Introduction to Logistics and SCM

– Distribution Logistics –

Distribution Network Design – Case Study

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1 INTRODUCTION

The following case study challenges you to apply certain logistic methods to solve a real world scenario. In order to be able to solve this case study you have to read carefully through the provided material and to understand the explained methods. This includes both logistics and spreadsheet related methods and calculations. You will read the case description, but the required data to conduct the analysis will not be provided beforehand. On the day of the case study you will have a short introduction to fresh up the required methods and to explain the case. Then you will work through the case step by step in groups over two weeks and present your findings in a one-page report.

2 CASE DESCRIPTION

Your group is a part of a logistics consultant company, and you have been given the task to analyze the distribution network of XYZ Company. Your group visited the CEO of the company, and you were informed with the following things.

Currently, XYZ has a decentralized distribution network with two warehouses - one in Bremen, Germany, and another one in Valencia, Spain. Both are serving a fixed number of retailers in certain locations of Europe. The product is brought from Shanghai, China via ship to Bremerhaven port in Germany, and to the Port of Santander in Spain. From Bremerhaven it is transported via truck to Bremen and from Santander it is transported via railway to Valencia. However, the management board has a plan to build a centralized warehouse in Paris, France. Your group is responsible to analyze a centralized warehouse compared to the actual given situation and present a conclusion.

The warehouse in Bremen serves retailers in Bremen, Hamburg, Berlin, Paris and Munich. The warehouse in Valencia serves retailers in Valencia, Madrid, Marseilles, Lisbon, and Bordeaux (cf. figure 1). For the new distribution network consider that the incoming goods will be shipped to port of Le Havre, and then be brought to Paris via train (cf. figure 2).

DATA PROVIDED BY XYZ COMPANY INCLUDES:

1. Average Incoming Transportation cost per unit to different locations.
2. Distances for Incoming Transportation.
3. Orders for the last twelve months.
4. Weights and purchase value of different item.
5. Transportation cost list from different warehouses to different customers.
6. Distances list from different warehouses to different customers.
7. Lead time for delivery to different locations from different warehouses.
8. Data involving redesign.
9. Average CO_2 Emission rates per Transport Type.

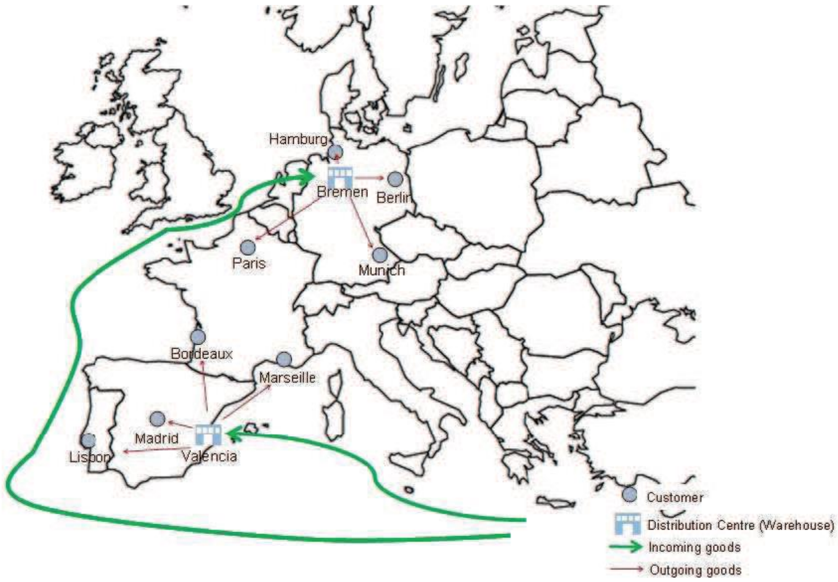

FIGURE 1. DECENTRALIZED DISTRIBUTION NETWORK (EXISTING)

