ECONOMICS OF PRODUCTION (EC0 424)

LECTURE NOTE

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Definition of production: is the process where firm combine various factor input to produce value for consumption. The process ends when it creates value for the final consumer. It is an act of creating output that can be a good or service which add utility value to economic unit. Production process creates what I known as economic wellbeing.

Economic wellbeing: it means economic activities that aim directly or indirectly to satisfy human wants and needs. The degrees at which means are satisfied is relative.

There are three major forms of production process

i. Market production
ii. Public production
iii. Household production

Market production: is the production process which creates and distribute income to stakeholders. Public and household production: are financed by the income generated from market production. Market production is a two edge sword in creating that is the role of producing goods and services and the role of creating income. Market production is known as Primus motor. It is the primus motor of economic wellbeing.

In principle there are two major activities in economy

Production and Consumption

There are two major actors

Producers and Consumer

Wellbeing is possible by efficient production and can lead to effective interaction between producers and consumers.

The consumers can be grouped into two

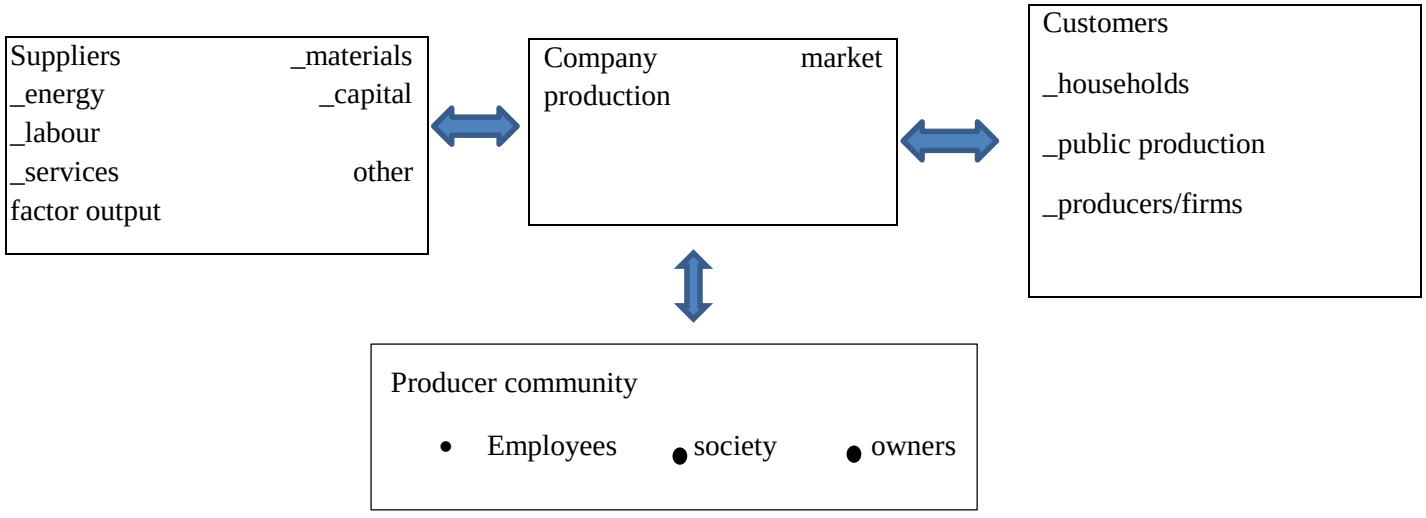
1. They can be consumers to the producers
2. They can be suppliers to the producers

STAKEHOLDERS OF PRODUCTION

They are persons, groups and organization with an interest in producing company. They are economic actors which have economic interest in the company. Either the company satisfies their utility, or they buy factor input from them or they are making profit.

They can be classified into three

1. Consumers 2. Suppliers 3. Producers



MAIN PROCESS OF A PRODUCING COMPANY

It explains a sub process in different ways with logic, objectives, theories and key figures of its own. The main processes of a company are as follows;

_ Red process

_ Income distribution process

_ Production process

_ monetary process

_ Market value process

1. **Real process**: production output is created in the real process from input by employing various production functions. It refers to series of event in production in which production input of different quality and quantity are combined into product of different quality and quantity.

