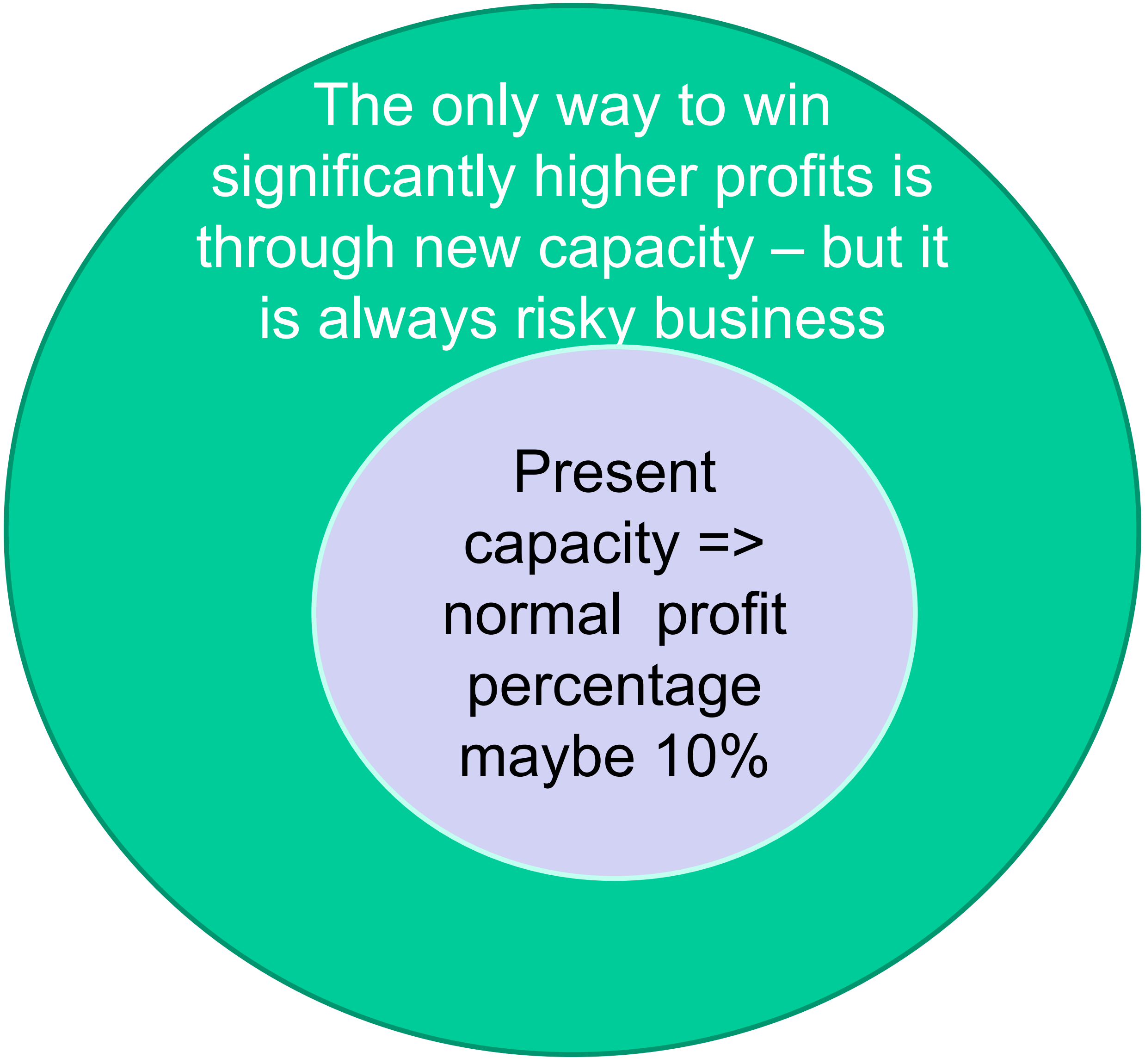
2 CAPACITY

Learning goals: After this chapter You will be able to

1. describe different ways to measure capacity, establish maximum capacity and calculate capacity utilization,
2. discuss long- and short-term strategies to ease bottlenecks and the concept of the theory-of-constraints approach,
3. explain the reasons for economies and diseconomies of scale,
4. discuss strategic issues such as capacity cushions, timing and sizing options and linkages with other decisions,
5. calculate capacity gaps and then evaluate plans for filling them and
6. describe how waiting-line models, simulation and decision trees can assist capacity decisions.


The only way to win significantly higher profits is through new capacity – but it is always risky business
Present capacity => normal profit percentage maybe 10%

Definition of Capacity

- Capacity is the limiting capability of a productive unit to produce within a stated time period, normally expressed in terms of output units per unit of time.

Fabrication Facilities - infrastructure as capacity, case Technip Ltd

Main Fabrication Workshops

Total area
40.000 m

Workshop 130 x 28 m
- Door 27,7 x 26 m
- Lifting height 25 m, 2 x 100 t
- Lifting height 16 m, 50 t

Workshop 130 x 28 m
- Door 19,5 x 10,8 m
- Lifting height 12 m, 2 x 50 t, 1 x 60 t

Workshop 190 x 38 m
- Door 34,6 x 14,4 m
- Lifting height 14 m, 2 x 80 t
- Lifting height 13 m, 60 t