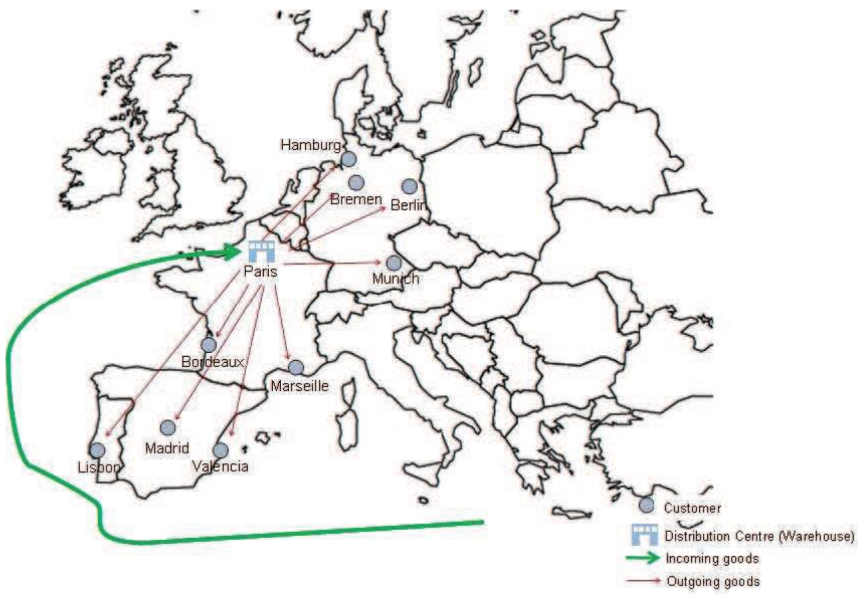

FIGURE 2. CENTRALIZED DISTRIBUTION NETWORK (PLANNED)

YOUR CONCLUSION SHOULD INCLUDE:

1. Is it profitable to change the strategy to centralized DC (without considering the cost involved for redesign)?
2. If so, considering the redesign cost, find the breakeven point.
3. What is your conclusion regarding the logistics performance (delivery time, costs, and total CO_2 emissions) of the warehouse scenarios?
4. Considering the trade off of logistics targets, what will your answer be to XYZ Company?

3 ANALYSIS

3.1 TRANSPORTATION COSTS

Transportation costs include multiple directly and indirectly related costs, such as drivers' wages, overhead, parking, environmental costs, congestion, etc., as well as distance of travel. Another factor affecting the transportation costs are the goods' characteristics, namely weight and volume.

In this case you have to consider two types of transportation during your analysis - incoming and outgoing shipments (cf. figure 3).

3.1.1 INCOMING SHIPMENTS

Incoming shipment includes transportation during procurement of goods. In our case, different items are procured from different manufacturers in China. Each item is shipped to different warehouses. This cost depends on ordering costs and the weight of the shipment charged by the shipper. To determine the number of shipments made in a year you have to find the economic order quantity (EOQ), and calculate the number of shipments. The weight of shipment affects the rate of transport. The cost for incoming shipments that includes ordering cost per shipment and rate per weight will be given. From this you should be able to calculate incoming transportation cost.

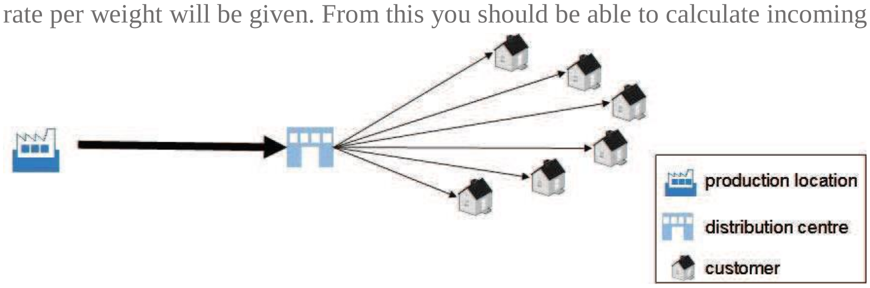

FIGURE 3. TRANSPORTATION

3.1.2 OUTGOING SHIPMENTS

Outgoing shipments include shipments during the distribution of goods from the warehouse. Their cost can be calculated from the cost table provided by the forwarding company. Information required for this calculation using spreadsheet (MS Excel or Open Office) is given in Table 1.

