Chapter 5
Strategic Capacity Planning

- Capacity Planning Concepts
- Determining Capacity Requirements
- Service Capacity and Service Quality

Case: Disneyland Paris

- 預估每天的遊客約3至6萬人
- 如何規劃自用車與巴士停車位？
- 如何規劃旅館房間數目？
- 如何規劃旅館的餐廳座位數？

What is Capacity?

Capacity: the upper limit on the rate of output
(amount of output over a period of time)

Measurement of capacity

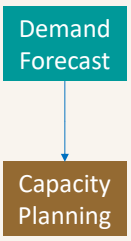
	Inputs	Outputs
汽車生產線	運轉時數	每日生產輛數
菓園	種植面積	每年蔬果產量
醫院	床位	每月住院人數
百貨公司	實際營業面積	每月營業金額

if an organization has many different products or services, …
frequent changes in the mix of output… use a measure of capacity that refers to availability of inputs.

3

I. Strategic Capacity Planning

Achieve a match between the long term supply capabilities and the predicted level of long term demand.



Key questions in capacity planning:

- What kind of capacity is needed?
- How much is needed?
- When is it needed?

焚化爐、大學數目、發電容量

4

Different Definition of Capacity

- Design capacity (max. capacity) 理想的最大產能

  maximum output rate or service capacity an operation, process, or facility is designed for

- Effective capacity 考量干擾因素後，應可達到的產能

  Design capacity minus allowances such as personal time, maintenance, and scrap

- Actual output

  rate of output actually achieved—may or may not exceed effective capacity

5

Determinants of Effective Capacity

A. Facilities 設施
1. Design
2. Location
3. Layout
4. Environment

B. Product/service 產品設計
1. Design
2. Product or service mix

C. Process 製程能力
1. Quantity capabilities
2. Quality capabilities

D. Human factors 人員因素
1. Job content
2. Job design
3. Training and experience
4. Motivation
5. Compensation
6. Learning rates
7. Absenteeism and labor turnover

E. Policy

F. Operational 現場管理
1. Scheduling
2. Materials management
3. Quality assurance
4. Maintenance policies
5. Equipment breakdowns

G. Supply chain

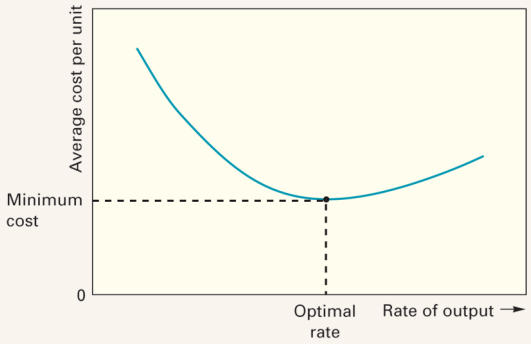
H. External factors 政府或工會
1. Product standards
2. Safety regulations
3. Unions
4. Pollution control standards

6

Optimal Operating Level

製程設計時規劃的產能水準，依此運作的單位生產成本最低

Best Operating Level ≤ Effective Capacity < Max. Capacity



7

II. Steps for Capacity Planning

1. Forecast future capacity requirements
2. Evaluate existing capacity
3. Identify alternatives
4. Conduct financial analysis
5. Assess key qualitative issues
6. Select one alternative
7. Implement alternative chosen
8. Monitor results

8

Calculating Capacity Requirement

Product	Demand	Std. Proc. Time	Proc. Time Needed
1	400	5.0	2,000
2	300	8.0	2,400
3	700	2.0	1,400

1. Forecast long term demand for individual products
2. Calculate equipment and labor requirements
3. Project and allocate resources over the planning period

year	1	2	3	4	5
forecast	135	185	245	297	348
% of capacity	30	41	54	66	77
machine	0.9	1.23	1.62	1.98	2.31