Spar Section Workshop

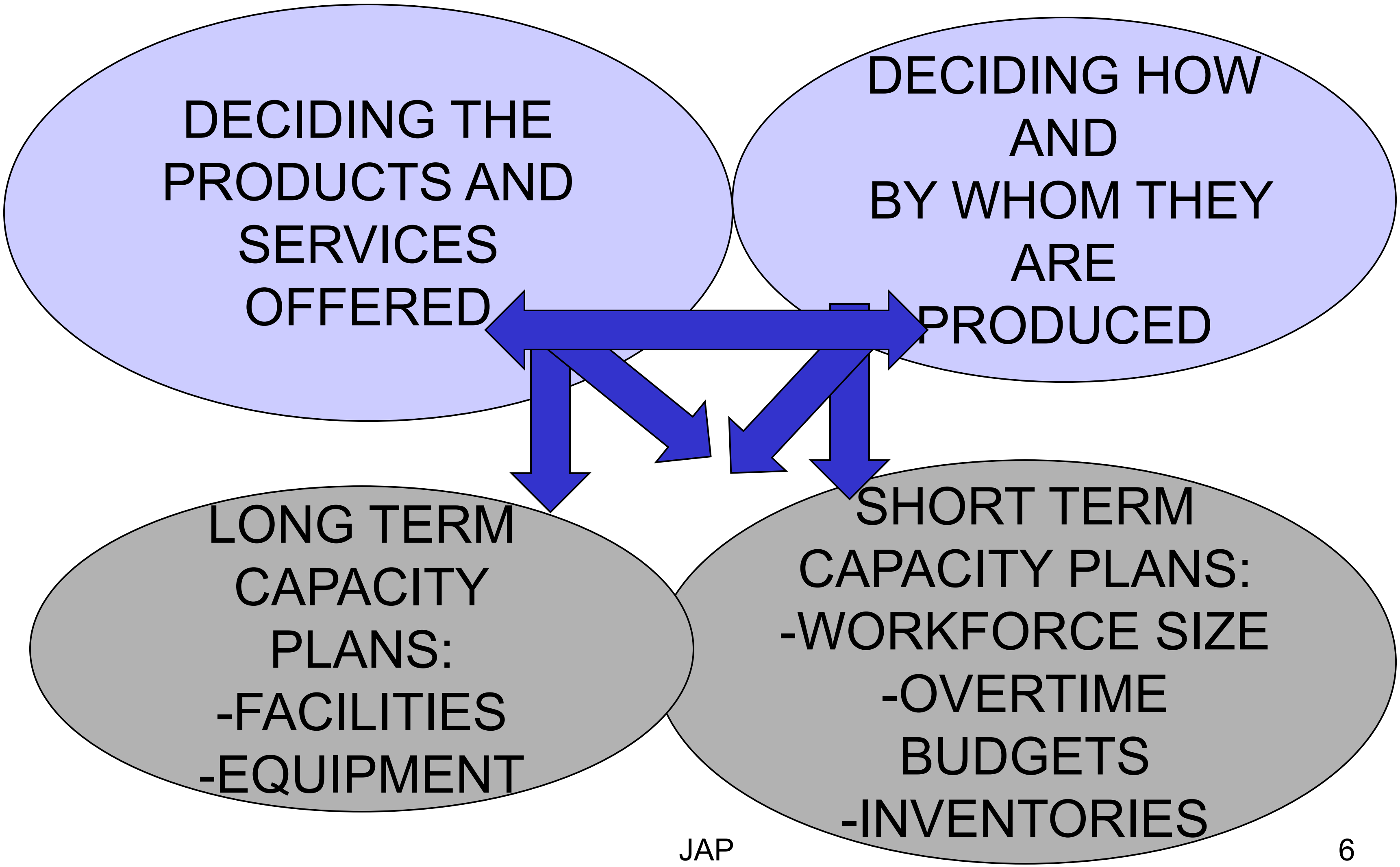
Workshop area 4.000 m^2, 100 m x 40 m
Door 20 m x 18 m
Lifting height 18 m, cranes 2 x 80 tonnes