The weight of the shipments affects the total costs of the shipment. The costs for first 100 kg is fixed, as can be seen from the freight forwarder, if the weight exceeds 100 kg then the shipment is charged per kg with a different shipment rate. The different per kg charges for different range of weights is also provided in the table (see below).

TABLE1. FREIGHT COSTS TABLE EXAMPLE

Weight		Zones				Unit
from (<)	up to (≤)	1	2	3	4	
0	100	27.30	23.17	31.07	30.35	price per shipment
100	300	0.443	0.375	0.521	0.494	price per KG
300	500	0.341	0.289	0.401	0.383	price per KG
500	1,000	0.248	0.295	0.339	0.330	price per KG
1,000	1,500	0,224	0.204	0.264	0.270	price per KG
1,500	2,000	0.121	0.153	0.212	0.236	price per KG
2,000	3,000	0.113	0.140	0.197	0.220	price per KG

3.2 STORAGE COSTS

Storage costs are the expenses associated with maintaining inventory. Standard accounting practice is to value inventory at purchase or standard manufacturing costs rather than at selling price. Determining the storage costs percentage rate requires assignment of inventory related costs. These can be divided into inventory holding costs and warehouse operation costs:

Inventory holding costs consist of capital tied-up costs, the appropriate charge to place on capital invested in inventory. The logic behind this is that the capital invested in inventory can be invested in the money market to gain return (opportunity costs). The costs of capital must be clearly specified since it has significant impact on system design and performance.

Warehouse operation costs include costs that are affected by storage and operation of the inventory. They consist of labour costs, space costs (e.g. rent), capital costs and depreciation of equipment, consumption and maintenance costs, overhead costs (e.g. electricity, taxes) and/or payment to external service providers.

According to Schönsleben the storage costs can be estimated to be 20% of the value of the average stock level:

$$Storage\ Costs = \left(\sum_{i=1}^{N}\left(\left(\frac{lot\ stock_i}{2} + safety\ stock_i\right) x\ purchase\ value_i\right)\right) x\ 0.2$$

- $lot\ stock_i$ – lot stock for product i
- $safety\ stock_i$ – safety stock for product i
- $purchase\ value_i$ – purchase value for product i

In order to calculate the storage costs it is necessary to know the lot stock, safety stock and purchase value of each type of product. There are many different ways to calculate lot stock and safety stock. In the following you will find simple but often used formulas for each.

3.2.1 ECONOMIC ORDER QUANTITY

The EOQ model is one of the earliest models used to determine the economic lot so as to strike up the balance between ordering costs when purchased (setup costs tied with the start of each production process) and the costs tied up with the inventory. Since ordering costs (or overall costs of production if produced) is reduced with large lot size while low inventory level can be achieved with the smaller lot size, EOQ model can be used to determine the economic lot size. To derive the economic lot size formula, the following assumptions are made:[3]

1. Production is instantaneous.
2. Delivery is immediate.
3. Demand is deterministic.
4. Demand is constant over time.
5. An ordering cost is fixed per order.
6. Products can be analyzed individually.

With this assumption, we can derive the formula for the economic lot size by using following notions:

D demand rate in units per year

c unit production costs in euro per year

A fixed ordering costs to purchase a lot in euro

h holding costs in euro per unit per year

Q lot size in units that is to be determined

i annual interest rate

In EOQ, both time and product are represented as continuous. Since demand is assumed to be constant and Q units are ordered each time the inventory reaches zero, the average inventory level is thus $\frac{Q}{2}$ (cf. figure 4).