9

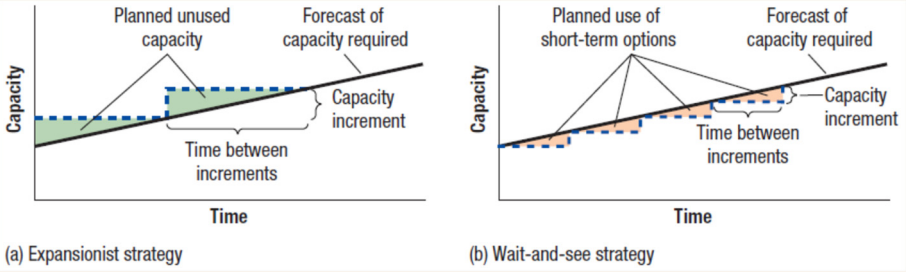
Capacity Timing and Sizing Strategies

- Sizing Capacity Cushions (why large cushions?)
- Timing and Sizing Expansion

Expansionist Strategy: 超前部署，積極擴充產能

Wait-and-see Strategy: 以加班或外包等方式，避免產能投資

Follow the Leader



10

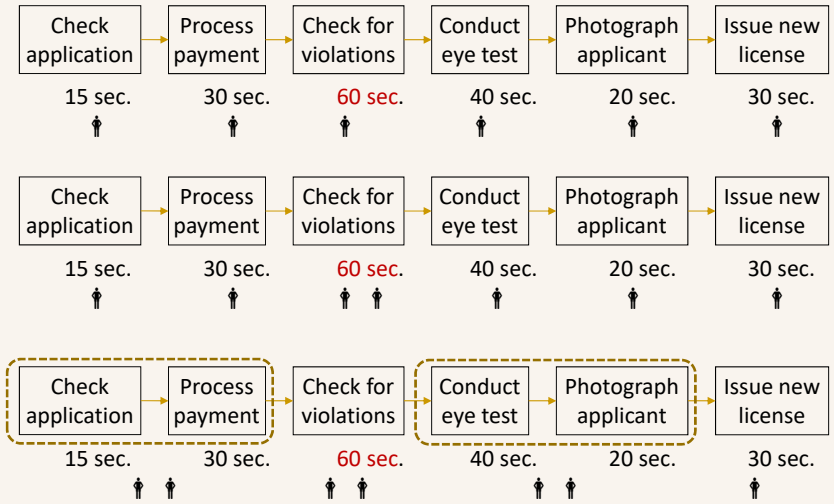
In-House or Outsourcing? Make or Buy

Outsourcing: obtain a good or service from an external provider

1. Available capacity 缺乏產能
2. Expertise 缺乏技術
3. Quality considerations 品質不如別人
4. Nature of demand 需求不確定
5. Cost 成本高於別人
6. Risk

11

Take a "Big Picture" Approach



12

Case: Tesla Motors

- Tesla announced plans in 2014 to build the world's largest battery factory at an expense of $4-5 billion.
- The factory would occupy 10M sq. feet and employ 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. 電池必須量產才能降低生產成本
- Other car manufacturers use batteries that are not compatible.

Economy of Scale

規模與產量增加，可分攤固定開銷，或自動化流程

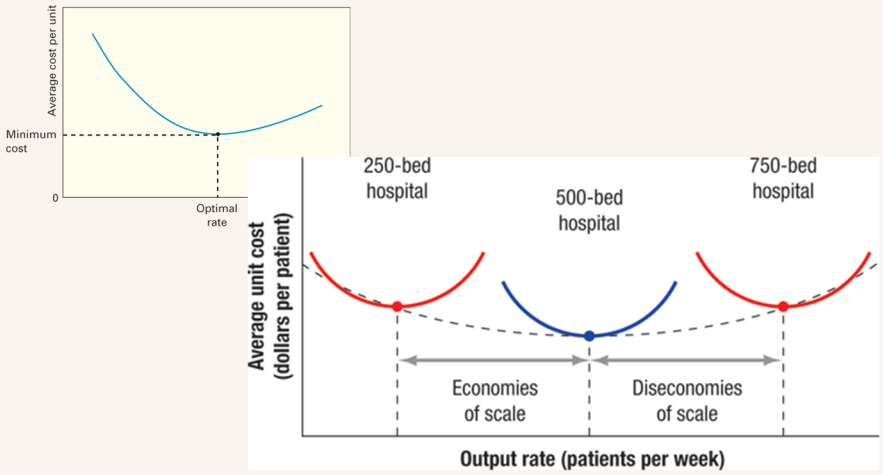
$$\text{Unit Cost} = \frac{\text{Fixed Cost}}{\text{Total Production}} + \text{Unit Variable Cost}$$