2. **Income distribution process**: It refers to series of output which the unit prices of constant quality product and input alters causing a change in income distribution among those involved in the exchange.
3. Production process: it consists of real process. The probability of production is a share of the real process result the owner has been able to keep to himself in the income distribution process. Factors determining the production process are the component of probability which is the revenue and cost.
4. Monetary process: it refers to the event related in financing the business. There are 2 ways a company can source for and either through equity or debt.
5. Market value process: refers to series of event in which investors determine the market value of the company investment market.

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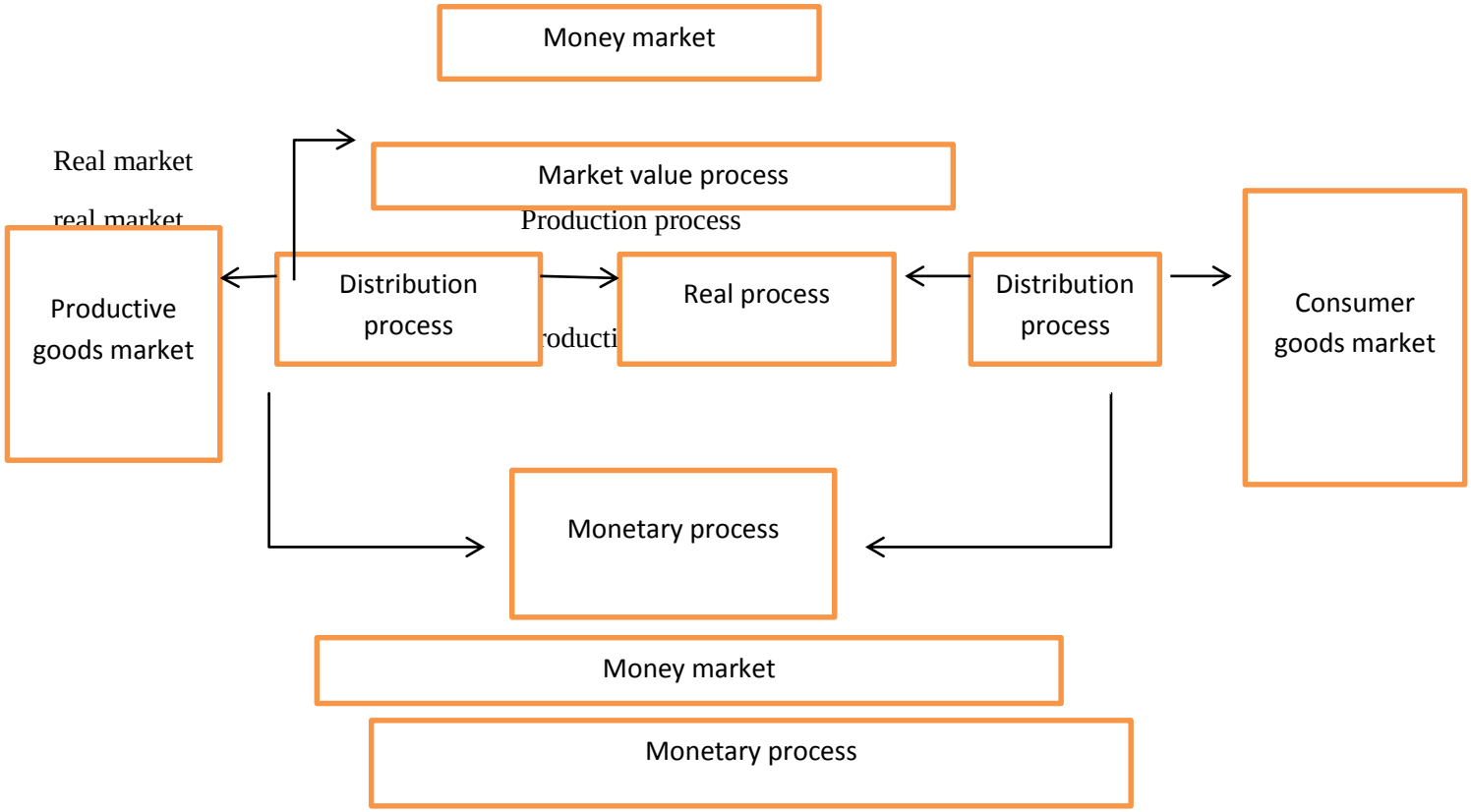


Main process of a producing company (saari 2006,3)

Production growth and performance

Production growth is defined as an increase in the production process. It is usually expressed as a percentage (%) of a real output produce. Real output is the value of product in the production process.