- Hence, holding cost associated with the inventory is $\frac{hQ}{2}$ per year
- The ordering cost is $\frac{AD}{Q}$ per year as $\frac{D}{Q}$ orders are placed per year
- The production cost is $c\ x\ D$ per year

Thus, the total cost per year can be expressed as:

$$Y\ (Q)\ =\frac{hQ}{2}+\frac{AD}{Q}+cD$$

The first derivative of $Y\ (Q)$ is:

$$\frac{dY(Q)}{dQ}=\frac{h}{2}-\frac{AD}{Q^2}$$

[3] Factory physics, Hopp, W.J. and Spearman, M.L., 2000, McGraw-Hill/Irwin

And the second derivative of $Y\ (Q)$ is:

$$\frac{d^2Y(Q)}{dQ^2}=\frac{2AD}{Q^3}$$

As the second derivative of $Y\ Q)$ is positive, the first derivative has minimum value when it is zero. Thus the lot size that minimizes $Y(Q)$ in the above costs function is Q^*:

$$Q^* = \sqrt{\frac{2AD}{h}}$$

If the holding costs consist entirely of interest on money tied up in the inventory $h = i\ x\ c$, where i is the annual interest rate, the lot size that minimizes $Y(Q)$ is:

$$Q^* = \sqrt{\frac{2AD}{ic}}$$

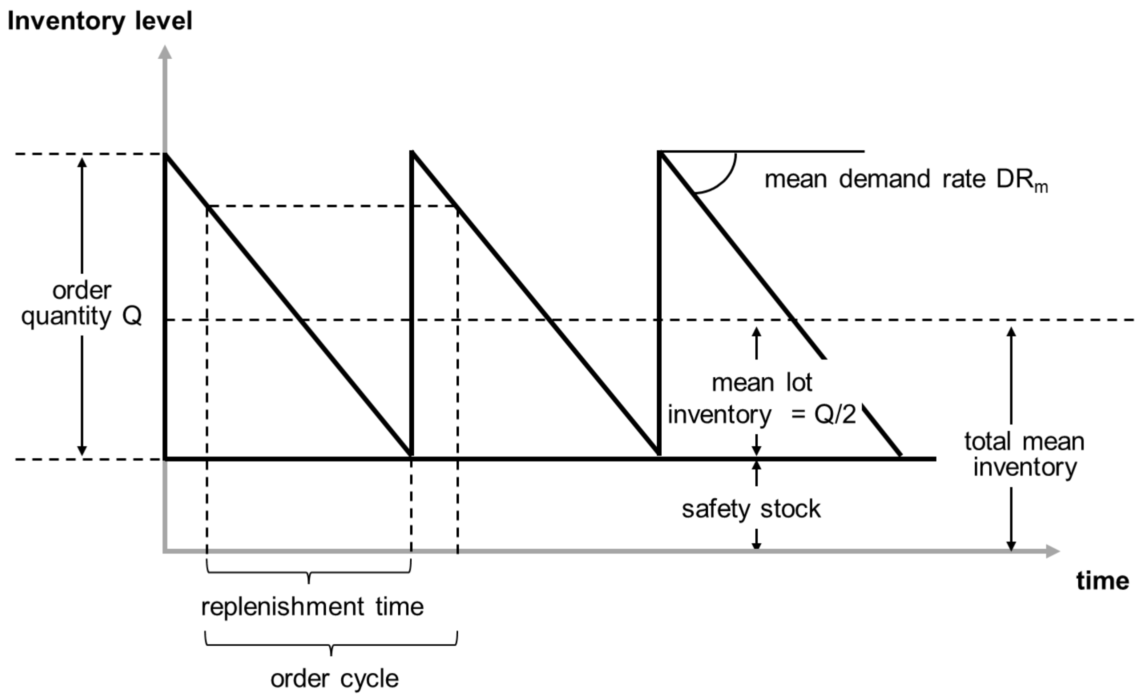

FIGURE 4. GENERAL STORAGE MODEL

We have calculated Q^*which is also mean store input quantity if we consider the general storage model (cf. Figure 4). We also know the demand rate given by the slope in the figure. Thus to obtain the replenishment time RT for our incoming lots, we have to divide Q^* by the demand rate.