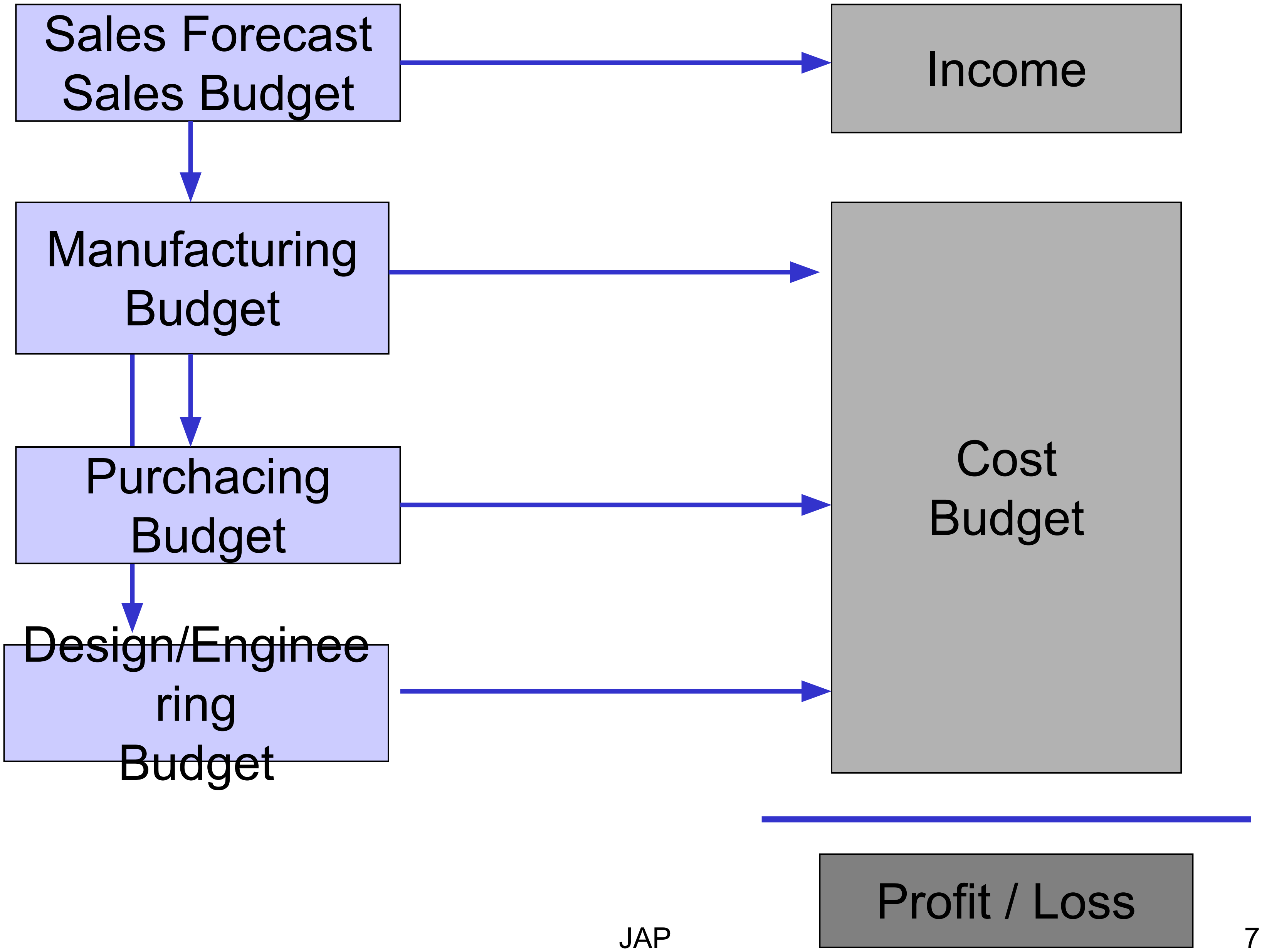
Measures of capacity

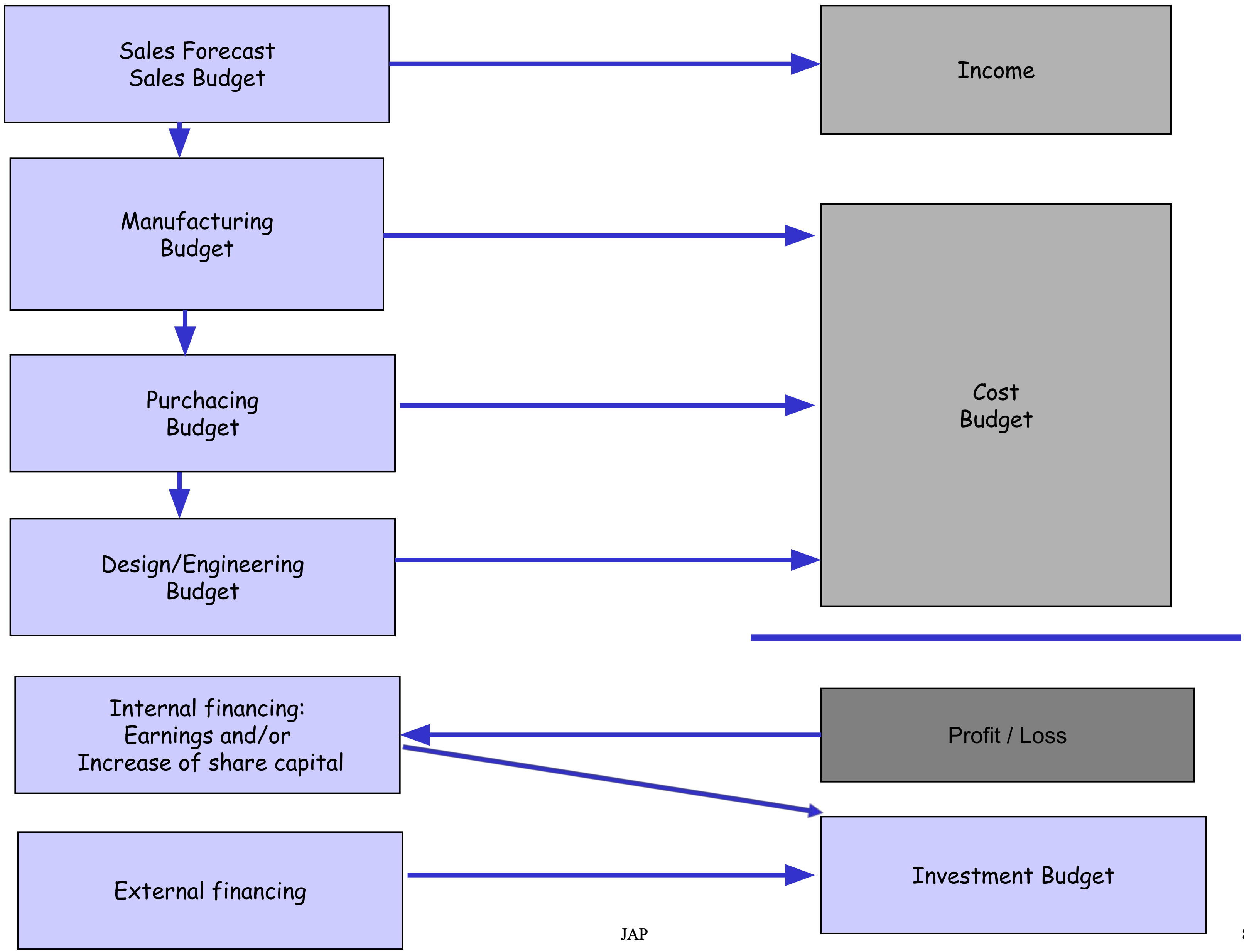
- Work shop – machine hours, labor (work) hours / day / week / month / year…
- Steel plant – tons of steel produced
- Saw mill – cubic meters of sawn timber
- Power plants – megawatts of electricity , kg's of steam, megawatts of heat
- Transportation (carrier) – ton kilometers, load carrying capacity

Notice! all in a certain period of time

DECIDING THE CAPACITY ?




