Thank you very much for attending this session.

Today we discuss simulation for break-even analysis

Lets first talk about the deterministic concepts in BEA.

Total fixed costs do not depend on the volume of production.

They are fixed over the time horizon. Usually a year

cost of human resources are fixed; because we cannot hire and fire as soon as production level goes up and down.

The same is for capital resources. We cannot purchase and sell equipment on a daily basis

We cannot rent buildings and terminate our lease on a daily basis.

The same is true for benefits on wages and taxes on properties.

The total fixed costs is fixed. It does not depend of the volume of production.

Fixed cost per unit of product is variable. It depends of the volume of production.

Total variable costs depend on the volume of production.

as we have learned in economics, through diminishing marginal return, and through economy of scale we know that these costs are not linearly related.

Diminishing marginal product

Dinosaur effect

In reality, total variable cost increases by decreasing rate, but after some point it increases by increasing rate.

For simplicity we assume the relationship is linear or can be well estimated by a line.

That means as production goes up or down, the total variable cost will change proportionally.

These are costs of row material, packaging, production water and power supply and so on.

Sometimes in some cost computations we see labor or operator cost is included among the variable costs.

In my belief human resource cost cannot be considered as variable cost because we cannot like

a piece of cheese cut them hide and fire them

when we hire someone we hire him for one year or if not one year maybe six months three months no one can hire people when production goes up and fire the minute goes down

and also in some

in our school of thought we differentiate between inputs and resources

inputs like natural or processed resources, parts, components, energy, are variables

human and capital are resources they are fixed they do not depend on volume of

production

inputs are flow units that go through a network of value-added (processes) and non-value-added (buffers and waiting lines) which are run by human and capital resources under an information infrastructure and become outputs.

we assume production is equal to sale whatever we produce we sell

total variable costs is variable and it linearly depends on the volume of production it means

variable cost per unit of product is fixed

if this is total variable cost then variable cost per unit of product is fixed

we show variable cost V. Total variable cost is V times Q where Q is the volume of production.

we show total fixed costs by F which is fixed and does not depend on the volume of production. But fixed cost per unit of product or F/Q is variable and depends on the volume of production.

the total cost will be summation of the total fixed cost F and the total variable cost VQ.

F+VQ forms the total cost curve.

we assume we do not have market segmentation and we do not have quantity discount

therefore the sales price is fixed and it does not depends on the volume of sales. This is not correct, but it provides good estimate. All of these assumptions could be modified or enhanced in a simulation model that we discuss later.

If price per unit of product is fixed the total revenue is PQ.

we draw our total cost curve we also draw our total revenue curve

we have a loss region and a profit region

the point partitioning them is break even point where we have no profit no loss and the total cost is equal to total revenue

fixed cost plus total variable cost multiplied by q is equal to tal revenue which is p multiplied by q

therefore we can

put those term containing q in one side of equation

and have p minus v here which we also call it contribution margin it is the

rate at which the enterprise brings money in

why it brings money in to recover its fixed costs and generate profit

therefore break-even point is a point in which this volume of production of cells

multiplied by contribution margin is equal to total fixed cost

before this point we are losing money after this point we are making money

now look at this simple example to open the stage for the our discussion one hundred

thousand dollars variable cost per unit of product is twenty dollars sales price

sixty dollars per unit therefore total revenue equal to total

cost 60 q is equal to 100 000

plus 20 cubed therefore 60 minus 20 which is 40 that is our

contribution margin that is the rate at which the enterprise bring money so if we

