Appendix Case-Study "Re-designing the Material Flow in a Global Manufacturing Network"

With the help of this case-study, materials of many chapters in this book can be applied to practical decision-making. In particular, knowledge on sourcing and production strategies, inventory management, transportation planning, linear and mixed-integer linear programming can be summarized.

Problem Description

In many cases, outsourcing or global sourcing is applied to cost reductions in material flows. At the same time, it can be possible to achieve similar effects by redesigning the material flow within the existing manufacturing network. Especially in industries with deep manufacturing penetration, such as plant engineering, there are many options to extend existing internal customer–supplier relations. In this situation, make-or-buy analysis should be performed for different modules and components at each location. The basis for the comparison of the make and buy efficiency is the total cost, comprised of production, logistics and follow-up costs. In addition, risks should be considered.

Consider an enterprise that produces systems for energy transmission and has two locations: factory A is located in Europe and factory B is located in China. Both factories have deep manufacturing penetration; in other words they are able to produce almost all the components and modules needed for the final product assembly. Both factories can assemble the same final products from the same components, known as shared components (see Fig. 1).

The final assembly always takes place in the country where the customer builds its energy system. It should be analysed to see whether the production of the shared components can be distributed within the network so that total network costs are minimized.

For analysis, a module has been selected that is needed for 54 % of all the energy system types. This makes the analysis representative and the results scalable. The module is produced according to ATO strategy and built into the final product at both factories. The module is composed of 13 components sourced from seven suppliers. At the first stage, four options for process design have been formulated (see Fig. 2)

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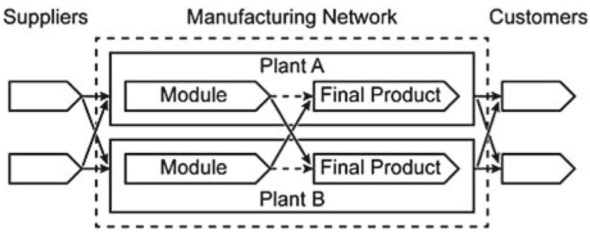

Fig. 1 Manufacturing network

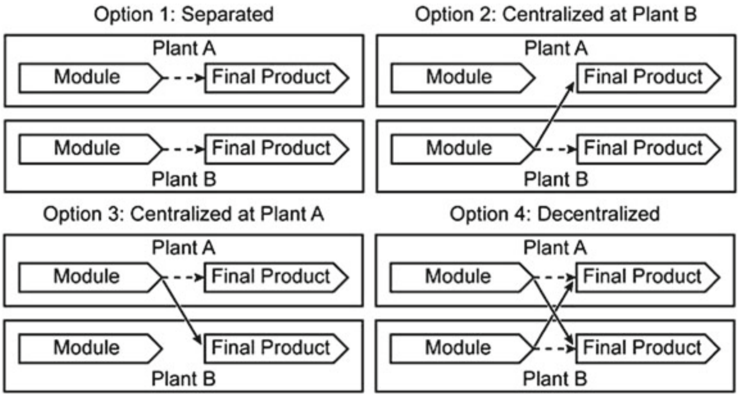

Fig. 2 Options for process design

At present, option 1 is used.

Questions

1. Formulate a mathematical model for the problem considered above! Select a standard model from Operations Research!

2. The model has now to be filled out with data. Describe your approach to get the necessary data!

Assumptions

- Material costs at location A is 212 €, labour costs is 40.50 € and overhead costs is 20.78 € for one module. Transportation costs for one module is 14 €.
- Material costs at location B is 143 €, labour costs is 20.0 € and overhead costs is 14 € for one module. Transportation costs for one module is 14 €.
- Consider inventory costs as composed of cycle and safety inventory costs. Select for calculation appropriate models of inventory management. Use transit price for the calculation.
- The following is true for location A: interest is 10 %, fixed costs is 23.2 €, service level is 95 %, standard deviation of lead time is 10 days and there are 250 working days in a year!

Table 1 Costs analysis for global sourcing

Costs	GER-GER	GER-CH	CH-GER	CH-CH
Material costs				
Labor costs				
Overhead costs				
Production costs				
Profit (5 %)				
Transfer price				
Customs duty (1.7 %)				
Transit price				
Transport costs				
Inventory costs				
Total landed costs				
Implementation costs				
Coordination costs				
Total costs				

- The following is true for location B: interest is 10 %, fixed costs is 13.2 €, service level is 95 %, standard deviation of lead time is 10 days and there are 250 working days in a year!
- Consider complexity issues if setting up coordination costs!
- Capacity at each location is 1200 units. Demand for one period is 1000 units at location A and 100 units and location B.

