Strategic planning of layout of the distribution center: an approach for fruits and vegetables hall

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Abstract

The layout design of distribution center should be considered as a smart decision system that includes the number of customers, demand forecasting, product groups, condition of product conservation, warehousing, transportation management etc. Decision support systems are used on a lot of stages of the layout of the distribution center which is handled as a whole. In this study, the layout of the distribution center is investigated as strategically and recommendations are made for the model that will be developed for the layout of the fruits and vegetables halls. The study is conducted in two phases. In the first phase of the study, supply chain network and specifically distribution centers’ literature is examined and classified. In the second phase, assumptions of the allocation models for layout design of fruits and vegetables halls and their prospective objective functions are tried to be explained considering the fruit and vegetable halls as a kind of urban distribution centers.

Keywords: Distribution center, Fruits and Vegetables Hall, Strategic Planning, Layout, Allocation,

1. Introduction

Survival of corporations, in the global market, is possible with providing of dynamic market demands with the minimal cost and within the required time by effective supply chain management. Corporations want to increase their profitability and efficiency addition to providing of market demands with the minimums cost and within the required time. Increasing competition, environment forces the companies to create more effective supply chains basing on management and engineering.

The role of distribution centers increases turnover and profit and also brings competitiveness for the firm by providing customer needs in a high level. Supply chain is a network of suppliers that works to deliver the raw materials, work-in-processes and finished products to production centers, warehouses, distribution centers, and
retailers. Distribution centers are one of the most important links of this chain for product deliveries to customer with the minimum cost, in the required service level and time along the chain.

The layout of distribution centers have a vital importance in terms of product conservation at the required service level and delivering of products to the customer from there.

In this study, supply chain network and specifically distribution centers literature will be examined and classified. Then prospective objective functions are tried to be explained for the layout of the fruit and vegetable halls a kind of urban distribution centers. The results of the analyses will be discussed at last section.
2. Classification of Distribution Center Problems in Supply Chains

A supply chain is a set of facilities, supplies, customers, products and methods of controlling inventory, purchasing, and distribution. The chain links suppliers and customers, beginning with the production of raw material by a supplier, and ending with the consumption of a product by the customer. In a supply chain, the flow of goods between a supplier and a customer passes through several echelons, and each echelon may consist of many facilities (Sabri and Beamon 2000). A supply chain can also be defined as a network of production and distribution sites. Final products are shipped from the production sites and sent to the customer distribution centers where customer orders are satisfied (Verderame and Floudas 2009). Increased competition in today’s business environment has highlighted the need to optimize the design and management of supply chains. Starting with effective product design, the selection of suppliers, facility location decisions, inventory management, distribution strategies, information technology, and finally the coordination and integration activities are critical factors for an effective supply chain. Supply chains generally consist of multiple agents, such as suppliers, manufacturers, warehouses, and distribution centers. (Palut and Ulengin 2011)

After the general information and definitions about supply chains, design of a supply chain network can be classified to three sub-problems:

- Location-allocation problems
- Inventory control problem
- Vehicle routing problem

The location-allocation problems are long-term strategic problems, which not only determine where a new set of facilities must be located in an existing network of facilities and customers, but also how much capacities must be allocated to the new facilities. The inventory control problems are intermediate-term tactical problems, which determine how much items must be ordered and when they must be ordered. Vehicle routing problems are daily operational problems, which determine the delivery schedules for each vehicle (Yepeng, 2010)

When the distribution centers are focused in a supply chain, it can be investigated according to time horizon and field of activity or location of the product placed. Time horizon can be separated as operational, tactical and strategic.

The features of operational stage are summarized as;

- It has a limited coverage of the processes of facilities or inter departments
- Resources and demands are stable or known
- Variability, considered as critical, is an exception
- Generally mathematical optimization methods as linear programming, integer programming or mixed integer programming are used.