multiply it by the units of production at break-even point

this should equate our total fixed cost and therefore

quantity at break-even point is 2500 for this specific example if our

marketing department expects demand to exceed 2500 we go for this

it is less than 2500 we don't go around 2500 for example

from 2000 to 3000 we need more information for example if

our marketing department expects that the

demand in future to have a pattern like this

we may go for this investment while we are around break-even point a

little bit higher a little bit lower but if they expect our demand to be

like this then we don't go because future is not bright and while for

example now we could be at 3 000 in future we may go under

2500 and even less and therefore we do not go for this investment

now i want to move from this basic foundation to a situation when

i want to play with probabilities now let's go to excel and conduct a

simulation for this process by simulation i mean

in reality we cannot say fixed cost is one hundred thousand dollars variable

cost is 20 sales price is 60. it may have a distribution around these

numbers for simplicity to start our discussion let's assume

these data have a uniform distribution so they have a lower limit upper limit

and they are uniformly distributed in between those two

for example in our problem fixed cost was 100 000 suppose it is

uniformly distributed between eighty thousand and one hundred and twenty thousand

we said our variable cost is twenty dollars suppose we don't know exactly it is

twenty dollars it can be think between ten and thirty of course ten and thirty is a

little wide estimate but just to show the technique show the approach let's

assume it is between 10 and 30 uniformly distributed suppose price

is uniformly distributed between 40 and 80 instead of being 60

and suppose sales and therefore production is uniformly

distributed between 2000 and six thousand

if that is the case then i know my

fixed cost has a uniform probability distribution it is between 80 000 and 120

000 and i know that in excel and in many computers we have a feature which can

give me a uniform continuous random number

between 0 and 1. in excel if i type run

a number between 0 and 1 will appear there and i can

generate another one another one another one or i can

go down from five to ten thousand and four

now i have ten thousand numbers between zero and one but i don't

want a number between zero and one i want something between eighty thousand and

one hundred and twenty thousand therefore i can come here

in this cell instead of typing land i can type

eighty thousand plus that random number and i lock a3 because

i want to copy down so i put two dollar sign in front of it and then i copy down

now these numbers start from 80 000 but unfortunately they don't go up to

120 000 because if i type max of

these numbers enter if i go there that max is almost eighty thousand and

one not one hundred and twenty thousand now i was able to create a number

between eighty thousand and eighty thousand and one what i need to do

is to make it possible that it goes from a thousand so

if rand is equal to zero zero multiplied by whatever i have

over there is zero but i want when rand is equal to one and this becomes

forty thousand which is the gap between one hundred and twenty thousand and

eighty 000 i want to multiply this one

and log so now

in this cell i have eighty thousand plus the gap between one hundred and

twenty thousand and eighty thousand which is forty thousand times rand

if rand comes out zero the product would be zero zero plum plus

eighty thousand is equal to eighty thousand if rand comes out one

the product would be one times forty thousand which is forty thousand plus eighty thousand would be one hundred and

twenty thousand therefore i was able to create a number

between eighty thousand and one hundred 000 and assume it is my fixed cost and i

can generate 10 000 instances of this number

let me also make it integer just to

reduce the number of decimal points and for this next line i

can do the same here i can say okay you want a number to start from 10

correct lock it because you wanna copy down plus the gap between these two lock it

and this one the gap is 20 and multiply it

by land therefore one instance of variable cost which is

between 10 and 30 will be generated i can come here i say equal to

40 which is the lowest lower limit lock it

plus the gap like it

like it multiplied by land

and this is another instance for price which is between

40 and 80. if you look at all these numbers they are between 40 and

but in order to avoid repeating these computations

let come and copy this here if i copy it here because

this a3 and a4 were locked they are

still locked while i have copied them into the

new column which is column b still i get something between 80 000 and 120

and if i copy this here again that's it because those two were

locked now what i will do i will go here a3 row three i wanna remain row three i

wanna lock it i want it absolute but if i go from column a to column b i want a to become

b therefore i can go and remove this dollar signed in front

of a a now is relative while 3 is absolute and i remove this one and i can

go here and i have to move this one now if i copy this here

a number between 10 and 20 is generated

let me undo and let me undo again

and let me go here i was going to remove dollar sign in front of a what i can do i can push f4

and dollar sign in front of a is gone i can go here f4 don't sign in front of a

is gone and f4 again so now those stars are not done i copy down

then i copy to the right and then i copy it to the right

so now if i go here this refers to column c

this refers to column b obviously that one refers to column a and this one refers to column d