Sales Forecast
Sales Budget
Income
Manufacturing
Budget
Purchacing
Budget
Cost
Budget
Design/Enginee
ring
Budget
Profit / Loss


Sales Forecast
Sales Budget
Income
Manufacturing
Budget
Purchacing
Budget
Cost
Budget
Design/Engineering
Budget
Internal financing:
Earnings and/or
Increase of share capital
Profit / Loss
External financing
Investment Budget

DEFINITIONS OF CAPACITY:

Capacity = the maximum rate of output for a process.

Utilization = The degree to which equipment, space or labor is currently being used.

$$\text{Utilization} = \frac{\text{Average output rate}}{\text{Maximum capacity}} \quad 100\%$$

Peak capacity or Effective capacity

Peak capacity = the maximum output that a process or facility can achieve under ideal conditions.

Rated capacity = an engineering assessment of maximum annual output, assuming continuous operation expect for an allowance for normal maintenance and repair downtime.

Effective capacity = The maximum output that a process or firm can economically sustain under normal conditions (varies according business economics).

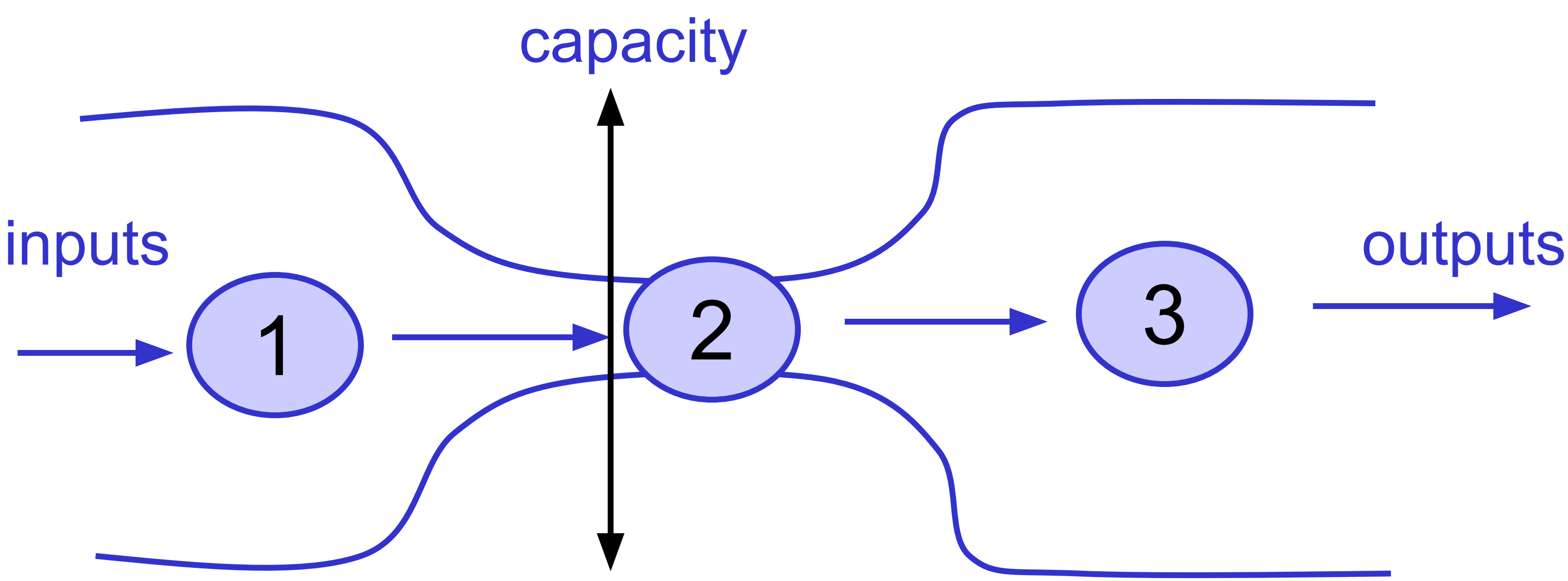
Problem 2.1. Peak and Effective Capacity

If operated around the clock under ideal conditions, the fabrication department of an engine manufacturer can produce 100 engines per day. Management believes that maximum output rate of only 45 engines per day can be sustained economically over a long period of time. Currently the department is producing an average of 50 engines per day. What is the utilization of the department relative to peak capacity and effective capacity.

More of this in OPT-technology

THEORY OF CONSTRAINTS (TOC)

The fundamental idea is to focus on capacity bottlenecks to increase their throughput. OPT is normally the next improvement after establishing JIT system.



Application of TOC involves the following steps:

1. identify the system Bottlenecks (observe the possible floating bottlenecks),
2. exploit the bottlenecks (create schedules that maximize the throughput of bottlenecks),
3. subcordinate all other decisions to step 2,
4. elevate the bottlenecks if they still after steps 1-3 are constraints to throughput (increase the capacity) and
5. do not let inertia set in.

TOC AND OPTIMIZED PRODUCTION TECHNOLOGY (OPT)

Main idea is to maximize the utilization of bottleneck operation and try to widen the bottleneck (raise capacity)

- Quality check before the bottleneck.
- Pull before and push after the bottleneck.
- Constant throughput.
- Total preventive maintenance.
- Observe! Variability in workload may create “floating bottlenecks”
- Seek for subcontracting.

