KS SUPPLY CHAIN FUNDAMENTALS

05 Capacity Planning

SS 2025

JKU
PLM Institute of
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Learning goals

Be able to ...

- ... name the key questions in capacity planning.
- ... explain the concept of capacity planning.
- ... calculate capacity requirements.
- ... assess alternatives.
- ... understand the decision making process and different types of decision making environments.

Literature

Stevenson, WJ: Operations Management. McGraw-Hill Education Ltd; latest edition - Chapter 5 and Supplement

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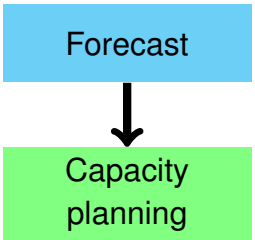
Key questions in capacity planning



- **What** kind of capacity is needed?
- **How much** is needed to match demand?
- **When** is it needed?

Capacity decisions are strategic

- Capacity limits the total output.
- Ideally, capacity should be tailored to the demand. If demand is heavily fluctuating: Balance cost of over- and undercapacity.
- Capacity is usually a major determinant of initial cost.
- Capacity investments are usually long-term investments.
- Capacity decisions affect delivery speed.
- Globalization has increased the importance and the complexity of capacity decisions.
- They usually have to be made far in advance.

Microsoft introduced the new Xbox in 2005. Insufficient supplies led to lost sales and unhappy customers.

Capacity planning process

1. Estimate future capacity requirements.
2. Evaluate existing capacity and facilities and identify gaps.
3. Identify alternatives for meeting requirements.
4. Conduct financial analysis of each alternative.
5. Assess key quality aspects for each alternative.
6. Select the alternative to pursue that will be best in the long term.
7. Implement the selected alternative.
8. Monitor results.

Forecasting capacity requirements

Example: A department works one 8-hour shift, 250 days a year, and has these figures for usage of a machine that is currently being considered:

Product	Annual Demand	Standard Processing Time per Unit (h)	Processing Time Needed (h)
1	400	5	2000
2	300	8	2400
3	700	2	1400
			5800

How many machines are needed?

Machines needed = $\frac{\text{Processing time needed}}{\text{Processing time capacity per Ma}}$

Yearly capacity: $8 \times 250 = 2000$ hours per year

$\frac{5800 \text{ hours}}{2000 \text{ hours/machine}} = 2.9$ machines

The decision making process

1. Identify the problem.
2. Set the goals and evaluation criteria for a solution.
3. Develop possible alternatives.
4. Analyze and compare alternatives.
5. Choose the best alternative.
6. Implement the chosen solution.
7. Control/Monitor whether goals were met.

Decision making environment

We distinguish between decisions under ....

Certainty All relevant parameters such as costs, capacity, demand have known values. [Profit per unit $5. Order of 200 pieces. Profit = $1000.]

Risk Some parameters have underlying probability distributions. [Profit per $5. 50% chance to order 100 pieces and 50% chance to order 200 pieces. Expected profit = $750.]

Uncertainty The probabilities of future events are unknown. [Profit per unit: $5. The probabilities for possible orders are unknown.]

Decision making under uncertainty

Four possible strategies:

Maximin (pessimistic) Choose the alternative that has the “best worst” payoff.

Maximax (optimistic) Choose the alternative with the highest possible payoff.

Laplace (indifferent) Calculate the average payoff and choose the alternative that has the highest.

Minimax Regret Determine the maximum “regret” for each alternative, and choose the alternative with the minimum maximum regret.

Example: payoff table

	Possible future demand		
Alternatives	**Low**	**Moderate**	**High**
Small facility	$10*	$10	$10
Medium facility	7	12	12
Large facility	-4	2	16

∗ Present Value in million $.

States of Nature: low, moderate, high demand
Alternatives: small, medium, large facility.

