**Topic 8 : Capacity Planning**

Overview

The capacity of a facility is the number of units that can be produced at a given time. The objective of planning a capacity is it must be able to achieve maximization utilization and providing a high return on the investment. It must be of an optimal size.

Learning Outcomes

By the end of this topic, you will be able to:

1. design the capacity for effective use.
2. able to manage problems related to bottleneck issues in the production facility.
3. explain the breakeven analysis and the breakeven points in terms of volume and dollars.
4. make responses to bring about reducing risks through incremental changes.

Introduction

8.1 Capacity planning is dependent on three basis: for short term, intermediate term or long

term.

8.2 The concept of design and effective capacity but its efficiency is dependent on its usage

and quality factors.

8.3 Demand and capacity management in the service sector

8.4 Constraints/bottlenecks analysis and the Theory of Constraints.

8.5 Breakeven analysis of capacity for achieving profitability.

8.6 Reducing risk and incremental changes.

**Lecture Notes**

**8. Capacity Planning**

The capacity of a facility is defined as the number of units that can be produced in a given time. It is also referred to as the “throughput” of the production facility.

The objective in capacity planning is to achieve high level of utilisation and a high return on investment. This means that the production facility is able to meet the demands of the market. Too big a facility than the expected demand will add cost to maintenance and of course increase the production cost. If it is too small, customers will be lost because of incapacity to accept more orders or sudden increase in demand of products. Once the capacity is decided it is possible to determine the capital requirement to establish the facility.

Capacity planning is based on three time horizons:

1. In the short term (up to 3 months), the concern is scheduling jobs and people and locating

of machines. Modifying capacity is difficult because of constraint in existing capacity.

2. In the intermediate range (3 to 18 months) it is possible to add equipment, personnel and

shifts or subcontract and build or use inventory.

3. In the long term (greater than 1 year), the concern is to add facilities and equipment that

have a long lead time.

**Options for Adjusting Capacity**

**Time horizon**

Long-range planning Add facilities \*

(> 1 year) Add long lead time equipment

Intermediate-range planning Subcontract Add personnel

(aggregate planning) Add equipment Build or use inventory

(3 to 18 months) Add shifts

Short-range planning Schedule jobs

(Up to 3 months) \* Schedule personnel

Allocate machinery

Modify capacity Use capacity

\* Difficult to adjust capacity as limited options exist

**Design and Effective Capacity**

***Design capacity*** – the *maximum* theoretical output of a system in a given period under ideal condition. It is normally expressed as a rate, such as the number of tons of material to be produced in a week, a month or per year. Other organisations may use total work time available as a measure of overall capacity.

Most firms operate their facilities at a rate less than the design capacity. This is a way to operate more efficiently when their resources are stretched to the limit. For example: A restaurant has set its tables and chairs for 270 people. The tables are set with 2 or 4 guests. But the tables are never filled that way. There are always unused chairs. The *effective capacity* is often close to 220, which is 81% of design capacity.

***Effective capacity*** is the capacity a firm expects to achieve given the current operating constraints such as product mix, methods of scheduling, maintenance and standards of quality. It is often lower than the design capacity.

Two measures of system performance are particularly useful: utilization and efficiency.

Utilization = actual output/design capacity (% of design capacity actually achieved).

Efficiency = actual output/effective capacity (% of effective capacity actually achieved).

A bakery has a plant for processing breakfast rolls and wants to better understand its capability.

Determine the design capacity, utilization and efficiency for this plant when producing this

breakfast roll.

Data available:

Last week the facility produced 148,000 rolls. The *effective capacity* is 175,000 rolls. The

production line operates 7 days per week, with three 8-hour shifts per day. The line was

designed to process the nut-filled, cinnamon-flavoured roll at a rate of 1,200 per hour. The

firm first computes the design capacity and then used equation to determine utilization and

equation to determine efficiency.

Solutions:

Design capacity = (7 days x 3 shifts x 8 hours) x (1,200 rolls per hour) = 201,600 rolls

Effective capacity = 175,000 rolls

Actual output = 148,000 rolls per week

Utilization = Actual output/Design capacity = 148,000/201,600 = 73.4%

Efficiency = Actual output/Effective capacity = 148,000/175,000 = 84.6%

If the actual output is 150,000 rolls, what is the efficiency?

Efficiency = 150,000/175,000 = 85.7%

Depending on how facilities are used and managed, it may be difficult or impossible to reach 100% efficiency. Operations managers tend to be evaluated on efficiency. The key to improving efficiency is in correcting quality problems and in effective scheduling, training, and maintenance.

