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Research Report: MISI-2015-6
Logistics Cost Optimization for Specialty Food Ingredient Industry in Asia Pacific Region
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Logistics Cost Optimization for Specialty Food Ingredient Industry in Asia Pacific Region

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Summary:

This thesis explores the cost effectiveness of setting up a regional distribution center in Asia for a food ingredient manufacturer. It examines the existing supply chain of the company in study and proposes a new supply chain strategy to capture the market growth in the Asia Pacific Region (APAC). A methodology is proposed to evaluate the optimal location of regional distribution centers for the company in study.

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KEY INSIGHTS

1. Different supply chains have to be designed for different type of products. Shelf-Life has been identified as the key parameter on which the supply chain decisions are made.
2. Postponement strategy can be used effectively to reduce the supply chain costs.
3. Location of RDCs plays an important role in Supply Chain costs.

Introduction

The Natural color market has been growing at a significant rate and has replaced the artificial colors in many industries (McCann et al., 2007). This has triggered a competition among various natural color manufacturers

to capture the market growth. Companies are looking to various strategies to improve their sales and at the same time to reduce their supply chain costs.

In order to reduce the costs of supply chain a study is performed on company “X” to improve their supply chain. The scope of this thesis is restricted to evaluation of their supply chain in Asia Pacific (APAC) Region. The supply chain network for this consists of manufacturing site, the customer centers and the transportation logistics to the customer countries from the manufacturing sites. Given this set up a study was performed to analyze the existing supply chain of the company.

One of the aspects of the study was to find whether a regional distribution center would help reduce the supply chain costs. Further the key parameter for having different supply chains for different products are identified and evaluated.

Literature Review

Literature Review for this research primarily consists of studies that have been performed on identifying whether a regional distribution center is required in order to reduce the costs of the supply chain.

A facility location problem involves simultaneously selecting a set of locations for facilities and assigning spatially distributed sets of demands to these facilities to optimize some specified measurable criterion. The objective function depends greatly on the decision maker of the organization which can be public or private nature. In fact, trying to find the best locations for public facilities such as schools, parks, utilities, sports and health centers is a different problem from that of locating private facilities, such as banks, shops, and private leisure facilities. The different decisions resulting different objective functions in public and private sector can be classified as:

- i) Profit maximization
- ii) Cost minimization
- iii) Improvement of quality
- iv) Maximization of the demand covering
- v) To balance utilization level of facilities
- vi) To maximize the minimum distance between new facilities

In addition to these decisions finding the optimum number of facilities to locate may be another decision to consider. But in some cases, the number of facilities to locate is an input of the problem and is known in advance.

In addition to different objective functions, there are various models developed based on the nature of the variables, that is, deterministic models, stochastic models and possibilistic models (Bouzemrak et al., 2013).

The model developed by Shang et al. (Shang et al., 2009) is considered as the starting point for this research. In their article they determine the optimal number of regional distribution centers and in addition identify the locations of those distribution centers. They come up with a nonlinear mixed-integer programming model, the authors develop a distribution network with a dual emphasis on minimizing the total distribution costs and improving the customer service levels. Finally, they conduct a sensitivity analysis to determine the impact of changes in problem parameters on the optimality of the proposed model.

Methodology

The company in study manufactures 759 SKUs of natural color products. The primary differentiation between SKUs is due to the value chain of the product, color of the product, the strength of the color and the packaging size. It is further noted that each SKU has a different shelf-life associated to it.

The existing supply chain does not differentiate the SKUs and it uses transportation based on the demand in the Asia Pacific region. The manufacturing plants are located in various parts of the world (for example in Italy, USA, Peru etc.). The company currently air freights most of its products based on the demand from its manufacturing plant locations.

The research proposes to set up a regional distribution center (RDC) in APAC region. The products are first imported to the RDC locations and further based on the requirement at the customer locations it is transported to those locations. This project proposes the products to be shipped in bulk to the RDCs and packaging can be done at the RDCs.

In order to evaluate the benefits of RDC, the supply chain costs are calculated and the best option for the product is identified with the help of a mixed integer linear program. The costs considered are the import duties, operation costs in the choice of location of RDC and transportation costs.

The import duties are a function of the product price that is imported into the countries. The operational costs include the costs to run the RDCs and the cost of packaging. The transportation costs include the transportation of products from the manufacturing units to choice of RDCs and the cost of transporting the products from RDCs to the customer locations.

The major factors that are considered are the shelf-life of the products and the demand of the product in each customer locations. The product is first segmented based on the shelf-life requirements. The products are segregated into two categories, that is, products with shelf-life greater than one year and the products with shelf-life between six months and one year.