copy these things down okay so now i have 10 000

instances of my fixed cost my valuable cost and

volume of sales now i can compute my profit which is equal to

contribution margin which is the gap between sales price

and variable cost multiplied by quantity of sales

minus fixed cost and that is one instance of my profit

i can create 10 000 instances and as you see

mean max

equal to mean of these numbers

is equal to max of these numbers

so in this probabilistic view my profit

can go from negative 86 000 to positive 300 000

of course i will be very happy to get this much profit

but assuming that i may experience this much

loss it may not convince me to go for this

operation now let me first copy and paste

this results and i paste it by value because i want

to do sorting now these are not formulas they are numbers then i type here equal to

small this array and i lock it because i'm

going to copy down and one the first one but if i copy down

that first the small will be there i can type here one two three

and then i say small instead of one i click on this

and then i copy down now this one is referred to the third the small and i

can get others if i keep a little bit down go up

series to 10 000 10 000

and in column okay and then i can copy down and find the

first the small second the small third is not but then i should have this extra

column so what i will do i will go here i say find the small of

that column then i type rows rows and then i click on this row

column and that row again appears i will go to the first one and make it f4 so it

means it tells me

how many rows are from e5 absolute to e5 relative and obviously

that is one the result is one then i copy down

now and copy down now let's look what is the formula it refers to the same matrix the

same row but says rows from e5 absolute to e7

why because in this formula the second e5 was relative and as i

copied down it becomes e6 and then e7 and so on and

so forth therefore i can find the first small second the small and the last

small number and then here i want to find percentages i type equal to

again i type rows from here

to here but i make the first one absolute so that is 1 divided by

count count from here to here

and i make it absolute right so that would be one divided by ten

thousand and if i copied down the last one would be ten thousand divided by ten thousand

which is ones are my x's these are my y's

i will go here and insert scatter graph

and i choose this one okay so now this is a better

understanding of break-even situation

it tells me there are some possibilities of losing money

and if i type call to count if

countif array this is the array

condition less than zero

okay 20 to 42 and then i divided by count

the numbers that i have and we know number is ten thousand

that's it now i go here and i type equal to

probability of failure

is equal to quotations and

this number and quotation

percentage rotation should have multiplied this one by 100 multiply by 100

probability of failure is 22 percent and i want to put it into the

title so i will go here and i say equal to

click on this one enter go here

equal to and i click on this one enter so in this project

probability of failure is 22 percent which is quiet high

right you may play with this graph and make it now let's see what we did

and try to get some idea about how i can extend it to normal

distribution and also to exponential distribution

this was the situation we had for example regarding the

fixed cost my fixed cost was uniformly distributed

between 80 000 and 120

000 and therefore this height

was 1 divided by forty thousand

because this is forty thousand here and forty thousand multiplied by

uh one over forty thousand is this area which is supposed to be one

okay we had a problem in which i should generate a

number between eighty thousand and one hundred and twenty thousand i know in a

computer or in excel i have something called land that creates

something between zero and one so what i did i said i should go from zero

to eighty thousand so i wrote eighty thousand

plus i should go through um the gap from eighty thousand to one

hundred and twenty thousand so that was forty thousand times that this was my

formula but i could have looked at it in a different way i could have said okay

this is the probability distribution right

this is my probability distribution i want to find a

random number in this range correct how can i find a random number in that

range i know that no matter what that random number is suppose it is u

it will it is associated with this area probability

of x being less than or equal to u is equal to that area

correct okay and what is that area it is

u minus eighty thousand

divided by height and height i just said it is one over forty 000

and what is that probability is equal to u divided by

thousand

and what is this area what is the characteristic of this area

what is the characteristic of this probability what is the most important feature of

this probability the most important feature of this probability it is it is less than or

equal to one or greater than report up to down to greater than or equal to zero it

is in a range between these two between zero and one and if it

wants to be a random value i can assume it is equal to

rand so each round is associated with a

probability as soon as i have that probability i can use that probability and find u