ECONOMIES OF SCALE – a concept that states that the average unit cost of a good or service can be reduced by increasing its output rate.

-fixed costs are spread over more units

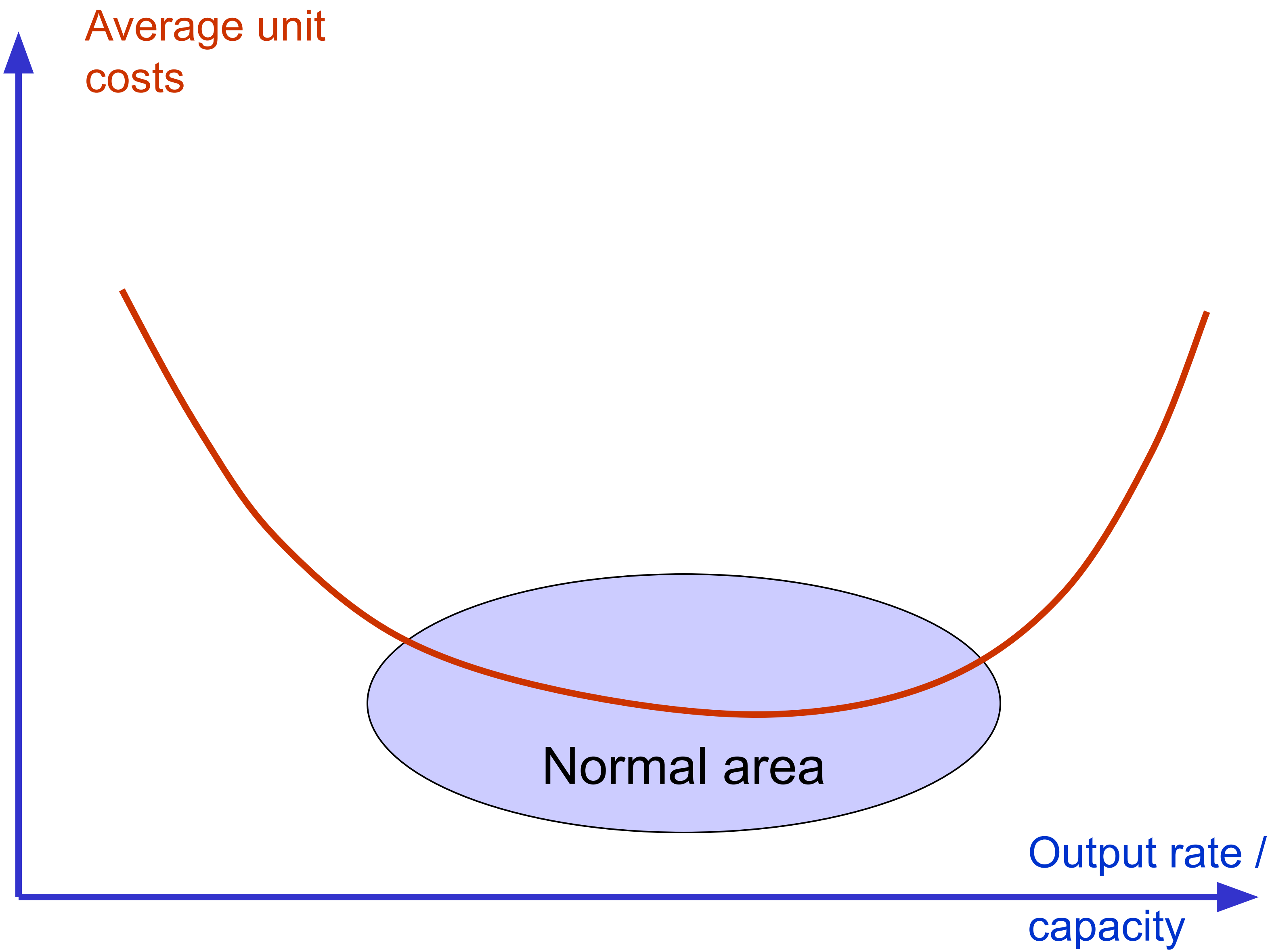
-Reducing construction costs / m^2

-Cutting costs of purchased materials

-Finding process advantages

DISECONOMIES OF SCALE

– at some point a facility (and firm) becomes so large that diseconomies of scale set in.
- size brings complexity, loss of focus and inefficiencies, bureaucracy, management loses touch with employees and customers


Average unit
costs
Normal area
Output rate /
capacity

CAPACITY CUSHION – the amount of reserve capacity that a firm maintains to handle sudden increases in demand or temporary losses of production capacity.

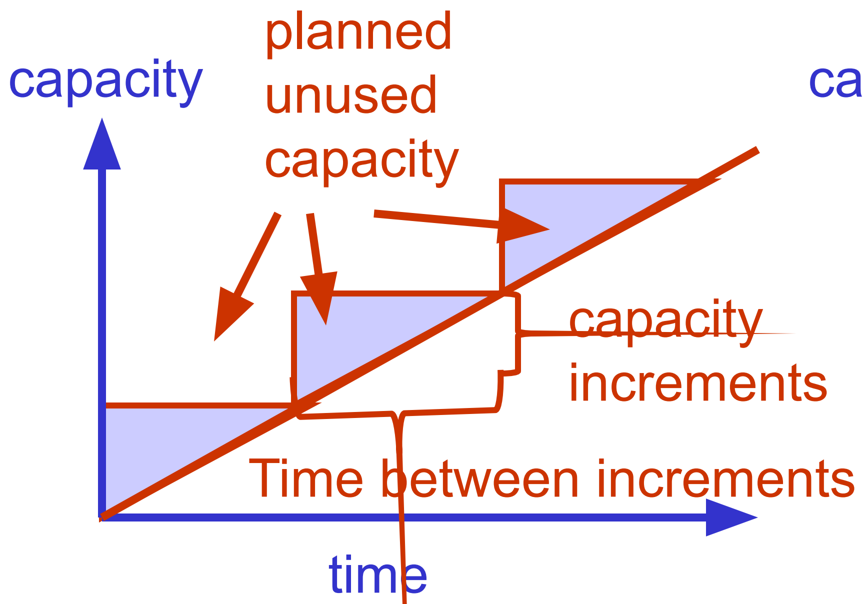
CAPACITY CUSHION = 100% - Utilization rate (%)