The features of tactical stage are summarized as;

- Time periods are longer and probably it considers several months.
- Ordering of resources can be expanded from the machine to the whole factory.
- Relationships and information about which product will be manufactured, which product will be manufactured in which factory and with which supplier is the subject.
- Demand forecasting is simply predictable. If forecast demand is based on the stochastic characteristics, simulation is the best solution on that stage.
The specialties of strategic stage are summarized as:

- The demand forecasting periods are very long and can continue for years.
- Strategic plan can be developed as covering the whole system or it can be reduced to production departments or products families.
- Generally, it is being acted under the assumption that all the components of the system are changeable.
- New production departments can be opened or existing departments can be closed, capital can be increased, strategic products layouts can be made etc.
- For this reason, stochastic modeling or simulation method generally used to create a strategic plan. (Paksoy, 2005)

The classification according to field of activity is considered in 3 stages: supply, distribution center and distribution. The following matrix shows combination of classification that are made according to time and field of activity.

<table>
<thead>
<tr>
<th>Table 1 The Schema of classification</th>
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<tbody>
<tr>
<td>Strategic</td>
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<tr>
<td>Supply</td>
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<tr>
<td>Distribution Center</td>
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<td>Distribution</td>
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Each class considered in Table 1 is classified according to the field of activity (which stage, inventory, operations etc.), method used (heuristic, linear etc.) and objective functions. The new sub-classification is shown in following section.

The field of activity, method, and objective functions that are about studies in class A are summarized as follows:

- **The fields of activity:** Supply, distribution center, fruits and vegetable halls.
- **The methods:** Possibilistic programming, mixed integer linear programming, assignment model, route choice algorithm, goal programming, multi criteria decision making, AHP.
- **Objectives:** the integration of the supply and distribution center with the minimum cost, supplier selection, editing the batch sizes, production planning, distribution planning, determining of the cost when there is or not a broker at the stage of the delivery of the products from producers to end user, multi model transportation, intermodal logistic and hub networks, logistic distribution network.

The field of activity, method, and objective functions that are about studies in class B are summarized as follows:

- **The fields of activity:** Multi echelon supply chain, fruits and vegetables hall.
- **The methods:** Non-Linear programming, mixed integer programming.
- **Objectives:** Minimum transportation cost between echelons (suppliers, producers/manufacturers, distribution centers and customers).

The field of activity, method, and objective functions that are about studies in class C are summarized as follows:

- **The fields of activity:** Supply chain optimization, scheduling, multi-site production and distribution networks, supply chain design; inventory, inventory ordering planning.
The methods: Mixed Integer Linear programming, cluster analysis, heuristic algorithm, excel spreadsheet model, Stochastic programming.

Objectives: Regarding the financial area, evaluation of the shareholder value, determining which orders can be satisfied at each customer distribution center and the requisite shipment profiles. Illustrating an original framework for the design and optimization of a multi echelon and multi-level production/distribution system that combines mixed-integer linear programming modeling with cluster analysis, heuristic algorithms, and optimal transportation rules. Studying about the operational efficiencies of a multi-product and a four-stage supply chain with multiple-retailers, wholesalers, manufacturers, and suppliers, coordination of inventory policies in a decentralized supply chain with stochastic demand by means of contracts. The solving of the supplier and distribution echelon models using analytical techniques, while the production and stockpile models are simultaneously optimized using non-linear programming, studying about the effects of volume flexibility, delivery flexibility and operational decision flexibility in operational supply chain planning under uncertain demand.

The field of activity, method, and objective functions that are about studies in class D are summarized as follows:

The fields of activity: Location selection, distribution centers operations, layout of distribution centers, design of distribution centers.

The methods: Fuzzy TOPSIS, tabu search, genetic algorithm, mixed integer non-linear programming, mixed integer linear programming, hybrid solutions and decomposed optimization, AHP, capital investment model, transportation model, ANP, Fuzzy DEMATEL.

