location problems have a large history and have received considerable research interest for decades. The location of a new facility is a long-term investment due to the high costs and difficulties associated with locating or altering the location of a facility after it is placed. Therefore, one of the important strategic challenges in today's competitive environment is to select the best location for new facilities (Owen & Daskin, 1998).

Generally facility location models and their application can be categorized differently on the basis of the number of facilities to be located, their size, the objective, the solution space, and the distance measure which are used in the models to make them comparable with the real world problems. Single-facility minisum location problem is a category of location problems that intends to find a single new location for the facility in a way that the total weighted sum of the distances between the new facility and all the existing facilities or demand points is minimized. The space can be considered as to be planar or network and also continuous or discrete. Continuous location problems means that the new facility location can be placed anywhere on the space whereas discrete location problems include predefined sets of locations for the new facility. Different types of distance measures can be chosen based on the problem definition such as rectilinear distance for instances like urban

settings due to the street layout or Euclidean distances in situations where the distance can be considered as a straight-line (Tompkins *et al*., 2010)

However, in classical facility location models the environment in which the decision is being made may change and considered parameters such as cost, demands, and distances may face uncertainties. Therefore this raises the need and importance of facility location models that consider uncertainty. Different approaches exist for overcoming this uncertainty in facility location problems which helps the costly decision of finding a new location for a facility that will result in its long-term profitability (Snyder, 2006).

1.2 Background of the Study

Changes in environmental factors, population and market trend make it very hard to find a robust facility location and for doing so, uncertainties of future occurrences should be taken into consideration by the decision makers. Most of the researches of location problems have been limited by this difficulty and considered as static and deterministic models (Owen & Daskin, 1998). For modeling more realistic situations the uncertainty of inputs such as demands, cost, travel time can be taken into account by stochastic (probabilistic) facility location models which consider these uncertainties in risk situations that uncertain parameters are defined by a known probability distribution in the facility location model (Arabani & Farahani, 2012).

Considering only a single objective in facility location problems has an old background. Moreover, since management science has been acquainted with the concept of multi-objective decision making, it has paved the ground for its application in location problems. In the past decade this concept has grown considerably and a new window has been opened to facility location science and its application in various businesses. This growth is because of the realization that for

modeling location problems that are closer to reality and more practical, sometimes it is necessary to consider more than one objective. There is no bound for the application of location science and as it can be seen in the literature it has been applied to a variety of scopes such as national and international, public and private facilities, business areas and military environments (Farahani *et al.*, 2010).

Most of the models that include more than one objective are considering deterministic parameters. As mentioned before, uncertainties should be taken into account in the location models in order to be closer to reality. Therefore, using stochastic optimization and robustness concept containing uncertainty, random parameters or probability distributions and combining it with multi-objective location problems can help to depict more realistic and practical problems (Farahani *et al.*, 2010). Also, there are only few stochastic location problems that have been actually applied to real world problems (Snyder, 2006).

1.3 Problem Statement

As most of the facility location problems have focused on deterministic models, there has been a significant growth in the need for considering more stochastic models that can cope with the uncertainties firms are facing in the real world when locating a new facility. In problems such as locating a new retail store or a supermarket because of the competitive environment that exists, besides the uncertainties, more than one objective should be considered to find more practical locations. However, to the best of my knowledge only few stochastic facility location models have been proposed in a competitive environment. In addition, the stochastic location models that have been actually applied to real world problems are limited. This study deals with finding a new location for the expansion of a chain supermarket that faces demand uncertainty which wants to be closer to more customers and also to have the minimum number of competitors around the new location in order to attract more market share. Customer locations or demand points

are considered to be regional with a probability distribution instead of just being points in a plane.

1.4 Objective of the Study

i. To develop a mathematical model for finding a practical single new location for a chain supermarket that aims to be located closer to more customers and to have minimum number of competitors around the new location with regional probability distributed customer locations.

ii. To determine the optimum location for the supermarket in the real solution space.

1.5 Scope of the Study

The scope of the study is:

i. Case study is a chain supermarket (S) that exists in one of the cities in Iran, Rasht.

ii. The solution space of the location problem will be the city map of Rasht considering only the central part of the city that shows the population distribution.

iii. The study will only consider rectilinear distance measure.

iv. Customer locations are not considered as point but instead will be considered as rectangular regions with probability distribution.

v. For solving the model, Matlab R2012a version 7.14 will be used.

vi. The cost of the land will not be considered for this study.

vii. Google Earth is used for the measurements of the coordinates of the regions and points.

1.6 Significance of the Study

The selection of location is a vital decision for retail stores such as chain supermarkets and can be considered as a huge competitive advantage which may result in their failure or success. This decision becomes even more important because once a location is selected it will be very costly to change the location and therefore is a long term investment. Hence, modeling more realistic problems in a competitive environment by considering the uncertainties of the real world and more than one objective will have a considerable effect on location decisions. The significance of this study is to use the stochastic facility location models in a competitive environment where the demand points or customer locations are uncertain and to consider more than one objective. This would help to make the model more practical and closer to reality and then applying the model to a case study. By doing so and achieving a good result, more firms and companies can be drawn to actually implementing these models to increase their profit and minimize their cost which is the aim of all business firms.

1.7 Organization of the Thesis

In this thesis chapter one contains a brief introduction of the study, its background, problem statement, objective and scope. A categorized literature review relevant to location problems is provided in chapter two. In chapter three, research methodology is explained and its structure and research design is shown. Chapter

four will contain the formulation of the model and also a brief introduction of the case study.

The data collection for the case study is provided in chapter five. Furthermore, chapter six includes the solution procedure for solving the model and the relevant results and discussion. Finally, chapter seven will contain the conclusion and the recommended future research directions.

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