Note:

With a knowledge of effective capacity and efficiency, a manager is able to find the expected output of a facility.

This is because:

Actual (or Expected) output = (Effective capacity) (Efficiency)

(Actual/Expected output is also known as *rated capacity*.)

If the effective capacity of the bakery is 175,000 rolls and its efficiency is expected to be 75%, then its expected output = 175,000 x 0.75 = 131,250 rolls.

The sales department can now be told the expected output is 131,250 rolls.

After one month of training, the crew on the production line is expected to perform at 80%

efficiency. The expected output = 175,000 x 0.8 = 140,000 rolls.

If the expected output is inadequate, additional capacity may be needed. We will be examining how this can be done.

*Capacity and Strategy*

Changes in capacity of operation will affect many elements in the organisation such as marketing and finance, quality, supply chain, human resource and maintenance and as a consequence the strategy of the organisation and its competitive position.

*Capacity Considerations*

Four special considerations for a good capacity decision:

1. Forecast demand accurately.
2. Understand the technology and capacity increments.
3. Find the optimum operating size (volume).
4. Build for change.

*Managing Demand*

Even with good forecasting and facilities built to that forecast, there may be a poor match between the actual demand that occurs and available capacity. A poor match may mean demand exceeds capacity or capacity exceeds demand. What are the options available for the firm?

*Demand exceeds capacity*

When this occurs the firm can curtain demand by raising prices, scheduling long lead times and discouraging marginally profitable business.

*Capacity exceeds demand*

When this situation occurs, the firm may want to stimulate demand by price reduction or aggressive marketing or accommodate the market through product changes. In the worsening situation where demand continues to decline, there may be layoffs and plant closing to bring capacity in line with the demand.

*Adjusting to seasonal demands*

Management may offer products with complementary demand patterns i.e. products for which the demand is high for one when low for the other. With appropriate complementing of products, perhaps the utilization of facility, equipment and personnel can be smoothed.

*Tactics for matching capacity to demand*

1. Making staffing changes (increasing or decreasing the number of employees or shifts).
2. Adjusting equipment (purchasing additional machinery or selling or leasing out existing equipment).
3. Improving processes to increase throughput.
4. Redesigning products to facilitate more throughputs.
5. Adding process flexibility to better meet changing product preferences.
6. Closing facilities.

The above can be used to adjust demand to existing facilities.

***Demand and Capacity Management in the service Sector***

In the service sector, scheduling customers is *demand management* and scheduling the workforce is *capacity management*.

*Demand management* - where demand and capacity are fairly well matched, demand management can be handled with appointment, reservations or a first-come, first-served rule.

In some businesses, such as doctors and lawyers’ offices, an appointment system is the schedule and is adequate.

Reservations systems, work well in rental car agencies, hotels and some restaurants as a means of minimizing customer waiting time and avoiding disappointment over unfilled service.

In retail shops, a post office, or a fast-food restaurant, a first-come, first-served rule for serving customers may suffice. Each industry develops its own approaches to matching demand and capacity. Other more aggressive approaches to demand management include many variations of discounts: “early birds” specials in restaurants, discounts for matinee performances or for seats at odd hours on an airline, and cheap weekend phone calls.

*Capacity management* - when managing demand is not feasible, then managing capacity through changes in full-time, temporary, or part-time staff may be an option. This is the approach to many services. For instance, hospitals may find capacity limited by a shortage of board-certified radiologists willing to cover the graveyard shifts. Getting fast and reliable radiology readings can illustrate, when an overnight reading is required (and 40% of CT scans are done between 8 pm and 8 am), the image can be sent by e-mail to a doctor in Europe or Australia for immediate analysis.

**Constraint/Bottlenecks Analysis and the Theory of Constraints**

The role of a constraint or bottleneck

A bottleneck is an operation that is the limiting factor or constraint. The term bottleneck refers to the literal neck of a bottle that constrains flow, or, in the case of a production system, constraints throughput.

A bottleneck has the lowest effective capacity of any operation in the system and thus limits the system’s output.

Bottlenecks occur in all facets of life - from job shops where a machine is constraining the work flow to highway traffic where two lanes converge into one inadequate lane, resulting in traffic congestion.

For example the constraint in a hospital for delivering more babies was availability of hospital beds. The long term solution to this bottleneck was to add capacity via a 4-year construction project. But the hospital staff sought an immediate way to increase capacity of the bottleneck. The solution: If a woman is ready for discharge and cannot be picked up prior to 5 pm, staffers drive home the woman and her baby. Not only does this free up a bed for the next patient, it also creates good will.