The following MILP model is used to identify the location of RDCs to minimize the costs of supply chain costs.

$$\begin{aligned}
 \text{Min} \quad & \sum_{k=1}^K \sum_{j=1}^J \sum_{i=1}^I g_{ijk} S_{ijk} \\
 & + \sum_{k=1}^K \sum_{j=1}^J \sum_{i=1}^I h_{lki} t_{lki} u_{kl} + \sum_{k=1}^K (f(W_k)) w_k \\
 & + \sum_{k=1}^K \sum_{j=1}^J \sum_{i=1}^I T_{jk} S_{ijk} + \sum_{k=1}^K \sum_{j=1}^J \sum_{i=1}^I T_{kl} t_{lki} u_{kl}
 \end{aligned}$$

1

Subject to

$$\sum_k u_{kl} = 1 \quad \forall l \quad 2$$

$$\sum_j s_{ijk} = \sum_l t_{ikl} u_{kl} \quad \forall i, k \quad 3$$

$$\sum_j t_{ijk} = \sum_l M u_{kl} \quad 4$$

$$\sum_k z_k \leq K \quad 5$$

$$\sum_k u_{kl} \leq z_k \quad \forall l \quad 6$$

$$\sum_k t_{ikl} = D_{il} \quad \forall i, l \quad 7$$

$$\sum_k t_{ikl} = w_k \quad \forall i, l \quad 8$$

$$w_k = M z_k \quad 9$$

$$u_{kl}, z_k = \{0, 1\} \quad \forall k, l \quad 10$$

$$s_{ijk}, t_{ikl} \geq 0 \quad \forall i, j, k, l \quad 11$$

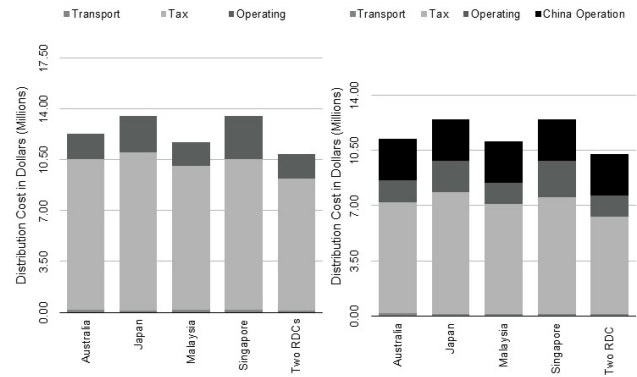
The objective function, Equation 1, minimizes the cost of transportation between plants and Regional Distribution Centers (RDCs), the cost of shipping between RDCs and Customer Distribution Centers (CDCs), the costs of operating RDCs and the costs due to import taxes. Constraints in Equation 2 are single-sourcing constraints that restrict a customer's demand for any commodity to be served by a single RDC. Constraints in Equation 3 ensure that all products shipped to an RDC will be shipped to CDCs. Equation 4 uses the Big M to change the non-linear constraint in equation 3 to linear constraints. Constraints in Equation 5 specify the maximum number of RDCs to open. Constraints in Equation 6 allow CDCs to be assigned to the opened RDCs only. Constraints in Equation 7 ensure that all customer demands are satisfied. Constraints in Equation 8 ensure that the sum of the sizes of the warehouse is equal to the total amount of the product shipped. Constraints in Equation 9 linearize the non-linear constraints using Big-M method. Constraints in Equation 10 ensure that u and zk are binary. Variables s and t are nonnegative, as required in the constraints in Equation 11.

Results

The results based on the model developed were found using the AIMMS software and sensitivity analysis was performed using MS Excel.

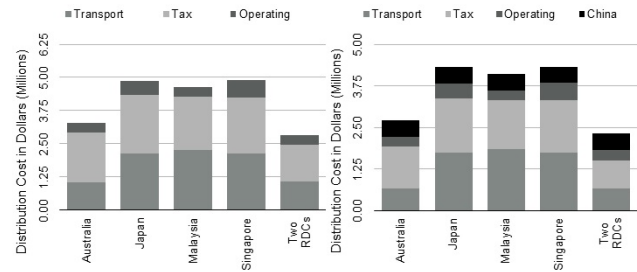
The results shows that having two RDCs (one in Malaysia and Australia) and in addition direct shipping to China reduces the overall costs of the supply chain in both the product segments (shelf-life greater than one year and shelf-life between six months and one year). The sensitivity analysis showed the results were robust.

Figure 1 Comparison of distribution cost for shipping through RDC or directly to China (shelf-life greater than one year)



Source: Authors

Figure 2 Comparison of distribution cost for shipping through RDC or directly to China (shelf-life between six months and one year)



Source: Authors

Conclusions

From the analysis it is apparent that having two RDCs (one each in Malaysia and Australia) and direct shipping to China reduces the costs of the supply chain. In addition, it gives the opportunity to improve the company's foot print in APAC region.

Further, the benefits of having different supply chains for different product segments, that is, sea-freighting the product from Manufacturing units to RDCs and Sea freighting to customer locations (in case of products with shelf-life more than a year) can be seen. While postponing the packaging operations reduces the transport costs of the bulk shipment of products to the RDC. The location of RDCs also plays an important role as the import duty is a critical component in supply chain costs.

References

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