The cost analysis includes so called Total Landed Costs and follow-up costs (Table 1):

3. Solve the model with the help of Excel Solver! Explain the results and link them to one of the four options! Do we have any costs savings if we change from the Option 1? What is your recommendation?

Costs c_{ij}	Location A (i = 1)	Location B (i = 2)	Capacity a_i
Location A (j = 1)			
Location B (j = 2)			
Demand b_j			

The objective function can be written as follows:

subject to restrictions:

As the basis for comparison, the *as-is* situation can be taken which is described as follows:

Quantity x_{ij}	Location A (i = 1)	Location B (i = 2)	Sum
Location A (j = 1)			
Location B (j = 2)			
Sum			

Z(x) =

The optimization model provides the following result:

Quantity x_{ij}	Location A (i = 1)	Location B (i = 2)	Sum
Location A (j = 1)			
Location B (j = 2)			
Sum			

Z(x) = €

The network costs is now €. The cost savings is €.

4. Analyse advantages and limitations of each option considering the following criteria:

- Coordination efforts
- Reaction speed
- Supplier management
- Scale effects
- Material and labour costs
- Transportation costs and lead-times
- Manufacturing complexity
- Quality
- On-time delivery
- Inventory
- Single sourcing risks

With the help of scoring analysis, the following results can be indicated (see Table 2):

5. Consider a third location in India which can be used as a hub in the network. The capacity is 1200 units, and there is no demand in India at present. Sourcing costs from India to Germany is 198 € and from India to China −181 €.

- calculate optimal solution!
- what qualitative factors would you consider?
- perform sensitivity analysis and explain its results!

Optimal solution is:

Quantity x_{ij}	Location A (i = 1)	Location B (i = 2)	Location C (j = 3)	Sum
Location A (j = 1)				
Location B (j = 2)				
Location C (j = 3)				
Sum				

Z(x) = €

6. Consider five markets (China, Germany, Russia, Egypt, and India) and three factories in China, Germany, and India. The capacity in China can be increased at 3000 € (Table 3).

Table 2 Scoring analysis

Criterion	Option 1	Option 2	Option 3	Option 4
Coordination efforts				
Reaction speed				
Supplier management				
Scale effects				
Material and labour costs				
Transportation costs and leadtimes				
Manufacturing complexity				
Quality				
On-time delivery				
Inventory				
Single sourcing risks				
Total				

Table 3 Represents initial data

	Demand region production and transportation cost per X units								
Supply region	GER	CH	IND	EGT	RUS	Fixed costs	Low capacity	Fixed costs	High capacity
GER	273	303	303	295	292	0	1.200	0	1.200
CH	200	177	182	190	195	0	1.200	3.000	1.600
IND	198	181	170	188	193	0	1.200	0	1.200
Demand	1.000	100	150	50	100				

Formulate and solve a mathematical model for the problem considered above! Select a standard model from Operations Research!

Additional Task

Consider another module for which production capacity of 1000 units in Germany and 600 units in China is available. The corresponding costs are given as follows:

Costs c_{ij}	Location A ($i = 1$)	Location B ($i = 2$)	Capacity a_i
Location A ($j = 1$)	12.276	13.990	1000
Location B ($j = 2$)	9.518	8.167	600
Demand b_j	1000	100	1100/1600

Formulate the mathematical model!

Calculate costs for Option 1!

$Z(x) =$

Calculate optimal solution and costs savings!

Quantity x_{ij}	Location A (i = 1)	Location B (i = 2)	Sum
Location A (j = 1)			
Location B (j = 2)			
Sum			

Z(x) =
This results in savings of € or % of costs reduction.

Additional Discussion Questions

1. Global sourcing is reasonable for items with high volumes, low demand fluctuations and low transportation costs as compared with the item value. Which methods of operations management could help you identify such items? Think up a numerical example for each method to describe your approach!
2. In the case study we considered deterministic demands. Which methods would you use to forecast demand if statistical information is (is not) available?
3. The plant in China was engineered with an excessive capacity. What could be the reasons for that? Which methods could be used to support this decision?
4. We considered one period analysis. Which methods could you use to lot-size optimization for multi-period problems?
5. Which trade-offs can you see between inventory and transportation costs? Is the *economic order quantity* (EOQ) optimal for integrated inventory and transportation costs? If yes, why? If not, which methods could be used to minimize total costs? Think up a simple numerical example to explain your approach!

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