Real income= Real output – Real input

Real output and input is been generated by real process of production

Linear production function

The movement from I_1 to I_2 leads to 2 growth. g_1 is growth caused by increase of output volume while g_0 is growth caused by productivity increase. It is also known as **production volume**. The increase is determined by moving along the initial production function (isoquant$_1$ (I_1). Income growth caused by increase in productivity is caused by a shift to Isoquant$_2$ (I_2). Whenever we want to maximize the production performance, we have to maximize the income caused by the production function.

Productivity growth is one of the main economic indicators of innovation. Income growth or productivity growth can also take place without innovation supply by replicating the existing technologies.

Production models/functions

Production model is a numerical description of the production process based on the prices and the quality of input and output. Production function can be presented by 2 main approaches

i. Mathematical formula
ii. Arithmetic model

We use mathematical formula mostly in macroeconomics and arithmetic models are used in microeconomics and most accounting. Most of the mathematical formula we are used to are homogenous production function.

Homogenous of degree K

Where $f(tx_1, tx_2)= t^k(x_1, x_2)$

If K>1= increasing return to scale

K=1= constant return to scale

K<1= decreasing return to scale

We also have the Cobb Douglas production function

CDP_f:$q= Ax_1^{\alpha}, x_2^{1-\alpha}$

$f(tx_1, tx_2)=A[(tx_2)^{\alpha}(tx_2)^{1-\alpha}]$

$=t(Ax_1^{\alpha}x_2^{1-\alpha})$

Here K=1

Therefore CDP_f is homogenous of degree 1: a constant return to scale

Another production function is constant elasticity of substitution

CES: $q= A(\alpha x_1^{-p}+(1-\alpha)x_2^{-p})^{-1`/p}$

Where $A>0$, $0<\alpha<1$

A generalized CES;

$q=B(\alpha x_1^{-p}+(1-\alpha)x_2^{-p})^{-k/p}$

Where $x_1\ x_2>0$;B, α, K are positive and homogenous of degree K

The generalized CES included the homogeneity of degree K that is just different between it α constant elasticity of substitution.

Arithmetic model

They are easily understood and applied in practice major advantage of the arithmetic model is it capability to depict production function as a part of production process. So we will use 2 types of arithmetic models to explain the production function.

i. Production income model
ii. Production analysis model

i. **Production income model**: According to saari(2006)

PRODUCTION INCOME MODEL

Period 1 Period 2

	1	2	3	4	5	6	7
Output	Quantity	Price	Value	Quantity	Price	Value	Q_1P_2
Product 1	210	7.20	1512	247.25	7.10	1755	1491
Product 2	200	7.00	1400	195.03	7.15	1394	1430
Total output			2912			3150	2921
Inputs	Quantity	Price	Value	Quantity	Price	Value	Q_1P_2
Labour	100	7.50	750	115	7.7	886	770
Materials	80	8.60	688	79.2	8.5	673	680
Energy	400	1.50	600	428	1.55	663	620
Capital	160	380	608	164.8	3.9	643	624
Total input			2646			2865	2694
Surplus value(Abs)			266			285.12	227
Surplus value(Rel)			1.101			1.100	

NB. Sv(abs)= output value-input value

Sv(rel)= output value

Input value

The success of this model is the ability to produce surplus value which is the criteria of probability. Surplus value refers to the difference between returns and production process. The starting point is a profitability calculation using surplus value as a criterion of its profitability. The surplus value calculation assists to understand the connection between profitability and productivity or real process and production process. Before the process of calculation is understood , apply the terms **ceten's paribus.** Stating that at a time, only the impact of one changing factor introduced is been examined; therefore, the calculation is a process presenting a step by step method first, the impact of the income distribution process are calculated and then the impact of the real process of the profitability of yhe production.

The first stage of the calculation is to separate the impact of the real process and the income distribution process respectively from the change in profitability.

$\Delta \pi = Sv_{a2} - Sv_{a1}$

=285.12-

$\Delta \pi = 19.12$

Column 3 and 7 depict the impact of change in income distribution process on the profitability.

