Decision Support for DCs Location and Distribute Range Planning: Case Study in Asia-Pacific Region

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Abstract  A major concern is to locate manufacturing plants and/or distribution centers to serve the needs of consumers widely and rapidly with reasonably distributive cost and flexible delivery time. The purpose of this research is to help enhance a decision support for three distribution center locations with different ranges of area in order that the distributors are able to serve appropriately the retailers in twelve large cities or capitals of the nine countries in Asia-Pacific region.

The researcher applies the theory of supply chain and logistics management systems with Excel, Visual Basic and Genetic Algorithms programs to find the research results. The research results revealed that the interfaces of Excel, Visual Basic, and Genetic Algorithms programs helped decision support in distribution range selection for 3 distribution center locations. Each of which had different ranges of area for distribution with a rapidly, flexibly distributed time. However, variables resulting in a decision-making should be adjusted under certain circumstances for more reliable, specific needs.

Key words  distribution centers; locations; range; Asia-Pacific region

Economic growth is highly expanding in Asia-Pacific region, which has approximately a population of 2 billion or one-third of the world population, so a purchasing power expands accordingly. As a result, manufacturing, distribution, and consumer sectors play a vital role in serving the FTA in the region and other parts of the world. It will be necessary for these sectors to cope with the economic changes to come.

Consequently, the location selection for manufacturing plants and/or distribution centers is primarily necessary for transportation, retailers, and consumers\(^[1]\). For better results, there are two decision factors: quantitative factor and qualitative factor\(^[2]\). Qualitative factor means nominal values or exact numbers, such as a number of customers’ need, land price, construction cost, wage rate, and infrastructure cost. Qualitative factor means non-nominal values or inexact numbers, but it is only rated high or low, such as political stability, law enforcement, local satisfaction, labor force employment, and owners and administrators’ satisfaction\(^[3]\). Therefore, location selection is considered quantitatively and qualitatively.

The purpose of this research is to help enhance a decision support for 3 distribution centers (DCs) locations with different ranges of area in order that the distributors are able to serve appropriately the retailers in 12 large cities or capitals of the 9 countries in Asia-Pacific region were shown in Fig.1

<table>
<thead>
<tr>
<th>Country</th>
<th>Population</th>
</tr>
</thead>
<tbody>
<tr>
<td>Japan</td>
<td>128 Mil.</td>
</tr>
<tr>
<td>S.Korea</td>
<td>48 Mil.</td>
</tr>
<tr>
<td>China</td>
<td>1296 Mil.</td>
</tr>
<tr>
<td>Vietnam</td>
<td>82 Mil.</td>
</tr>
<tr>
<td>Philippine</td>
<td>81 Mil.</td>
</tr>
<tr>
<td>Thailand</td>
<td>63 Mil.</td>
</tr>
<tr>
<td>Malaysia</td>
<td>24 Mil.</td>
</tr>
<tr>
<td>Singapore</td>
<td>4 Mil.</td>
</tr>
<tr>
<td>Indonesia</td>
<td>231 Mil.</td>
</tr>
</tbody>
</table>

Fig.1  Map of Asia Pacific region
1 Problem Characteristics

The research problem was an NP-Hard type by which the algorithm complexity theory was applied. It took a long time to determine the optimum solutions due to the exponentially increasing time to find solutions. When the problems increased, structural flexibility was low accordingly. Therefore, genetic algorithms were appropriately employed for the practical solutions by means of random search to obtain better results and optimum outputs. The researcher also intended to find a practical means to related solutions.

1.1 Definition of NP-Hard Problem

The complexity class of decision problems is intrinsically harder than those can be solved by a non-deterministic during machine in polynomial time. When a decision version of a combinatorial optimization problem is proved to belong to the class of NP-complete problems, which includes well-known problems such as traveling salesman, then the optimization is NP-hard. Algorithm Complexity Theory: the search for fundamental distinctions in tractability of problems. Classify problems in order of computational resources required to solve using digital computer algorithms. Number of computations expressed as $O(n^k)$. Mainly concerned if computations grow with size:

- Logarithmically (or slower).
- Polynomial (tractable/easy).
- Exponential (intractable/hard).

Algorithm is bounded: polynomial $O(n^2)$, or exponentially $O(2^n)$, where $n$ is the size of the problem (e.g. variables), $NP$ is the set of all problems that can be solved by total enumeration, $P$ is the subset of $NP$ consisting of problems having efficient algorithm (bounded by polynomial), and $NP$-hard is the subset of $NP$ bounded exponentially.

1.2 Definition of Genetic Algorithms (GAs)

A genetic algorithm (GA) is an algorithm used to find approximate solutions to difficult to solve problems through application of the principles of evolutionary biology to computer science. GAs use biologically derived techniques such as inheritance, mutation, natural selection, and recombination. GAs are a particular class of evolutionary algorithms. GAs are typically implemented as a computer simulation in which a population of abstract representations (called chromosomes) of candidate solutions (called individuals) to an optimization problem evolves toward better solutions. Traditionally, solutions are represented in binary as strings of 0s and 1s, but different encodings are also possible. The evolution starts from a population of completely random individuals and happens in generations. In each generation, multiple individuals are stochastically selected from the current population, modified (mutated or recombined) to form a new population, which becomes current in the next iteration of the algorithm.

The following Fig. 2, the flowchart shows the iterative cycle of a basic GAs. The following flowchart shows the iterative cycle of a basic GAs. Firstly, an initial population of strings is created. The process then iteratively selects individuals from the population that undergo some form of transformation (via the recombination step) to create new a population. The new population is then tested to see if it fulfills some stopping criteria. If it does, the process halts, otherwise another iteration is performed.