Average CAPACITY CUSHION in US is 18 % (7-27%) and it varies by industry. The more capital intensive the industry is the less cushion (paper industry < 10%, cruise ship industry such as Carnival Cruise 5 %).

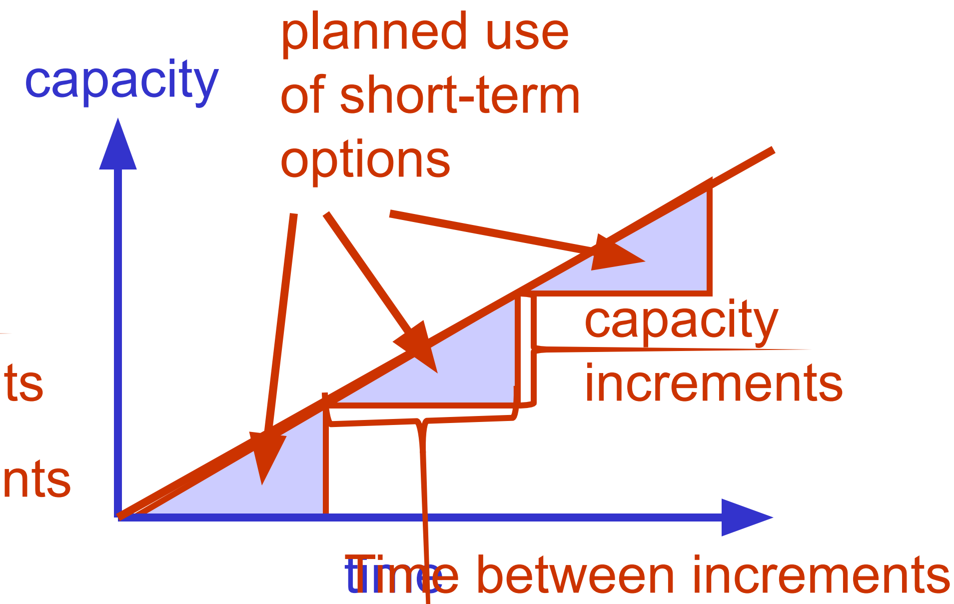
Businesses find large cushions appropriate when demand varies or future demand is uncertain.

TWO CAPACITY SRATEGIES (proactive – reactive)

Expansionist (Proactive) strategy



Wait-and-see (reactive) strategy



Base Case: The act of doing nothing and losing orders from any demand that exceeds current capacity.

Although each situation is somewhat different, a four-step procedure can help managers make sound capacity decisions.

1. Estimate future capacity requirements. => forecasting
2. Identify gaps by comparing requirements with available capacity.
3. Develop alternative plans for filling the gaps.
4. Evaluate each alternative, both qualitatively and quantitatively, and make a final choice.

STEP 1. ESTIMATE CAPACITY REQUIREMENTS

$$\text{NUMBER OF MACHINES REQUIRED (M)} = \frac{\text{PROCESSING }\overbrace{}^{\text{and setup}}\text{ HOURS REQUIRED / YEAR}}{\text{HOURS AVAILABLE FROM ONE MACHINE PER YEAR AFTER DEDUCTING DESIRED CUSHION}}$$

Where

$$M = \frac{\text{Sum } [D*p+(D/Q)*s]_{\text{products } 1\text{->}n}}{N * (1-(C/100))}$$

D = number of units (customer) forecast per year

p = processing time (in hours per unit or customer)

