Chapter 4
Planning Capacity

- Capacity Strategies
- Determining Capacity Requirements
- Supplement A & B: Decision Tools

Case: Tesla Motors

- Tesla announced plans in 2014 to build the world's largest battery factory with 6500 employees.
- Much of the price reduction of the new car would come from a significant decrease in the cost of battery made possible by the scale economies. 電池成本
- The plant's excess capacity maybe underutilized in the first three years.
- Other car manufacturers use batteries that are not compatible.

What is Capacity?

Capacity: The maximum rate of output of a process or a system.

- Managers are responsible for ensuring that the firm has the capacity to meet current and future demand. Otherwise, the organization will miss out on opportunities for growth and profits. 降低產能
- Capacity decisions must be made in light of several long-term issues such as the firm's economies and diseconomies of scale, capacity cushions, timing and sizing strategies, and trade-offs between customer service and utilization. 長遠的影響

Measures of Capacity

	Input	Output
汽車生產線	運轉時數	每日生產車數
葡萄園	種植面積	每年葡萄產量
醫院	床位	每月醫療人數
百貨公司	實際營業面積	每月營業金額

- Use **Output** Measures when:
  - The firm uses **high volume**, **standardized processes**
- Use **Input** Measures when:
  - The firm uses **low-volume**, **flexible processes**

當產品/服務多樣少量時

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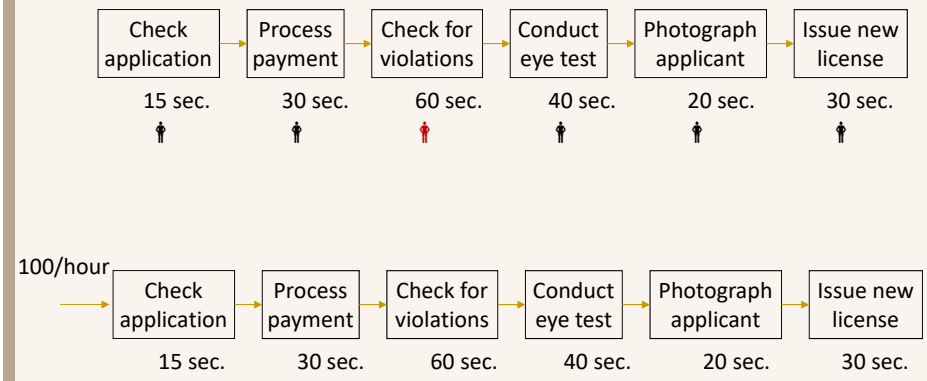
Bottlenecks Determine Line Process Capacity



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Measures of Capacity and Utilization

- Design capacity (max. capacity)
  - maximum output rate or service capacity a process can reasonably sustain for a long period.
- Effective capacity
  - Design capacity minus allowances such as personal time, maintenance, and scrap.

$$\text{Efficiency} = \frac{\text{Actual output}}{\text{Effective capacity}} \times 100\%$$

$$\text{Utilization} = \frac{\text{Actual output}}{\text{Max. capacity}} \times 100\%$$

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Economies of Scale: the average unit cost of a service or good can be reduced by increasing its output rate.

Total Cost = Fixed Cost + Variable Cost

$$\text{Unit Cost} = \frac{\text{Fixed Cost} + \text{Variable Cost}}{\text{Total Output}}$$

- Spreading fixed costs
- Reducing construction costs
- Cutting costs of purchased materials
- Process advantages: At a higher output rate, the process shifts towards a line process with resources dedicated to individual products.

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Diseconomies of Scale

A facility can become so large that the average cost per unit increases as the facility's size increases.

- **Complexity**: Too many layers of employees and bureaucracy
- **Loss of focus**: A less agile organization loses the flexibility needed to respond to changing demand
- **Inefficiencies**: Large companies become more involved in analysis and planning that they innovate less and avoid risks

Bigger is not always Better　　三校合併

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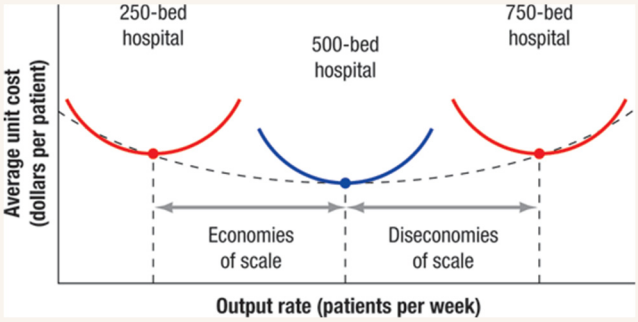
Economies and Diseconomies of Scale

Best operating level: 可使單位生產成本最低的產能水準，通常是設計建廠時規劃的產能水準



Total Output ≠ Total Sale

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Bigger is Better in South Korea?