*Process Time for Stations, Systems and Cycles*

Three situations are important to analyse production system capacity:

1. Process time of a station - it is the time to produce a given number of units (or a batch of units) at that workstation. E.g. if 60 windshields on a Ford assembly line can be installed in 30 minutes, then the process time is 0.5 minutes per windshield. Therefore in one hour, 120 windshields should be installed.

2. Process time of a system – it is the time of the longest process (the slowest work station)

in the system. It is defined as the process time of the bottleneck.

3. Process cycle time – it is the time it takes for a unit of product, such as a car, to go through

the entire empty system, from start to finish.

Note:

The process time of a system and the process cycle time are quite different. It may take Ford to roll out a new every minute from the assembly line i.e. the process time of a system. However, it may take 30 hours to make a car from start to finish i.e. the process cycle time. This is because the assembly line has many workstations, with each station contributing to the completed car. From here, it can be seen that the system’s process time determines its capacity (one car per minute) while its process cycle time determines potential ability to build a product (30 hours).

*Theory of Constraints (TOC)* - a body of knowledge that deals with anything that limits an organisation’s ability to achieve its goals. (It is taken from the book The Goal: A Process of Ongoing Improvement, by Goldratt and Cox, 2004.)

*Constraints refer to physical (e.g. process or personnel availability, raw materials or supplies) or non-physical (e.g. procedures, morale, and training).*

Suggested steps to overcome constraints:

Step 1: Identify the constraints

Step 2: Develop a plan for overcoming the identified constraints.

Step 3: Focus resources on accomplishing Step 2.

Step 4: Reduce the effects of the constraints by offloading work or by expanding capability.

Make sure that the constraints are recognized by all those who can have an impact on

them.

Step 5: When one set of constraint is overcome, go back to Step 1 and identify new

constraints.

*Bottleneck Management*

A critical constraint in any system is the bottleneck and managers must focus significant attention on it. Four principles of bottleneck management:

1. Release work orders to the system at the pace set by the bottleneck’s capacity.
2. Lost time at the bottleneck represents lost capacity for the whole system.
3. Increasing the capacity of a non-bottleneck station is a mirage.
4. Increasing the capacity of the bottleneck increases capacity for the whole system.

Ways to overcome a bottleneck

1. Synchronising the process time of one station with another.
2. Making possible the availability of the process or personality
3. Ensuring the availability of raw materials or supplies.
4. Having procedures, morale and training.
5. Increasing the capacity of the bottleneck.

*Breakeven Analysis (BEA)*

It is the critical tool for determining the capacity a facility must have to achieve profitability.

The objective of the BEA is to find the point in dollars and units, at which costs equal revenue.

Total fixed cost

Breakeven point (BEP) in units = units

Price/unit – Variable cost/unit

Total fixed cost

Breakeven point (BEP) in dollars =

1 – Variable cost/Selling price

Total revenue line

Total cost line

*Profit*

*corridor*

Cost

*Breakeven point:*

*Total cost = Total revenue*

*Variable cost*

*Loss*

*Corridor*

*Fixed cost*

Volume

For multiproduct case

Most firms have a variety of offerings. Each offering may have a different selling price and variable cost. For breakeven analysis, the equation to reflect the proportion of sales for each product is:

Fixed Cost

Breakeven point in dollars (BEPs) =

Vi

1 - x (Wi)

Pi

where v = variable cost per unit

P = price per unit

W = percent each product is of total dollar sales

i = each product

***Reducing Risk with Incremental Changes***

Forecasting demand for goods and services become difficult when factors (technology, competitors, building restrictions, cost of capital, human resource options and regulations) determining the breakeven point and capacity requirement start to change. This situation of uncertainty is further compounded by small demand growth and where capacity additions are sudden and in large units. The state of uncertainty in fact increases the risk in decision making. One way to reduce the risk is to bring about incremental changes to the changing demand in order to bring about increasing the capacity requirement.

There are three possible approaches to new capacity:

1. Leading strategy – acquire capacity to stay ahead of demand (time) at the beginning of a period. As the demand increases acquire more capacity at the beginning of the next period. This is repeated at each period.
2. Lag strategy – use overtime or subcontract to accommodate excess demand.
3. Straddle strategy – building capacity that is ‘average’, sometimes lagging demand and sometimes leading it. Both lag and straddle option have the advantage of delaying capital expenditure.

1. Leading Strategy 2. Lag Strategy 3. Straddle Strategy

Expected Expected

demand demand

Expected New

Demand New demand New capacity

capacity capacity

Time (Period)

**Applying Investment Analysis to Strategy-Driven Investments**

* Investment, variable cost and cash flow
* Net Present Value