- Change of distribution in absolute value will be the surplus value of column 7- Sv of column 3= -39
- Distribution index of output = total output of column 7/ Total output of column 3=1.003
- Distribution index of output = total output of column 7/ total input of column 3= 1.018
- Distribution index=distribution index of output =0.985

Distribution index of input

Production process

1. **Productivity** = Total output of column 7/Total input of column 7= 1.084

Productivity = Total output of column 6/ Total input of column 6= 1.10

2. **Productivity index** = productivity 2/ productivity 1= 1.014
3. **Change of productivity (in absolute value)** = (product index – 1) * output of column = 41
4. **Volume index of output**= output of column 6
   Output of column 7
5. **Change of input volume (in absolute value)**= (volume index of input – 1)* (surplus value in column 7 * productivity in abs value)

Volume index of input = input of column 6 = 1.063
Input of column 7
(1.063 -1)* (227 +41.12)
=16.89 ≈17

6. **Change of productivity** = Sv in rel. value of column 6
   Sv in rel. value of column 3
   = 1.1 = 0.999
   1.101
7. **Change of returns** = output of column 6 = 3150 = 1.082
   Output of column 3 2912
8. **Change of cost** = input of column 6 = 1.083
   Input of column 3

The accounting results are easily interpreted when compared to modeling. The real income has increased by 58.12 i.e. 41.12 + 17. The total increase of real income (58.12) is distributed to the stakeholders of production. In this case 39.00 unit to the customers and the remaining 19.12 to the owners. This kind of production is on the path of

increase returns on production function the condition where productivity * production volume increases or productivity * production volume decreases.

On the other hand, on the path of diminishing returns in production function is when productivity increases and volume decrease. The volume growth is been represented by change of input volume in abs terms (17) while productivity growth is change of productivity in abs value (41.12).

Project network analysis

In organization they are frequently engaged in large complex operation or project and this requires many different steps of operation to be performed in other to finish the project. Introduction of new project is a good example of a complex project since it requires many operational processes such as R & D, product testing marketing, design and package design. The job of planning and controlling project becomes difficult. A major question a manager will ask focus around 2 completion of the production. Since many variable affect the time of completion of production, it's very important to have a mechanism or decision making aid to assist in answering such question as ,when is the appropriate time to complete the production? In a case where operation takes longer than expected, what effect will this have on the overall completion of the production?, what is the probability of completing the project by the scheduled date? If there are additional funds that can be spot to reduce the time to perform certain operation and how should they be spend on each operation?

To be able to answer these questions we employ two techniques or methodology for planning and control of project implementation. They are, programs evaluation and review techniques (PERT), critical path method (CPM). PERT and CPM facilitate the basic function of planning, scheduling and control. The planning phase separate an entire project into a well-defined list of associated job e.g. each job is further specified by clearly defined requirement for materials, manpower and equipment. These are accompanied by associated estimate of time and cost.

The scheduling phase is concerned with arranging the well-defined jobs into a time sequence of performance.

The control phase focuses on the review analysis and adaptive correction for difference between schedule and actual performance.

Benefits of PERT and CPM

1. They provide management in the clear definition of time, cost and resource requirement and operational network that relate all activities in a time dimension and a method for pin pointing critical sub-critical.
2. They provide management math a tool to isolate and minimize potential trouble areas it is a tool to reduce bottle necks, interruptions, conflict and delays.
3. To provide a systematic means for better coordinating and synchronizing of the component path of the large project.
4. They also facilitate communication, coordination and cooperation of divers project team effort.
5. They keep management informed as to where they are and where they used to be.
6. They facilitate a smooth, coordinated or time completion of mostly vast complex or 1 time project.

Application of networking models is used in production and many other areas of activities.

Fundamental concepts of network analysis

1. **Project:** This is a set of task, job or activities that are related to the achievement of certain goals. The activities are related in a logical sequence called **Dependency Rule**.
2. **Activity:** This is the early portion of a project that consumes time, effort or resources and has a definite beginning and a definite end. It include paper work, machineries etc. And it is been represented by →or ∩ and activity can be denoted by capital letters A, B, C, D or natural numbers 1,2,3,4.
3. **Events:** this is any point in time indicating the beginning or end of an activity. It is usually represented by O. It is also called a node. Event showing the beginning of activity is called the tail event while an event showing the end of activity is called the head event.
4. **Network:** This is a graphical representation of a project showing the interrelation between various activities. It is a diagram showing the inter-dependency and precedence relationship. It is called the arrow diagram or activity on arc (AOA) diagram.