Objectives: Location planning of distribution centers under fuzzy conditions. Determining of logistics distribution centers locations with a minimum cost and maximum incomes, minimum total transportation cost, product handling costs, cost of settlement building. The establishment of the fuzzy neural network model for logistics distribution center location. Optimization of material flows throughout the supply chain and providing the best assignment of distribution centers to customer zones.

The field of activity, method, and objective functions that are about studies in class E are summarized as follows:

The fields of activity: Multi echelon supply chain network design, multi echelon inventory management, the planning of the distribution centers operations, fruits and vegetables halls.

The methods: Non-linear programming, mixed integer programming, mixed integer non-linear programming, artificial neural networks, local search, RFID.

Objectives: Minimization of the possessions and order costs at distribution centers, minimization of unnecessary and unused capacities of distribution centers and plants considering the transportation distance between echelons, the structure of multi stage inventory management for stochastic and fuzzy supply chain, determining of the distribution center operation planning model by deciding of storage size, location of the storage of the products in distribution centers, the types of storage rules, examining the potential of the distribution centers ability to modify delivery decisions, identifying and quantifying the cost factors that influence the distribution centers modification ability, establishing a relationship between the distribution centers location and its modification ability, and showing the trade-off between the s modification ability and related costs. To help DC facilitates the food safety control activities in receiving areas by generating a proper safety plan.

The field of activity, method, and objective functions that are about studies in class F are summarized as follows:

The fields of activity: Warehousing.

The methods: Mixed integer linear programming.

Objectives: Minimization of losses of fruit and vegetables in the storage process in distribution centers and optimization of distribution of the products and minimization of the storage costs. The supplier and distribution echelon models are solved using analytical techniques, while the production and stockpile models are simultaneously optimized using non-linear programming.

The field of activity, method, and objective functions that are about studies in class G are summarized as follows:

The fields of activity: Routing, Allocation of customers.

The methods: Genetic algorithm.

Objectives: The providing of customer demands is suitable with the minimum total transportation cost and capacities of the vehicles and branches, allocation of customers to distribution centers.
The field of activity, method, and objective functions that are about studies in class H are summarized as follows:

- **The fields of activity:** Multi echelon supply chain network design, the planning of the transportation, distribution centers operations, routing.
- **The methods:** Mixed integer linear programming, mixed integer programming, non-linear programming, and a new hybrid solution of tabu search and decomposed optimization.
- **Objectives:** Minimization of the possessions and order costs at distribution centers, minimization of unnecessary and unused capacities of distribution centers and plants considering the transportation distance between echelons, the planning model of the distribution center operation to decide of location and distribution plan by considering of providing of the products by a single supplier.

The field of activity, method, and objective functions that are about studies in class I are summarized as follows:

- **The fields of activity:** Distribution, multisite production and distribution networks.
- **The methods:** Mixed Integer Linear programming.
- **Objectives:** Providing of customer demands with minimum cost; determining which orders can be satisfied at each customer distribution center and the requisite shipment profiles, studying about the effects of volume flexibility, delivery flexibility and operational decision flexibility in operational supply chain planning under uncertain demand.

As a result of the classification and analysis on the distribution center, the main problems and deficiencies are determined as follows:

- Mostly, location selection or vehicle routing has been studied about distribution centers
- There isn’t sufficiently study about layout of the distribution centers.
- Less studies about fruits and vegetable halls have been encountered
- In studies, mostly minimization of material handling cost has been calculated; but multi objective model that includes investment cost, storage cost of products with material handling cost and qualities factors about storage conditions has not been found.

Fruits and vegetables halls in metropolises are a kind of urban distribution centers which affect the transportation density of the neighborhood and the city. The management of the fruits and vegetables hall is so important for traffic as well as customer satisfaction, environmental impact, extra cost, and time consuming. Therefore, management of the layout of fruits and vegetables halls must be considered strategically.