![Fig.2 The Iteration loop of basic GAs](image)

2 Research Procedures

All 3 DCs providing the best services to retailers occurred in three factors:

1) Recognize certain locations and suitable ranges.
2) Estimate total ranges of all DCs for best locations.
3) Determine suitable locations n’ ranges for 3 DCs.
2.1 Scopes and Criteria

1) Distribution range is the diameter of DCs or the circular distribution of DCs.
2) To determine the locations of DCs, some locations may partly cover the sea areas. In case the rating falls on the sea area, it is necessary to adjust the ranges of all DCs to find the trials and minimal total ranges.
3) Population or customers of each retailer in large cities are counted as the total population in each country in place of a number of customers.

2.2 Relations of Research

Relations are shown in Fig.3.

Problems
Difficult to decide the best location, distribute ranges

Effected
1. High risk of investment
2. Low return (low market opportunity)

Scope
1 Case study in Asia-Pacific region
2 Range is the circular distribution of DCs.
3 Population of each retailer counted as the total population in each country

Objectives
1 To help enhance a decision support for 3DCs locations with different ranges
2 To reduce the risk of future invest cost, time and business pressure
3 Plus system flexibility and market opportunity

Theory and tools
- Supply Chain and Logistics Management
- Operation research
- Genetic Algorithms
- MS Excel, Visual Basic and GAs Program
- Others relate fields and techniques

Index
1 No of customers and total distribute ranges

Benefits
1 Easy to decide the DCs location n’ ranges
2 Reduce cost, time, risk n’ business pressure
3 Plus system flexibility n’ market opportunity

2.3 Scale of Map

Diameter of earth that appeared most often was 12,756 km, therefore, the circumference of earth will equal 40,074 km. This research scale fixed 10 units or one block in distribution range for 15 degree or 1,670 km (1 unit of distribution range is 167 km)

3 Research Results

The data were analyzed and processed by Excel Visual Basic and GA programs. The details before and after processing were shown as follows.

3.1 Recognize Certain Locations and Suitable Ranges

In Fig.4, primary problems were to maximize the number of customers. Secondary problem was to recognize certain locations after fixed suitable ranges. Input: the 3 first location of decider’s imaginable (in this case, fixed suitable ranges of 3 DCs, equal 8 units and locations were in Tokyo, Chengdu and Singapore).

Fig.4 Before recognize certain locations process

The results shown in Fig.5 were locations of 3DCs that marked and area in order that the distributor are able to serve appropriately the most retailers (in this case, this decided can service 11 retailers except Philippine that 81 millions in population).

Fig.5 After recognize certain locations process
3.2 Estimate Total Ranges of All 3 DCs for the Best Locations

In Fig.6, primary problems were to minimize the best distribution ranges of each DC which related to secondary problem. Secondary problem was to estimate distribution ranges of all 3DCs after fixed the locations. First input, in this case, will assume the suitable distribution ranges of 3DCs, equal 8 units and locations were in Tokyo, Chengdu and Singapore).

Fig.6 Before estimate total ranges process

![Fig.6 Before estimate total ranges process](image)

The result shown in Fig.7 was distribution ranges of all 3DCs and area in order that the 3 distributors are able to serve appropriately the most retailers (in this case, this decided can service 11 retailers).

Remark The explanations from Fig.4 to Fig.7 are similar in contents and can explain in details of next phase (3.3 to determine suitable locations and ranges for all three DCs)

3.3 Determine Suitable Locations and Ranges for 3 DCs

Step 1: Plan the 3 DCs locations, the details were shown as follow:

![Fig.8 Before recognize certain locations process](image)

![Fig.9 After determine suitable locations for all DCs process](image)

Step 2: Find the 3 DCs ranges by using result from first step, the details were shown as follow:

![Fig.10 Before determine suitable locations and ranges for DCs process](image)

![Fig.11 After determine suitable locations and ranges for DCs](image)
If some locations may partly cover the sea areas in case the rating falls on the sea area, it’s necessary to adjust the ranges of all three DCs to find the trials and minimal total ranges for 3 DCs.

4 Conclusions

In case the certain locations were indicated, the appropriate ranges were also determined. However, ranges should be indicated following the distributive costs to specific DC areas due to different costs in each area, such as labor cost, freight cost, plots of building land cost, including other qualitative and quantitative factors. When the costs had been calculated, trials and minimal total ranges could be determined.

In case the total ranges of all 3 DCs were estimated, the exact locations were also determined. In this case, qualitative and quantitative factors of the locations were primarily processed. In case the rating was at the sea area, it was adjusted to suit the DC’s ranges. The trials should then be found out.

In case it needed to locate the locations and ranges of all 3 DCs. Qualitative, quantitative factors were primarily considered in locating the optimal selections (either locations or ranges by considering both qualitative and quantitative data). Trials have to be done to find the suitable locations or ranges.

This research finding may be further applied to related fields by merely adjusting variables to meet such circumstances. For example, the selection on the locations and ranges of newspaper distribution center with sparsely populated area and different living conditions differs in some respects. In a high-rise building residential areas, distributive cost was lower than in customary resident areas.

References

Brief Introduction to Authors

WATTANAAMAT Patikorn is currently a doctor degree candidate in Management System Engineering at Tokai University. He received his undergraduate degree in Mechanical Engineering from South East Asia University and his Master of Mechanical Engineering from Kasetsart University. During his undergraduate and master in mechanical engineering studies he worked for Pornwiwattana Autoparts Company as a mechanical engineer and assistance factory manager. Following after award a master he worked as a senior project engineer for Aoyama Seisakusho (Thailand) Company. During that time he studied his second master degree in Management Engineering at Kasem-bundit University. His current research interest is management system engineering.

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