5. **Project scheduling:** This is a management science that deals with the order of sequence of performing the activities of a project so as to optimize resource and time.

Steps involved in construction of network diagram

1. No activity can begin until all activities preceding it are completed.
2. Two events can be directly connected by at most 7 activities.
3. The network should have only one event and only one terminal event.
4. The network is a progression of activities is moving on used in time.
5. The length of the arrow does not have any significance, it only implies precedence.

Critical path method (CPM): CPM is a technique of project for determining the minimum completion time of a point. It makes use of only 1 duration estimate and as such it is deterministic in nature.

E.g. construct a network for the production process below

Activity	**Immediate predecessor**	**Duration (day)**
A	_____	35
B	_____	21
C	A	35
D	A	42
E	B	14
F	C,E	70
G	C,E	77
H	F	21
I	D,G	14

Note:

Initial activity is A and B

Terminal activity H and I

Path A → D → I

A → C → G → I

A → C → F → H

B → E → F → H

B → E → G → I

5 Critical Path

E.g. 2 Draw the activity of the project below

Develop a cpm and identify the critical path

Solution

Draw the activity on arc diagram for the project below

Predecessor Events (weeks)	Successor event	Time estimate
1	2	12
1	3	20
2	4	20
3	4	24
3	5	12
4	5	28
4	6	12
4	7	20
6	7	0
5	8	20
7	8	8

Note: Activity can't start until an event is completed

Dummy activity (DA): is an activity that was not originally part of the project but was only produced to help attain the logical

Activity	Immediate predecessors	Duration [weeks]
A	———	13
B	A	13
C	A	13
D	C	15
E	B,C	16
F	D,E	19
G	E	15
H	G	13
I	G,F	15
J	I,H	16
K	J	14

dependency among activities. A DA is used when two or more parallel independent activities have the same head or tail to ensure that identities of activities are not lost so we use broken arrow or dot and the duration is always(D).

Critical path (CP): this is a path in network that consists of all activity that will lead to the completion of project on schedule. Any delay along this path will lead to delay in the completion of the project.

Note:

1. There may be more than one critical path in a network
2. A CP can run through a dummy activity
3. The duration of the CP is equivalent to the expected minimum completion of the project
4. The duration of the CP=either the earliest or latest event of the terminal event

Basic time estimate of CP

A. **Event times**

i. Ei-represent the earliest event time schedule commence or completion of the event

ii. Li-represent the latest event time

iii. Si –represent slack time ;it is the difference between L1-E1≥0

B. **Activities time**

The head and the tail event can be considered to fixed boundaries between which activity can move, this movement can be described by four different activity time systems.

i. Ei-represent earliest start time it is the earliest possible time by which an activity can start. It is given as the earliest event time of the tail event of the activity.

ii. Ej –represent earliest finish time, it is the earliest possible time by which an activity can finish. It is given as the duration of the activity plus its earliest start time. Ej =Ei +Dj

iii. Li- represent latest finish time, it is the latest possible time by which an activity can finish, it is given as the latest event time of the head event.

iv. Lj: latest start time; it is the latest possible time by which an activity can start. It is given as the latest event time of the head event –duration of the activity. Lj=Li-Dij.

*The CP is determined based on the following computation

1. Forward pass (FP): it is the computation of the earliest event time E1 for the initial event, E1=0, for the subsequent event the FP=earliest time event of the tail event plus duration of the activity. This is the earliest finish time of the activity.

Note: when two or more activities terminate in an event then the FP of that event is the maximum of the earliest finish time of all the activities FP is using represented in a rectangular box above the event under consideration.