$$RT = \frac{Q}{D}$$

NOTE: as the demand rate (D) is given per year, the calculated replenishment time will also be expressed in terms of year. To convert the RT into days (needed for further calculations) please multiply it by 365(366 for leap year).

3.2.2 SAFETY STOCK

Safety stock is required to tackle various deviations, e.g. deviation in delivery due date, deviation in delivery quantity, or deviation in demand. For the present case deviation in delivery due date and delivery quantity is considered to be zero. Thus, we will rather focus on the deviation of demand during the safety stock calculation. A simple way of calculating safety stock is based on the following formula:

$$SS = (DR_{max} - DR_m) \times RT$$

SS safety stock [units]

DR_{max} maximum demand rate [units/SCD]

DR_m mean demand rate per item [units/SCD]

RT replenishment time [SCD]

Naturally, you need to calculate the safety stock for each type of product individually, due to the fact that offering product X instead of Y will not satisfy the customer. In addition, in order to limit the effect of outliers in the data on your safety stock levels, you need to calculate the average daily demand for each month (the total number of products ordered within a month divided by the number of days in that month). You can then use the average daily demand from the 12 months to calculate DR_{max} (the maximum of the average daily demands from the 12 months) and N_0 (the mean of the average daily demands from the 12 months).

3.3 REDESIGN COST

In case of the analysis of distribution networks, the redesign cost includes all modifications in the layout of the supply net. These modifications are targeted towards a distribution center or existing facilities. The cost is primarily affected by two decisions:

1. Building a new distribution center (DC) or enlargement of existing DC facility.
2. Decrease or shutdown of an existing DC.

When a new DC is to be built or the existing one is to be expanded with the addition of new facilities, the cost of redesigning is influenced by various factors, such as the new infrastructure, slow warehouse utilization, ramp up costs, etc. Downsizing or shutting an existing DC down also influence redesign costs. Performing either of the two actions will cause unemployment, call for employee and partner compensations, incur maintenance costs and run out costs, etc.

In our case, calculation base for the construction of a distribution center can be estimated based on the following assumptions:

- 1m^3 stock volume is calculated for 150 kg
- additional 50% of the stock volume is required for corridors
- additional 50% of the stock volume is required for loading and unloading area
- additional 100% of the stock volume is required for testing, painting, packing area
- 1 m^3 = 45 Euro (costs for the building only)
- 1 m^3 = 45 Euro (costs for installations)

For the shutdown of the warehouse, the costs of selling the equipment are positive. However, the other costs that are to be borne, for example breaking of the contract, run out costs, etc., are negative. This shutdown costs will be given as provided by XYZ Company.

3.4 COST COMPARISON

After calculating the different kinds of costs your team has to come up with a final conclusion for the costs analysis. Therefore, a second look at the calculated costs is necessary. You can differentiate between periodical costs and one-time costs. Transportation costs and storage costs are periodical costs that occur over and over. Redesign costs on the other hand are an investment. In case the periodical costs of a future scenario are lower than the current periodical costs the amortization time of the investment has to be determined. Amortization time is the period of time until the investment pays off. To determine the length of this period in years one has to divide the investment costs by the annual savings:

$$amortization\ time = \frac{\sum investment\ costs}{annual\ savings}$$

3.5 DELIVERY TIME

All the above mentioned methods are cost-based analysis. However, delivery performance also plays a very important role during the analysis. Hence, your analysis should also be based on delivery time, which is one of the key indicators of logistics performance. It can be seen from Figure 5 that delivery time covers time for order preparation and material handling process as well as the transportation time. Delivery time basically is the period between the order placement by the customer and receiving of the goods.