Diseconomies of Scale

- 當規模過大時，可能因管理不易或內部作業過於複雜，使單位成本不降反升。
- 當市場需求不及設計產能時，可能被迫降價以消化庫存，或讓產能閒置而造成單位成本上升。

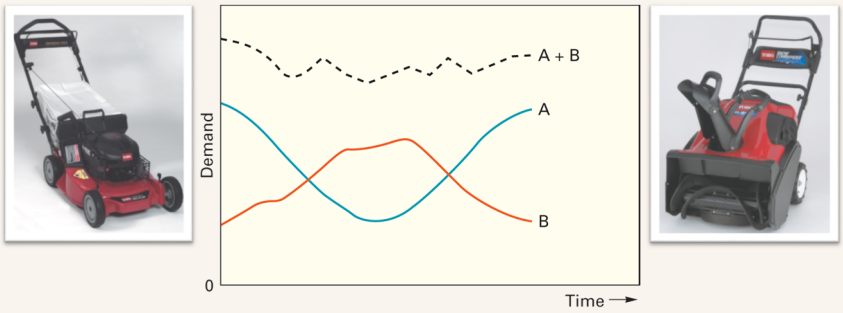
daewoo

Economies and Diseconomies of Scale



Smooth Out Capacity Requirements

unevenness in demand $\Rightarrow$ inventory or lost sales

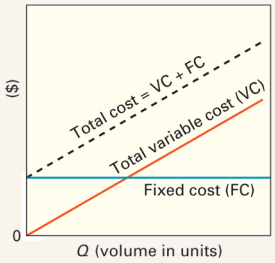


Identify products or services that have complementary demand patterns.

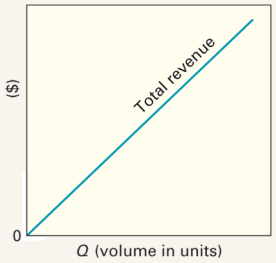
III. Break-Even Analysis

Profit = Revenue –Cost = 總銷量Q × 單價R – (固定成本FC + 變動成本VC)

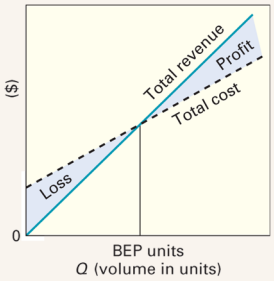
$$P = 0 \Rightarrow Q \times R = (FC + VC) = (FC + Q \times v) \Rightarrow Q = \frac{FC}{R - v}$$



A. Fixed, variable, and total costs



B. Total revenue increases linearly with output



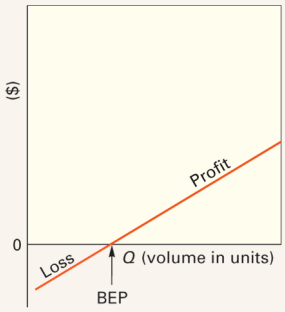
C. Profit = TR – TC

17

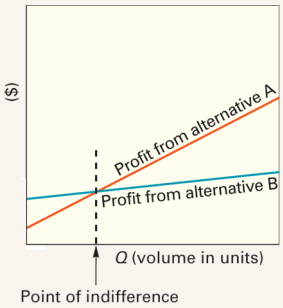
Evaluating Alternatives

$$P_A = P_B \Rightarrow Q \times R - (FC_A + Q \times v_A) = Q \times R - (FC_B + Q \times v_B)$$

$$\Rightarrow FC_A + Q \times v_A = FC_B + Q \times v_B \Rightarrow Q = \frac{FC_B - FC_A}{v_A - v_B}$$ point of indifference



D. Profit versus loss



E. Point of indifference for two alternatives

18

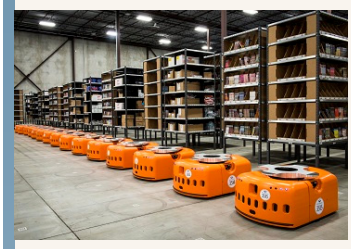
Financial Analysis

- 水餃店原本雇用兼職人員包水餃，時薪$150。
- 現在考慮購買包水餃機以取代人工。
- Consider time value of money
- Present value=150,000, annual interest rate=5%
- Payback period=5 years
- Annual net cash flow=
  =PMT(5%,5,150000,0)
  =$34646

19

Amazon's Kiva Robots

Movie: Kiva



2012年初，Amazon以7億7千5百萬美元併購Kiva Systems，這家新創公司的主要產品就是Kiva Robots，可負載300公斤，行駛速度每小時8公里。