The results of the literature review shows that, there is not sufficient study about fruits and vegetables halls. According to the discussions with experts of fruits and vegetables halls, it is decided that layout of fruits and vegetables halls is strategically important and have to be considered. An improvement on the layout of the hall will be very effective on city traffic. The layout of distribution centers is studied by analyzing of inventory, shipping, capacity plans, and material flows as strategically

### 3. Fruits and Vegetable Halls

The fruits and vegetable hall is a kind of distribution centers which are active along the night with handling operations. The products are exhibited by brokers, the price is formed according to the demands of customers and the products are sold to customers in these halls (Tanyas, 2010).

The supply chain of the perishable products with limited shelf life has various critical decisions in strategic and operational levels. Harvesting, packaging, transporting and warehousing can be considered as the main operations of the supply chain and have a vital effect on the shelf life and salability of the perishable products. Most of the products, which transported from harvest place to the city where they are sold, spend a short time for cross docking operations in wholesale market halls. These halls have dynamic environments where the products arrive and leave almost the same day. Beside the accurate operational decision in wholesale market hall, strategic decisions play an important role to deal with quick changing environment. A well designed layout is one of the most important points in terms of the stakeholders’ benefits (Tanyas et al, 2011).
The storage of fruits and vegetables has a great importance to the establishments that commercialize it, because they are very perishable and sometimes become a detriment to the establishment, due to the great quantity of product waived because of loss of quality.

It is known that the management of a deposit of fruits and vegetables is more complex than a deposit of processed products as the first ones need rapid commercialization and special conditions of storage to reduce its loss of quality, because it reflects in reduction of its commercial value (Borghie et al., 2009).

Issues should be considered in the layout planning of the distribution center can be explained as follows:
- The layout of distribution center should be integration with handling, storage, packaging and logistic that includes value added services.
- Input-output time of vehicles to the distribution centers should be minimized.
- The products should be delivered to customers with at least transportation and handling.
- The products should be storage according their characteristics.
- Building, plumbing, equipment, et al. investment costs should be minimized.
- Labor, energy, and operating costs etc. should be minimized.
- Support services such as safety, cleanliness, auxiliary materials, accommodation etc. should be provided at low cost.
- It should be flexible and expansion possibilities should be considered. (Tanyas, 2010)

The facility design process of, especially, a Fruit & Vegetable Wholesale Market Hall (F&VWMH) should perform the expectations of various actors like sponsors and founders of the hall, retailers, wholesalers, truck drivers and pickup drivers, who are the decision makers of this study. Truck and pickup drivers claim to minimize the total duration between entrance and leaving times to the F&VWMH. Retailers hope to see more exhibits of the wholesalers as much as possible in a short time. (Tanyas et al, 2011)

4. Fruits and Vegetable Halls

The fruits and vegetables hall, a kind of large distribution center, affects the urban traffic situation since many customers enter and exit to it frequently. The bad layout of fruits and vegetables halls affects the freight transportation of the neighborhood and the city. A carelessly designed hall influence the elements like customer satisfaction, damage to the environment, extra cost and loss of time adversely. The layout of a distribution center should be considered as a long term plan. It should provide not only today’s needs but also next ten or twenty years’ needs. The allocations of the wholesalers, products and trucks in a hall are vitally important for the most appropriate layout. Therefore, we solve the mathematical model of a layout which ensures the best coordination between customers, trucks and wholesalers based on allocation.

In this paper, the requirements of the mathematical model that will be used to developing a decision making system for that layout of distribution center will be determined. Fruits and vegetable halls will be processed as a kind of distribution center.

The layout design of a fruit and vegetable hall should consider the logistical principals before the architectural and esthetical aspects. While designing hall layout alternatives, integrated logistics activities should be taken into account such as, transportation, warehousing, packing, and value added services etc. (Tanyas et al, 2011)

The new approaches will be developed for the inner of the new fruit and vegetable hall selected by Tanyas et al. study on International Logistics and Supply Chain Congress’ 2011. Fuzzy AD was used for the selection of the new fruit and vegetables market hall layout project. The evaluation scores were determined by expert decision makers who are customers, fruit and vegetable wholesalers (brokers), truck drivers and pickup truck or van drivers.