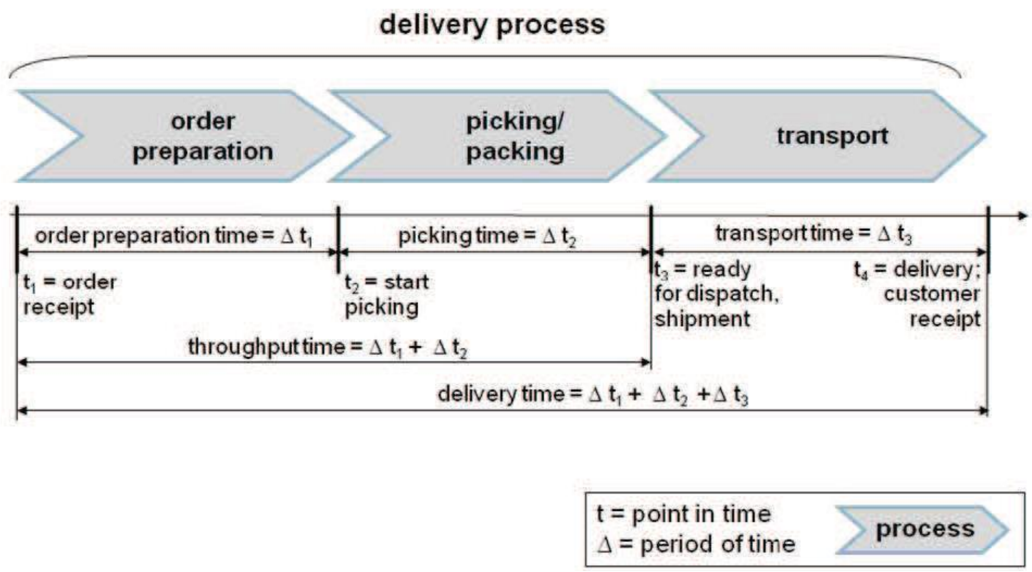

FIGURE 5. DELIVERY TIME

The order preparation and picking/packing time is affected by processes involved during these operations. In our case, the existing warehouses take two days for order preparation and picking/packing. However, the warehouse to be built in Paris will take only one day for the same processes because of the increased automation. The transport time from warehouses to different locations will be provided in the master data. You should calculate the average delivery time per order, and based on this analysis should be provided in the conclusion.

3.6 CARBON FOOTPRINT

As an additional factor, it is also important to consider the carbon footrpint of a given scenario. Thus, your analysis should also include the total CO_2 emission as another key performance indicator. Different transportation types have different emission rates, dependent on the weight of the good and the transport type. In this case you have to calculate the total emissions for both incoming and outgoing shipments.

For incoming goods, the logistics provider who transports the goods uses a mixture of transport modes as stated previously. From Shanghai, China to Bremen, Germany, the goods are first transported by sea freight to the port of Bremerhaven and then by truck to the warehouse in Bremen. From Shanghai, China to Valencia, Spain, the goods are first transported by sea freight to the port of Santander, and then by train to the warehouse in Valencia. If the warehousing operations are to be centralized in Paris, France, the goods from Shanghai, China would first be transported to the port of Le Havre, and then by train to Paris. The distances between each location are included.

All outgoing goods are transported by trucks from the warehouse to the customer. The distances from each location are already included.

The different emission rates by freight type are also included:

- Ship freight: 7.7 g CO_2/km*tonnes = 0.0077 g CO_2/km*kg
- Train freight: 23 g CO_2/km*tonnes = 0.023 g CO_2/km*kg
- Truck freight: 54.5 g CO_2/km*tonnes = 0.0545 g CO_2/km*kg

4 LITERATURE

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