2. Backward pass (BP): it is the computation of the latest event time and it is as follows. So starting with the terminate event set it's BP=FP. For other preceding event BP=BP of the head event of the activity –the duration of the activity leading to that event.
   Note: where there are two or more activities emanating from an event, the BP of such event is the minimum of the BP of all the activities emanating from it.
3. Total slack float: this is equal to the BP of the head event –the FP of the tail event-duration of the activity. When the total of an activity is zero (0) such an activity is a critical activity or bottle neck activity and the critical path is said to pass through such activity. The existence of a float or slack in network indicate that the resources available for the performance of an activity have not fully utilize Lj-Ei-Dij

Types of float

- Total float: this is the time by which an activity can be extended without changing the total project duration Ts1=L1-E1-Dij
- Independence float :this is the time by which an activity can expand without affecting without affecting other activity either precious or subsequent ID1=E1-L1-Dij
- Free float: this is the time by which can activity can expand without affecting subsequent activity. This is obtained as earliest event time of the head event – the earliest event time of the fail event- duration of the activity F1=Ej-Ei-Dij
- Fluid float; this is the time lag between two activities. It also represents the slackness in an activity.

INVENTORY CONTROL AND PRODUCTION MODELS

Inventory is any resources that has valve to satisfy future need. Inventory can be in form of raw material, it can be work in process, it can be a finished goods, it can be loose tools, it can be consumables, it can be human, physical or financial resource. An inventory manger is faced with the following problems;

1. Inventory planning: decision has to store or produce, where to buy it, the best means of transport and storage and inspection.
2. Inventory control: it is concerned with the decision of when to order or produce, how much to order or produce and what kind of material control to adopt.

The Inventory problems focused on the selection of the decision variables

1. Recorder variables.
2. Recorder quantity.
   The criterion of selecting this variable is minimization of total Inventory related cost.

PURPOSE OF HOLDING STOCK

1. To ensure goods are available to meet anticipated demand.
2. To act as a goffer when there is unusual high rate of dd over anticipation.
3. To take advantage of seasonal and other price fluctuation.
4. To take advantage of quantity discount by purchasing items in bulk.

Categories of Inventory cost

1. **Total critical cost(TC):** TC=C+H+St+Paem

   Where C= ordering cost

   H=carrying or holding cost

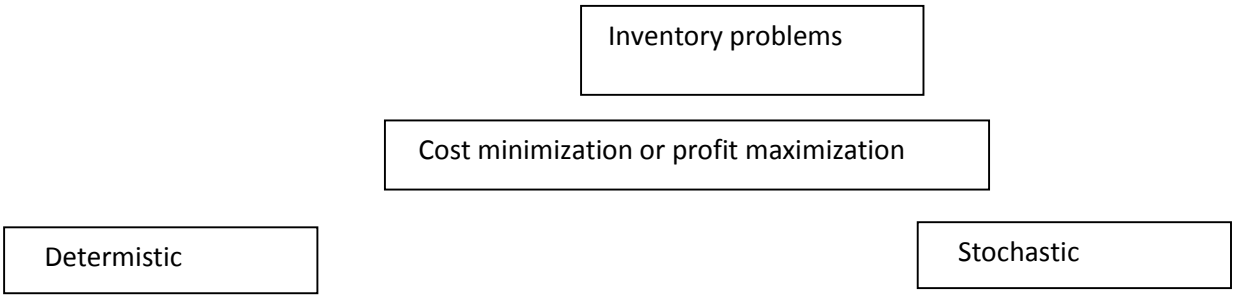
   St= stock out cost

   Pd= cost of inventory

Pd-Inventory cost: this represent the actual purchase of items placed in inventory.

- Ordering or setup cost: these are the cost in making the stock item available in the present location. If the goods are purchased from outside supplies those cost are called ordering cost. If on the other hand it is produced in the company, it is referred to as setup cost. The total annual setup cost increases as the number of orders or production increases.
- Carrying or holding cost: this is incurred in the process of keeping an item of inventory in the store. It also includes cost of capital tired up in the store, insurance premium on stock item and obsolesces , d cost of breakage, presage, cooling cost, depreciation of bio can tags and protection. The selection of the reorder level will also increase carrying cost.
- **STOCK OUT COST:** This is incurred when the customer demand cannot be fulfilled because the inventory is completely depleted.

CLASSIFICATION OF INVENTORY PROBLEMS



The Deterministic Model

The basic problem of inventory model is characterized by determistic demand with uniform depleted, fixed load time and infinite production rate. The major inventory decision is to determine the economics order quantity (EOQ) that will minimize inventory circle cost which include cost of inventory. If items are produced instead of been purchased, the basic deterministic inventory system is easily converted to the deterministic production run system.