In this study it is considered to develop the new mathematical model application that will be used for the organizing the inner of the selected hall. An allocation model should be developed for the inner layout.
To develop the new model firstly, we give information about assumptions for the halls.

The principles of logistics that should be considered on the layout plans of the hall as follows: (Tanyas, 2010):

- The halls should be appropriate for logistic integration which consists value added services such as handling, warehousing, and packaging.
- The input–output time of the truck–tractor trailers to the hall should be minimized.
- The input–output time of light commercial vehicles to the hall should be minimized. Customers should be able to view more products in a short time.
- Products should be transferred to customers with at least transport and handling. Fresh and quality products should be exhibited in a hygienic environment.
- Investment costs should be minimized.
- Operating costs should be minimized.
- A modern working environment should be developed, support services (security, cleaning, auxiliary materials, accommodation, etc.) should be provided at low cost.
- Expansion possibilities should be considered.

Considering the layout of fruits and vegetable halls, interests of the brokers and the hall management of the Metropolitan municipality are contradictory. Brokers want the point store/warehouse where it minimizes the cost, on the other hand the management of the hall is planning to assign brokers to stores/warehouse considering minimum total operating time and minimum costs. Currently the brokers are assigned to stores/warehouses with the draw.

It is decided to develop an allocation mathematical model that will be used to assign brokers to the stores in hall, when the studies in literature and developed model are investigated and principles of the logistics are handled.

A mathematical model should be developed for the assignments of the brokers to the stores in the fruits and vegetable halls.

When the previous studies are analyzed, the objective functions should consist:

- Minimization of the investment costs (the storage conditions of the products are different according to the product type, so it includes the storage costs as well as the operating and labor costs.
- Minimization of the transportation cost/duration of the products from the entrance of the hall to store
- Minimization of the product costs/duration
- Minimization of the walking cost/duration of the customer in the hall
- Minimization of the loading and unloading duration of the products

To summarize:

- The objective functions above should be taken into considering on the stage of developing of the model.
- At the same time when constraints are determined for the model, techniques of data mining may be used. The results of the data mining study may be used for the constraints.
- The developing model will be multi objective.
- Because of the multi objective model, the model may be not solved by linear programming.
- Heuristic algorithms may be used to solve the problem

5. Conclusion

A Supply chain includes suppliers, manufacturers, transporters, warehouses, distribution centers, retailers and customers. A supply chain that tries to provide customer demands on time is a dynamic system. Distribution centers are one of the important circles of that chain. For this reason, effective management of distribution centers comes into prominence and it should be studied on the management of the distribution center in a strategical level.

In this study, the literature related to supply chains and distribution centers were investigated. Firstly, supply chain network problems in the literature were examined and classified. When the classification was analyzed, enough numbers of studies about the layouts of the fruits and vegetable halls in strategic level have not been encountered. It is
determined that the most appropriate layout of fruits and vegetables halls should have been studied after making interviews with experts focused on fruits and vegetables halls.

As a result, it is decided that a mathematical allocation model may be developed for allocating the elements in a layout. Some introductory information was provided about objective functions that are include by the mathematical model which will be used for the layout of the fruits and vegetable halls. The result shows the setting of the locations of wholesalers has effects on arrangement of the traffic in hall and urban in a good way. In the future research, the mathematical model will be developed and solved with a convenient solution technique. The model may be multi objective and fuzzy approach may be added to the model because of the uncertainties. Data mining techniques may be used to develop the constraints. It is expected that complexity level of the model will be high and linear solution techniques may not be enough to find the optimal solution. Also finding detailed real data may be difficult. Thus heuristic algorithms may be used to solve the model.

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