- 省去員工在貨架間行走、尋找儲位等時間，提高出貨量。
- 24×7運作，節省揀貨成本22%。
- 讓競爭對手失去機器人供應來源。
- 節省員工停車場空間。

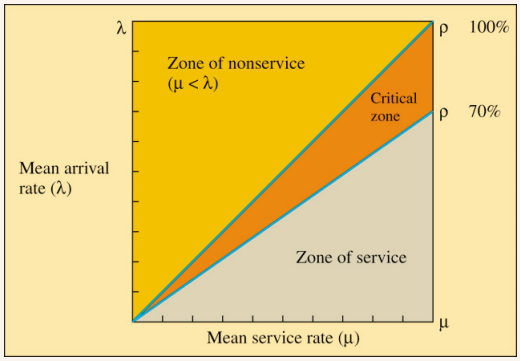
III. Planning Service Capacity

- 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

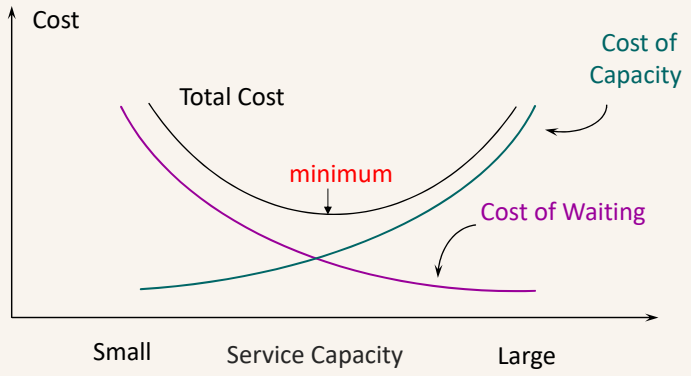
Solution: 價格行銷、兼職人員、等候線管理、預約、連鎖店、自助服務、作業標準化

Capacity Utilization vs. Service Quality

Optimal operating level ≈ Design capacity的70%



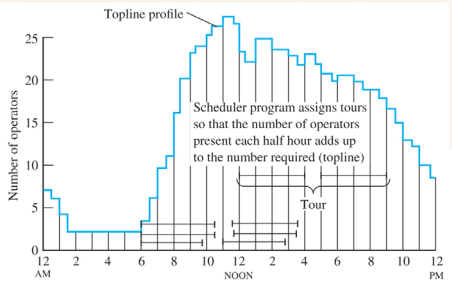
The Economies of Waiting

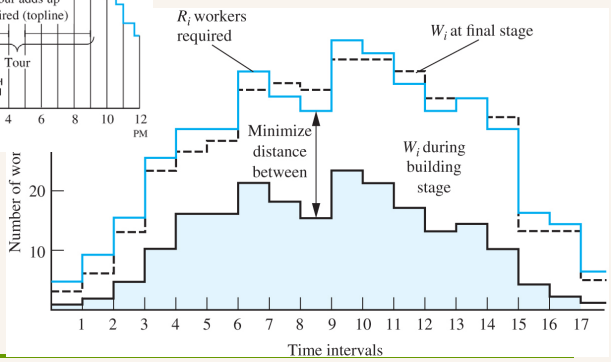


Total cost per hour = Cost of capacity per hour + Cost of Waiting Time

23

Work Shift Scheduling





24

Cross-training & Part-time Employees

Training employees to be able to do different tasks

- Demand peaks: Each employee performs his specialized work (e.g., cashier in a supermarket) 尖峰時集中服務顧客
- Low demand: Employee performs additional tasks: Job is enlarged (e.g., filling the shelves in a supermarket) 離峰時後勤工作

Using part-time employees

- When demand peaks can be foreseen: Additional staff can be employed for these times (e.g., X'mas) 季節性需求
- Skills needed low: Students can be taken (e.g., bakery) 訓練容易

Customer Participation

Objectives:

- Cost reduction (less personnel is needed) 節省人力
- Capacity becomes more "variable", according to demand

Disadvantages:

- Customer expects quicker service 要讓顧客覺得有利
- Customer expects low prices (compensation for his help)
- Quality of customers "work" cannot be controlled (e.g., customer can leave his waste on the table) 顧客不遵守指示

服務業與規模經濟

- 服務業多以連鎖店來擴充規模，並可大量採購以降低成本
- 旅行社常大量購買航空公司機位或旅館房間，以獲得降價優惠或追加佣金。

- 連鎖店經營可分直營、自願加盟、特許加盟
- 加盟者可能經營不善或不遵守總部規範
- 總部可能擴充過快或缺乏產品研發能力

27

Conclusion

- 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
- 產能擴充需考量時機、幅度、方式
- 評估economies of scale的利弊
- 以財務成本觀念來評估不同的產能選擇
- 服務業產能特性與規劃方式不同於製造業，且影響服務品質

28