大宇曾是南韓五大財團之一，崛起迅速，被稱為大宇神話，但解體速度之快也讓人驚嘆。大宇集團由金宇中創辦于1967年，他從業務員起家到自己設廠出口紡織品。當美國準備對紡織品進口設限時，配額將依據企業過去表現而定，金宇中立刻收購同業，低價搶單，結果大宇獨得南韓配額的近40%。

60年代，南韓政府為刺激經濟起飛，補貼銀行以零利率借貸給企業。在市場占有率至上的觀念下，企業高額負債來擴大規模、搶占市場。這創造了南韓的工業奇蹟，也使家族控制的財閥(chaebol)主宰了南韓經濟。大宇在十幾年內由5名員工擴張到總資產高達650億美元，擁有600多家公司，遍及汽車、電子、通訊、機械、化纖、造船、貿易等產業，員工人數超過二十五萬人，金宇中形容自己**到哪裡都聞得到錢的味道**。

Capacity Timing and Sizing Strategies

- Sizing Capacity Cushions = total capacity - expected capacity needed
- Timing and Sizing Expansion

  Expansionist Strategy: stays ahead of demand, large and infrequent jumps in capacity.

  Wait-and-see Strategy: lags behind demand and relies on short-term options. Small and frequent jumps.

  Follow the Leader (intermediate strategy)　各自的優缺點？

- Demand uncertainty vs. resource inflexibility

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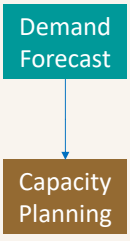
A Systematic Approach to Long-Term Capacity Decisions

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



焚化爐、大學數目、發電容量

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1. Estimate Capacity Requirements 1/2

For one service or product processed at one operation with a one year time period, the capacity requirement (workers or machines) is

$$M = \frac{D \times p}{N \times [1 - (C/100)]}$$

單站、單一產品

D = demand forecast for the year (number of customers served or units produced)

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

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

C = desired capacity cushion (expressed as a percent)

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1. Estimate Capacity Requirements 2/2

Setup times may be required if multiple products are produced.

$$M = \frac{[D_1 p_1 + (D_1/Q_1)s_1] + [D_2 p_2 + (D_2/Q_2)s_2] + \ldots + [D_n p_n + (D_n/Q_n)s_n]}{N\,[1 - (C/100)]}$$

單站、多種產品

D = demand forecast for the year (number served or units produced)

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

Q = number of units in each lot

s = 換線時間 setup time in hours per lot

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

C = desired capacity cushion (expressed as a percent)

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Example 4.1

A **copy center** in an office building prepares bound reports for **two clients**. It currently has three copy machines.

Item	Client X	Client Y
Annual demand forecast (copies)	2,000	6,000
Standard processing time (hour/copy)	0.5	0.7
Average lot size (copies per report)	20	30
Standard setup time (hours)	0.25	0.40

The center operates **250 days** per year, with **one 8-hour shift**. Management sets a capacity cushion of **15 percent**.

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Calculating Capacity Expansion and Timing

1. **Forecast long term demand** for each product line
2. Calculate equipment/labor requirements
3. Project and allocate resources over the planning period

year	1	2	3	4	5
forecast	135	185	245	297	348
machine requirement	0.9	1.23	1.62	1.98	2.31

4. Utilization > 80%, Overtime/Subcontract < 25%

Setup time requirements?

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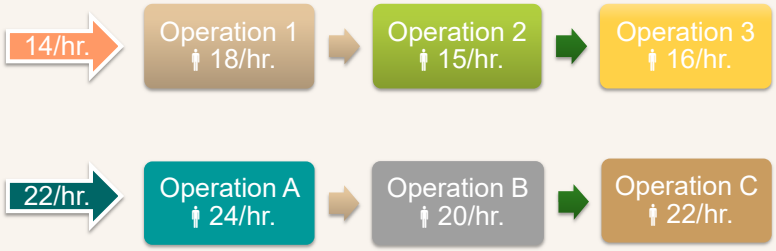
2. Identify Capacity Gaps

- Identify gaps between projected capacity requirements and current capacity
  - Complicated by multiple operations (bottlenecks) and resource inputs



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3. Develop Alternatives

- **Base case** is to do nothing and suffer the consequences
- Expansion vs. wait-and-see vs. follow the leader
- 短期對策: overtime, temp. workers, subcontracting
- **Make or Buy**: expertise, quality, cost, risk…
- 降低產能: closing, laying off, reducing work time

4. Evaluate Alternatives

- **Qualitative** concerns 市場與技術
- **Quantitative** 投資報酬

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Supplement A: Break-Even Analysis

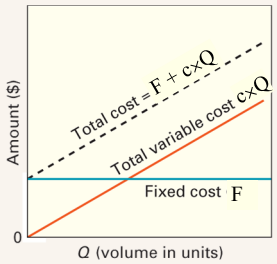
- **Unit variable cost (*c*)** cost per unit for materials, labor and etc.
- **Fixed cost (*F*)** the portion of the total cost that remains constant regardless of changes in levels of output.
- **Quantity (*Q*)** the number of customers served or units produced per year.