During the production process the carrying cost is included in the EOQ. The Rl which is the record level is a gain to the dd during the lead time Lt. The order Q is received from the supplier at the end of the lead time. The inventory is depleted at a constant rate until the Rl has been reached and as at that time the order for Q item is placed with anticipation with end of the lead time the basic objective is to determine the opinion value of EOQ and Rl that minimize I related cost.

DERIVATION OF OPTIMAL ORDER QUANTITY

1. **What is EOQ:** It is the reordered quantity that maximizes all the inventory related optimally.

Elements in EOQ

D = annual demand

Q = reordered quantity per order.

C = ordering.

H = holding / carrying cost per unit.

Q/2 = Average stock.

D/2 = no of order per annum.

Pd = Purchased cost.

1. For total holding cost (THC) = $\frac{QH}{2}$. ……(1)
2. For total ordering cost (TOC) = $\frac{DC}{Q}$. ……(2)
3. Purchased cost = THC
4. Total inventory cost TC = pd+ $\frac{Dc}{Q}+\frac{QH}{2}$ ……

Differentiate eqn 3 with respect to Q

$TC = Pd\ DCQ^{-1} + \frac{1}{2}QH$

$d\frac{Tc}{dQ} = DCQ^{-2}+\frac{H}{2} = 0$

$\frac{1}{2}H - \frac{DC}{Q2} = 0$

$\frac{H}{2}=\frac{DC}{Q2}$

$Q^2H = 2DC$

$Q^2 = 2\frac{DC}{H}$

$Q=\sqrt{\frac{2DC}{H}} \longrightarrow$ EOQ

Note: if the cost is constant differentiation is irrelevant (do not differentiate). In that case, TOC=THC

$\frac{DC}{Q}=\frac{QH}{2}$

$Q=\sqrt{\frac{2DC}{H}}$

Assumption of EOQ

1. The purchase price is known and constant

2. Annual dd for the stock item is known [uniformity in dd throughout the period]

3. The lead time is known and constant [lead time is the time interval when order is initial and the time goods are received in the stock]

4. There is no instantaneous build-up of stock

5. Holding cost per unit is known and constant during the period

6. Stock-out are not allowed [no opening and closing stock]

7. Ordering cost per annum is known and constant

2. **Economic reorder level(Rl):** The Rl represent the point of inventory at which an order is placed on Q item, the period of receiving the order is placed on the lead time. Rl=Lt×Ut

Where Lt=lead time

Ut= daily utilization rate

$U_R = \frac{Annual\ dd}{No.\ of\ days}$

Example: 1

The following order quantity information is available for JR's fashion house. dd for the next 4 months is 2880 units the lead time is 8 days, the ordering cost is 96, the annual carrying cost per unit is her working days per year is 320. You are required to determine the optimum value for the inventory policy decision variable i.e. EOQ and Rl

Answer

1. Annual dd= $\frac{2880}{4} \times 12 = 8640$

EOQ= $\sqrt{\frac{2DC}{H}}$

=$\sqrt{\frac{2\times8640\times96}{24}}$

=$\sqrt{\frac{1658880}{24}}$ =$\sqrt{}69120$=262.91 ≈263

2. (a)No. of order per year = $\frac{D}{Q} = \frac{8640}{263}$= 32.8 ≈ 33 units

(b) Time gap of ordering = $\frac{No.\ of\ days\ in\ a\ year}{No.\ of\ orders\ in\ a\ year} = \frac{320}{33}$= 9.6 ≈10 days

(c) Usage per day = $\frac{EOQ}{time\ gap}$ = 26.3 ≈ 26 unit

Rl = usage per day × lead time = 26×8 = 208 unit

or

2nd method: lead time ×utilization rate

Assignment

Esther venture engineering company uses a chemical at the rate of 5500 per day at a price of ₦19.10K per barrel the company uses the chemical at the rate of 2200 barrel per day, and 550000 barrels per year and the holding cost of 25% of the price per barrel per year the No. of days is 250 required, calculate the EOQ, TC and Rl using the second method.

EOQ with discount

In reality, most companies buy in bulk and it always attracts discount and definitely discount will affect the price. So, the discount given will determine the best EOQ to be used when we have discount of 3 ranges of quantity he should be able to determine the best in respect to cost e.g.