N = total number of hours per year during which the process operates

C = desired capacity cushion

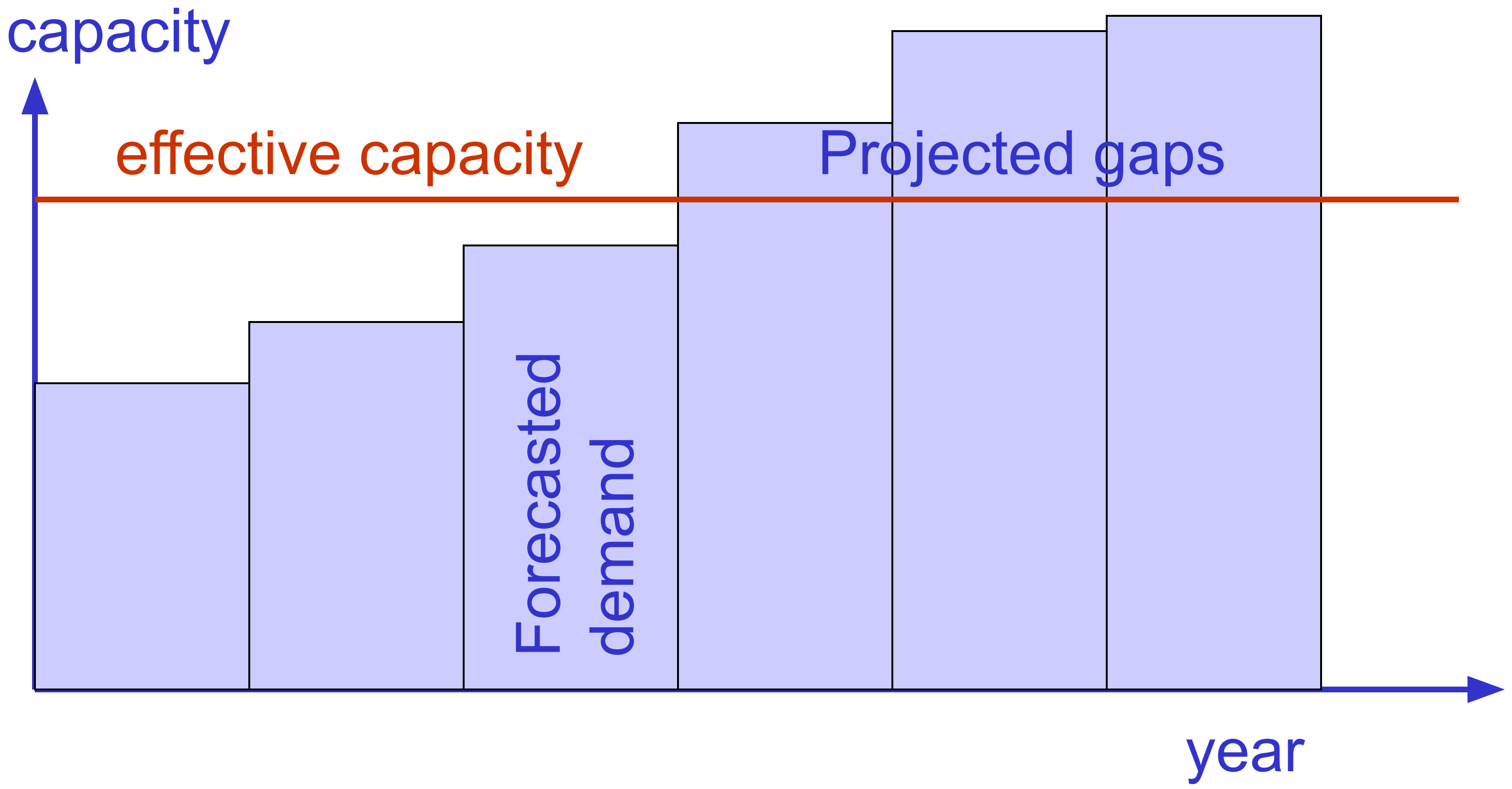
Q = number of units in each lot (lot size)

s = setup time (in hours) per lot

Problem 2.2. A copy center in an office building prepares bound reports for two clients. The center operates 250 days per year, with one 8 hour shift. Management believes that a capacity cushion of 15 percent (beyond the allowance built into time standards) is best. Based on the following table of information, determine how many machines are needed at the copy center.

ITEM	CLIENT X	CLIENT Y
Annual demand forecast (reports)	2000	6000
Standard processing time (hour/report)	0,5	0,7
Average lot size (copies of a report, the number of same kind of reports)	20	30
Standard setup time (hours)	0,25	0,40

STEP 2: IDENTIFY GAPS - A capacity gap is any difference (positive or negative) between projected demand and current capacity



STEP 3 – DEVELOP ALTERNATIVES – to cope with projected gaps.

-“Base case” - do nothing and simply lose orders exceeding current capacity.

-Choose proactive or reactive strategy

- expand own capacity, create partnerships for subcontracting

- use short term options such as overtime, temporary workers, and subcontracting.

STEP 4 – EVALUATE ALTERNATIVES – both qualitatively (other aspects than money) and quantitatively (estimates of cash flows, assets…)

Problem of capacity: part X requires grinding (work phases A and B). How many machines are needed in order to manufacture 2500 parts in a week, when you know that the workshop operates 18 hour a day, 5 days a week.

You know also that:

Work phase	STD-time	efficiency	yield	defects
A	2 min	95%	95%	2%
B	4 min	95%	90%	5%

Notice that this machine needs tool change and maintenance after every 400 products, and it takes 30 min.

Problem 2.3. Grandmother's Chicken Restaurant is experiencing a boom in business. Although the kitchen is operating at 100 percent capacity (80000 meals per year), the dining room can handle a total of 105000 diners per year. Forecasted demand for the next five years is as follows:

Year 1:	90000 meals
Year 2:	100000 meals
Year 3:	110000 meals
Year 4:	120000 meals
Year 5:	130000 meals

What are the capacity gaps?

Problem 2.4. Evaluating the alternatives:

One alternative for Grandmothers kitchen is to expand both the kitchen and the dining room now, bringing their capacities up to 130000 meals per year. The initial investment would be 200000 €, made at the end of this year (year 0). The average meal is process at 10 €, and the before tax-profit margin is 20 percent. (6 € covers variable costs and 2 € goes toward fixed costs. The remaining 2 € goes to pretax profit.) What are the pretax cash flows from this project for the next five years compared to those of the base case doing nothing?

Cash flow is the difference between the flows of funds into and out of an organization over a period of time, including revenues, costs and changes is assets and liabilities.

TOOLS FOR CAPACITY PLANNING:

WAITING LINE MODELS

- Because arrival time to a work center and processing time varies, waiting line models use probability distributions to provide estimates of average customer delay time, average length of waiting line and utilization of the work center.

SIMULATION – More complex waiting line problems must be analyzed with simulation. It can identify process's bottlenecks and appropriate capacity cushions.