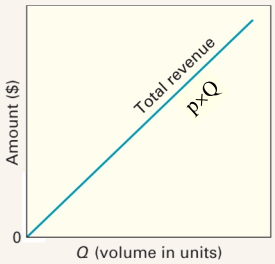
- Total Cost = Fixed Cost + Total Variable Cost = $F + c \times Q$
- Total Revenue $\overset{?}{=}$ unit revenue (p) $\times$ Quantity (Q)
- Total Profit = $p \times Q - (F + c \times Q)$

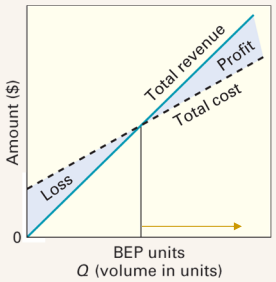
Break-Even Quantity 損益平衡點 (Indifference points)

Total Profit = $p \times Q - (F + c \times Q)$

Total Revenue $\geq$ Total Cost $\Rightarrow$ $p \times Q \geq (F + c \times Q) \Rightarrow Q \geq \dfrac{F}{p - c}$





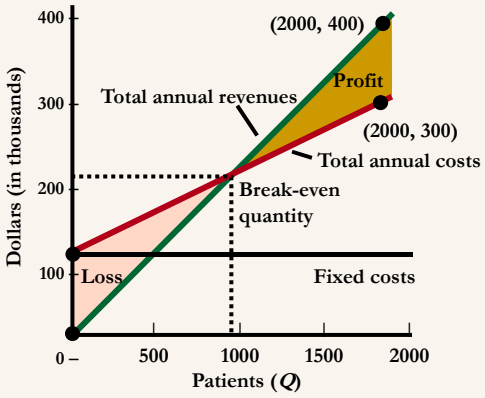


Example A.1

A new procedure will be offered at \$200 per patient. The fixed cost per year would be \$100,000 with variable costs of \$100 per patient. What is the break-even quantity for this service?

$$Q \geq \frac{F}{p-c} = \frac{100{,}000}{200-100}$$

$= 1{,}000$ patients



損益平衡分析的建議方式？

Evaluating Alternatives

- F_b : The fixed cost (per year) of the B option
- F_m : The fixed cost of the M option
- c_b : The variable cost (per unit) of the B option
- c_m : The variable cost of the M option

  - Total cost of the B option = $F_b + c_b \times Q$
  - Total cost of the M option = $F_m + c_m \times Q$

What if $F_m > F_b$, $c_m > c_b$?

$$F_b + c_b \times Q \geq F_m + c_m \times Q \quad \Rightarrow Q \geq \frac{F_m - F_b}{c_b - c_m}$$

Example A.3 : Make or Buy

- A fast-food restaurant is adding salads to the menu.
- Make ⇒ Fixed costs: $12,000, variable costs: $1.50 per salad.
- Buy ⇒ Preassembled salads could be purchased from a local supplier at $2.00 per salad. It would require additional refrigeration with an annual fixed cost of $2,400
- The price to the customer will be the same.
- Expected demand is 25,000 salads per year.

$$Q \geq \frac{F_m - F_b}{c_b - c_m} = \frac{12{,}000 - 2{,}400}{2.0 - 1.5} = 19{,}200 \text{ salads}$$

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Financial Analysis

- 水餃店雇用兼職人員包水餃，每小時包250個水餃，時薪$150。
- 現在考慮購買包水餃機以取代人工。
- 機器單人操作，每小時可達450個水餃
- Consider **time value** of money, present value=$150,000
- Payback period=5 years
- Annual interest rate=5%
- Annual net cash flow=
  =PMT(5%,5,150000,0)
  =$34646

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Planning Service Capacity

- Need to be near customers
  服務產能必須位於或接近需求所在，無法運輸
- Inability to store services
  服務產能具有易滅性，無法庫存，必須在需求發生時提供
- Volatility of demand
  服務產能容易受到需求時機、內容、顧客行為變化的影響

Solution: 價格行銷、兼職人員、等候線管理、預約、連鎖店、自助服務、作業標準化

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Summary

- Strategic capacity planning 必須以長期需求預測為依據，決策會顯著影響營運成本
- 產能擴充需考量市場不確定性、時機、幅度、方式
- 評估economies of scale的利弊
- Supplement A: 以財務成本觀念來評估不同的產能選擇
- 服務業產能：無法庫存，高使用率容易影響服務品質

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