

## Factory planning

- Factory location
- Manufacturing allocation to factories

### Introduction

- Factory location is a major issue strongly dependent on markets, technology, transportation time and costs etc. and therefore it is a strategic decision
- As the am. factors change, the strategy and even factory locations and production allocation is sometimes changed
- Factories are not built or stopped lightly, but their capacity, product allocation and markets served are easier to change
- Mechanical manufacturing is usually not very strongly dependent on any single factor's, like energy, water, customers, proximity and it is generally environmentally problem-free
- Therefore, location decisions are affected by many factors. In the following, we focus on general cost issues

## Factory location and production allocation

### On costs and other issues

- Economies of scale favor concentration of production to few large factories
- On the other hand, transportation costs, delivery times, and local presence demand decentralization of production to many markets and locations
- Optimal plant location depends on market sizes, logistics costs, costs of factors of production, used technologies, and already existing resources. All these factors should be considered simultaneously
- In practice many other issues influence the decisions, like historical decisions and qualitative non-economical issues
- However the effects of purely technical and economical factors should be known and they can usually be estimated quantitatively using appropriate models

## Factory location and production allocation

- **In the short run** production allocation is mainly determined by variable costs and capacities of the factories
- **In the long run**, factories can be started and ended
- The problem can be formulated as an IP and solved easily

We have only one average product and we assume that the transportation cost is included in the variable cost:

$$\begin{aligned} \text{Min } C &= \sum_{\forall i} \sum_{\forall j} V_{ij} x_{ij} + \sum_{\forall i} F_i y_i && \text{Variable cost } V_{ij} \text{ for production of } x_{ij} \\ &&& \text{units at factory } i \text{ for market } j \text{ and fixed} \\ &&& \text{cost } F_i \\ \text{s.t.} &&& \\ \sum_{\forall i} x_{ij} &\geq D_j, \quad \forall j && \text{Demand } D_j \text{ must be satisfied} \\ \sum_{\forall j} x_{ij} &\leq W_i, \quad \forall i && \text{Capacities of factories } W_i \text{ must not be} \\ &&& \text{exceeded} \\ y_i M &\geq \sum_j x_{ij} \quad \forall i && \text{Setting of binary auxiliary variables} \\ y_i &\in \{0,1\}, \quad \forall i && y_i \text{ are binary auxiliary variables} \end{aligned}$$

## Factory location and production allocation

Excel model:

Variable cost	Markkina, <i>j</i>	Factories, <i>i</i>			Demand
		Europe	Americas	Far-East	
	Europe	200	750	600	3000
	Americas	800	250	400	2000
	Developing c.	1000	1500	1200	1000
	Far-East	800	700	120	2000
Fixed cost, <i>F<sub>i</sub></i>		500000	650000	700000	
Capacity, <i>W<sub>i</sub></i>		3500	3500	3500	
Production, <i>x<sub>ij</sub></i>					Total
	Europe	3000	0	0	3000
	Americas	0	2000	0	2000
	Developing c.	500	0	500	1000
	Far-East	0	0	2000	2000
		3500	2000	2500	
	Factory produces, <i>y<sub>i</sub></i>	1	1	1	
9999	Big-M:	9999	9999	9999	
Total cost		1600000	1150000	1540000	4290000

## Factory location and production allocation

### Some observations about plant location models

- Optimal solutions have the following interesting properties, which also have some practical value:
  - If unit costs of transportation decrease as distance increases (normally valid), optimal production location is always in an end of a line segment connecting locations – “End point optimality”
  - If unit production costs decrease as production volume increases (also usually valid) and there are no capacity constraints, each market is fed by only one factory – “Single assignment property”
- With delivery time or capacity constraints a.m. properties are not often valid (example)
- Constraints and costs related to delivery time, local value added content, purchasing, etc. are easy to add to optimization models

## Factory location and production allocation

### Other factors

- In addition to cost factors mentioned many other indirect and often qualitative factors must be considered when making decisions. These may not be reasonably contained in optimization models. This type of factors are for example:
  - Cultural issues
  - Political risks
  - Local legislation
  - Natural environmental phenomena
  - Labor availability
  - Labor unions
  - All types of infrastructure
- These may be evaluated using AHP or SWOT analysis etc.
- Such analyses, although systematic, is largely based on subjective evaluation and is therefore approximate. Comparison to results of quantitative cost analyses is also difficult.

## Factory location and production allocation

### Exact location

The exact location of the factory in the chosen area is again a result of many rather technical and easily judged factors:

- Access to transportation: Roads, railways, harbor, airfield
- Utilities: Water, sewer, electricity district heating
- City planning
- Cost of land and room for extension
- Soil
- Building cost
- Available services
- Supplier closeness
- Labor availability