DECISION TREES

Management is redesigning the customer service process at helpdesk. Accommodating four customers is important. Customers take contact at desk at a rate of two customers per hour. What is the probability that four customers call during any hour?

$$P(n) = \frac{(\text{Lambda (average workload/period)* T (time period)})^{n}}{\text{n (number of arrivals in scope) !}} * e^{-\text{lambda} * T}$$

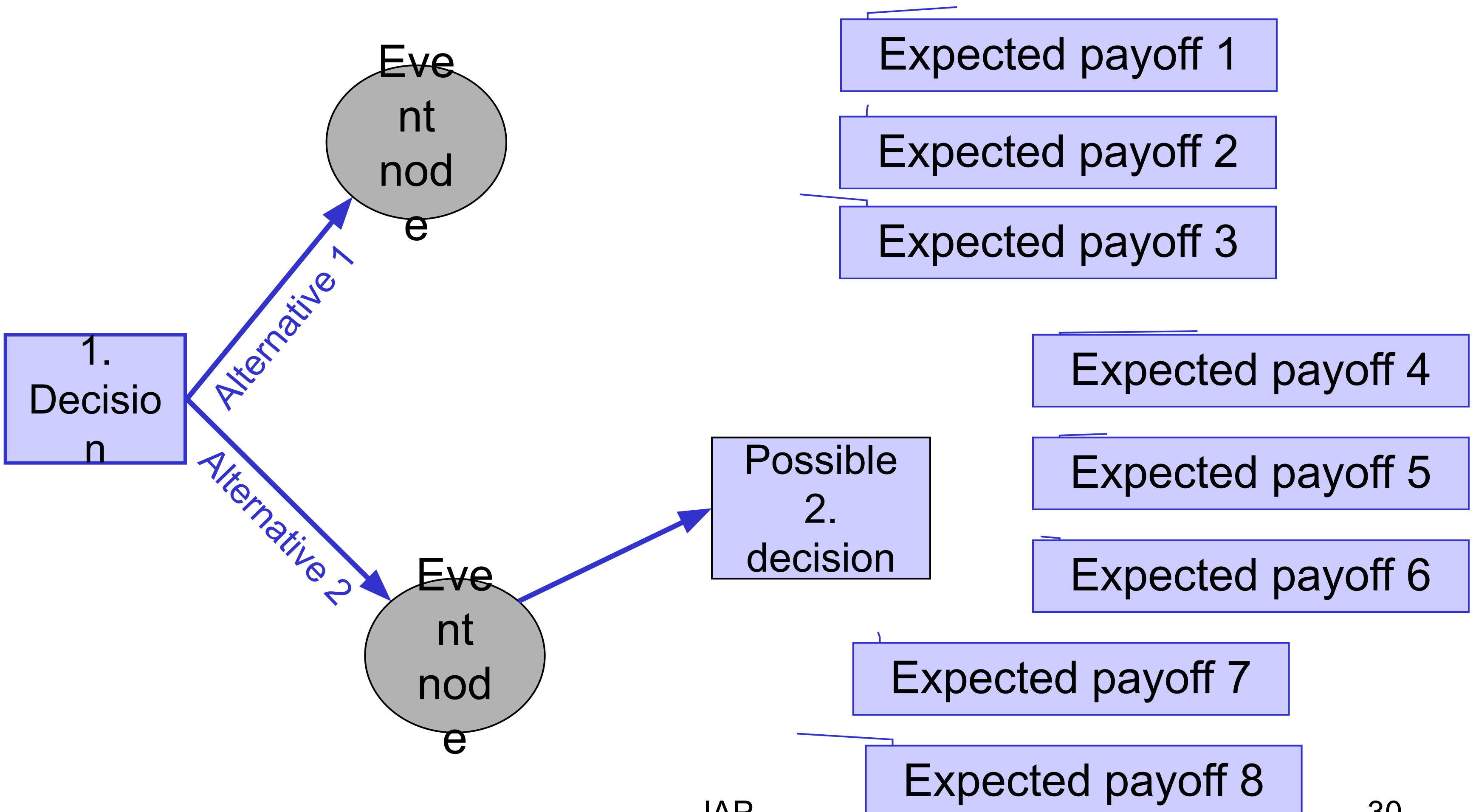
$$P(4) = \frac{(2*1)^{4}}{4!} \; 2{,}7183^{-2*1} = 0.090$$

Problem 2.5. Finding break even quantity

A machine job is considering to start with a new product of their own offered at 200 € per product. The fixed costs per year are about 100000 € and variable costs about 100 € per product. What is the break even quantity for this product. Use both algebraic and graphic approaches to get the answer.

2.6. Then proceed with Sensitivity Analysis by testing different changes for each factor of the new product.

Decision is a schematic model of alternatives available to the decision maker, along with their possible consequences



Problem exercise 2.6. Decision tree

A producer must decide whether to build a small or large facility at a new location. Demand at the location can be either high or low, with probabilities estimated to be 0,4 and 0,6, respectively. If a small facility is built and demand proves ti be high, the manager may choose to expand (payoff = 223000 €) or not to expand (payoff = 270000 €). If a small facility is built and demand is low, there is no reason to expand and the payoff is 200000 €. If a large facility is built and demand proves to be low, the choice is to do nothing (40000 €) is to stimulate demand through local advertising. The response to advertising may be modest or considerable, with their probabilities estimated to be 0,3 and 0,7, respectively. If it is modest, the payoff is estimated to be only 20000 €; the payoff grows to 220000 € is the response is sizable. Finally, if large facility is built and demand turns out to be high, the payoff is 800000 €. Determine the expected payoffs.

2.7 A machine job is considering to start with a new product of their own offered at 200 € per product. The fixed costs per year are about 100000 € and variable costs about 100 € per product.

What is the break even quantity for this product? Use both algebraic and graphic approaches to get the answer.