Example: results using different strategies

Maximin (pessimistic)

	Possible future demand		
Alternatives	**Low**	**Moderate**	**High**
Small facility	**10**	10	10
Medium facility	**7**	12	12
Large facility	**-4**	2	16

Maximax

	Possible future demand		
Alternatives	**Low**	**Moderate**	**High**
Small facility	**10**	10	10
Medium facility	7	**12**	12
Large facility	-4	2	**16**

Example: results using different strategies

Laplace

	Possible future demand			
Alternatives	**Low**	**Moderate**	**High**	Avg.
Small facility	10	10	10	30/3 = 10
Medium facility	7	12	12	**31/3 = 10,33**
Large facility	-4	2	16	14/3 = 4,67

Minimax Regret

	Possible future demand			
Alternatives	**Low**	**Moderate**	**High**	Max Regret
Small facility	**10 (0)**	10 (2)	10 (6)	(6)
Medium facility	7 (3)	**12 (0)**	12 (4)	**(4)**
Large facility	-4 (14)	2 (10)	**16 (0)**	(14)

Decision making under risk

- The probability of occurrence for each state of nature is known.
- Probabilities have to add up to 1 ($\sum_i p_i = 1$).

Expected Monetary Value (EMV) Choose the alternative that has the best expected payoff.

- Most appropriate when a decision maker is neither risk averse nor risk seeking, but is risk neutral.
- If this criterion is applied to a large number of similar decisions, the expected payoff for the total will approximate the sum of individual expected payoffs.

Example: EMV

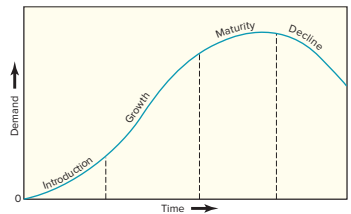
	Possible future demand		
Alternatives	**Low**	**Moderate**	**High**
Small facility	10	10	10
Medium facility	7	12	12
Large facility	-4	2	16
Probability p_i	0,3	0,5	0,2

$EMV_{small} = 0,3 \times 10 + 0,5 \times 10 + 0,2 \times 10 = 10$
$EMV_{medium} = 0,3 \times 7 + 0,5 \times 12 + 0,2 \times 12 = 10.5$
$EMV_{large} = 0,3 \times -4 + 0,5 \times 2 + 0,2 \times 16 = 3$

$\rightarrow$ build the medium facility.

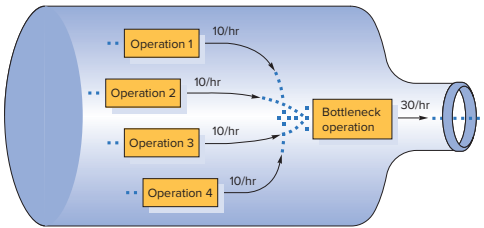
Developing capacity strategies (1)

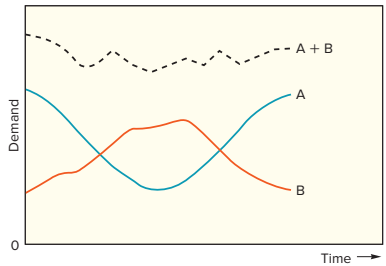
- Design **Flexibility** into systems (eg possibilities to expand capacity).
- Take **life cycle stage** into account.
  - *Introduction:* capacity requirements hard to predict.
  - *Growth:* increasing demand for capacity. Risk of overcapacity (if competitors use similar strategies).
  - *Maturity:* full use of capacity through cost reduction.
  - *Decline:* Reduce excess capacity through use of alternative products or move production to a location with low labor costs.



Developing capacity strategies (2)

- Take a **big picture** approach. Consider interrelations between the parts of a system. Increasing capacities is only useful if, eg suppliers can cover the added demand. Inefficient systems can be identified through the existence of **bottlenecks**.
- **Capacity chunks** Capacities can usually not be freely increased, only in larger chunks.
- Smooth **capacity requirements**, eg through products with complementary demand.





Summary

- The key questions in capacity planning are what kind of capacity, how much and when is it needed.
- Capacity decisions are strategic (long-term), affect responsiveness as well as resilience.
- The capacity planning process requires forecasting the capacity requirements, the identification and evaluation of decision alternatives, and finally the selection and implementation of the best alternative.
- Depending on the setting, decisions are taken under certainty, under risk or under uncertainty.
- Capacity increases can only be achieved by loosening limiting constraints, not by increasing other resources. Therefore, it is necessary to identify constraining resources and to focus on those.