Kg	Price/Kg
<2500	₦60
2500≤8000	₦59
8000≤20000	₦58

We will calculate the EOQ with the entire price

The annual dd is 40000 Kg per annum, stake holding cost is 20% of price and the ordering cost are based on the discount.

1. I.EOQ = $\sqrt{\frac{2DC}{H}}$ H= $\frac{20}{100} \times 60 = 12$

= $\frac{2\times40000\times60}{12}$

EOQ= 632.46 Kg

EOQ= 632 Kg

II. Ordering cost $= \frac{DC}{EOQ}$

$= \frac{40000 \times 60}{632}$

$= 3747.47$

III. Holding cost $= \frac{QH}{2}$

$= \frac{632 \times 12}{2}$

$= 3792$

IV. Purchase cost (PC) $= 40000 \times 60$

$= 2400000$

V. Total inventory cost = OC +HC +PC = 2407589.47

2. I. EOQ $= \sqrt{\frac{2 \times 40000 \times 60}{11.8}}$ H$= \frac{20}{100} \times 19$

II. HC $= \frac{QH}{2} = \frac{2500 \times 11.8}{2} = 14750$

III. OC $= \frac{DC}{Q} = \frac{40000 \times 60}{2500} = 960$

IV. Pd $= 40000 \times 59 = 2360000$

V Total inventory cost = HC +OC +Pd = 2375710

3. i. $EOQ_3 = \sqrt{\frac{2 \times 40000 \times 60}{11.6}} = 634$ Kg

ii OC$= \frac{DC}{EOQ} = \frac{40000 \times 60}{8000} = 300$

iii HC $= \frac{3000 \times 11.6}{8000} = 46400$

Pd $= 40000 \times 58 = 2320000$

iv Total inventory cost =2366700

The best EOQ is at ₦58/kg

Within 8000kg ≤ 20000kg

PRODUCTION RUN MODEL

It is a situation where the producer produces their input themselves instead of buying. It is a bit by bit production because of the size of the stock.

To determine the EOQ in this case the following must be ascertain;

1. Rate of receipt per day from the factory.
2. The time the whole order will be received.
3. Rate of consumption throughout the period.
4. Maximum quantity is installed at a period.
5. Average inventory in the stock at a period.
6. Set up cost like the ordinary cost.
7. Holding/carrying cost.

During the production period, items are produced at a rate P and demand at a rate D. Inventory will be accumulated at a rate P-D. The duration of the production run is where P $\frac{r}{number\ of\ days}$

r= rate of production per day

The size of the inventory at the end of the production run

$$= \left(\frac{Q}{r1} \times r^2\right)$$

Where $r_2 = \frac{no\ of\ dd\ per\ day}{no\ of\ day\ in\ a\ year}$

During the production period, the inventory level start at zero and accumulate to $Q\left(1 - \frac{r^2}{r^1}\right)$ and the average inventory level would be

$A\downarrow = \frac{1}{2}\left[(Q - \left(\frac{Q}{r^1}\, r^2\right)\right]$

$= \frac{1}{2}[Q\ (1\text{-}\frac{r^2}{r^1})]$

$Hc = \frac{1}{2}\left[Q - \left(\frac{Qr^2}{r^1}\right)\right] + 1$ or $+1\frac{(P-D)Q}{2P}$

Set up cost = $\frac{Dc}{Q}$

Total cost = $\left(\frac{Dc}{Q}\right) + [\frac{1}{2}\left(Q - \left(\frac{Qr^2}{r^1}\right)\right] + 1$

Different T(cost Q and set at 0)

$Q = \sqrt{\frac{2Dc}{1+(1-\frac{r^2}{r^1})}}$

$$TC = \frac{Dc}{Q} + \frac{1+(P-D)Q}{2P}$$

$$\frac{dTC}{dq} = 0$$

$$Q = \sqrt{\frac{2Dc}{H}}\left(\frac{1}{1-\frac{D}{P}}\right)$$

REORDER LEVEL IN PRODUCTION RUN

A lead time is required for planning and set up of production run. During the lead time production will be depleted so enough inventories must be available to prevent what is called stock out.

Reorder level= L_t x usage per day

It is necessary to know the optimal number of production run for a year.