so the area is this much and this is equal to a number between 0

to 1 which i assume is rand

therefore u minus eighty thousand is equal to rand

multiplied by forty thousand and therefore u

is equal to 80 000 plus

40 000 times the line

given this idea

oh

okay now let's go to normal table and

okay now

okay now let's go to normal distribution

this is a this is a normal distribution suppose it

has a mean of mu and the standard deviation of sigma just for simplicity suppose this is 20

and this is 100 and we want to generate a random

variable from this distribution so i close my eyes and i put a

cross here this is a random distribution if i could have closed my

eyes and put a dot around there

but what is the feature of this probability distribution

the feature of drop this problem

okay this is a general normal probability distribution

suppose its mean is mu and its standard deviation sigma and for simplicity

suppose mu is equal to 100 and sigma is equal to 20.

now i want to generate a random variable

from this distribution suppose i can close my eyes and randomly

put a point over here this is an x of this distribution

but what is the characteristic of this x what is the most important feature of

this x the most important feature of this x is

this area which is from infinity up to

x is something between 1 and

0. right and i also know that each normal

variable is associated with a standard normal variable

where standard normal variable has a mean of zero and standard deviation of

one right and this x here

is associated with a z here

so if i have this probability

i can look for this probability here for the same probability

here

find the corresponding z and then transform z back into x

and the correct one important characteristic of this

probability is it is between 0 and

1. all probabilities are between 0 and 1.

so if i go and generate a random number

and associated with this probability then using that probability i can find

the corresponding z as soon as i have z i can use the

formula z equal to x minus mu divided by

sigma and then x would be mu

plus z sigma i will summarize

the procedure

generate a random number

assume this is a probability probability of z

being less than or equal to a specific value z random variable z to be less

than or equal to a specific value z and that is equal to rand

because you have prob this probability you can find z

this can be done in excel or in using the table so you can find

z after you generate the random number

you can go with it find z now you have z you can go from z to x

which is equal to mu plus sigma times c

therefore for example if land comes out 0.5

that will correspond to z equal to 0 right

and if that is equal to 0 x would be equal to 100 which was mu plus

20 times 0 which is 100. so you use this land of 0.5 you created

the z using z you created x i will explain it

in i assume i still assume that

the fixed cost has a uniform distribution in

between

eight thousand and one hundred and twenty thousand but

i assume valuable cost has a mean of 20

and a standard deviation of say five okay

then what i will do i will go here

first i generate a random number okay the first thing i will do

i will generate a random number let me go to a new page the first thing i will do i

create a random number so this is a random number i don't know what it is each time i go here delete a

new one comes so this is a random number then i go

equal to nor nor so norm standard

node and then is say okay given the probability

what is z that is c i created a z and i know that this c is equal to

x minus mu divided by sigma or x is equal to mu plus z times sigma so

this is equal to mu which we assume is 100 you know

is what was the thing in this case

is 20 in this case z is equal to 20

plus sigma was 5 in this case multiplied by the

z value and that's it so now this is a random

number with mean of

20 and the standard deviation of 5. okay

but we know a random number can also become negative there is a probability

that any random number becomes negative no matter what the sigma and

mu are because random variables go from negative

infinity to positive infinity to make sure that they will not be negative i may say

if this value is

less than or equal to zero

type it or i can say this let me say better than

equal to mean value of this one and zero

so whenever it becomes

i can say max

of 20 and now if it becomes negative it will automatically

come out zero right now i have a normal variable here

i will go there

equal to

mean which is this one lock it plus standard deviation which is this one

lock it multiplied by norm

standard inverse rand

this is a normal random variable between a normal random variable with mean of 20

and a standard deviation of 5 and then i copy it out just to make it um

more comfortable i will round it around

to zero so it will be rounded up or down but with no

decimal point

suppose sales price also follows a

normal distribution so i come here this one i make it be relative

be relative and enter copy down

and paste it here and then copy it here

and copy down

okay here standard deviation cannot be admin can be but

let's assume this has mean of 60 and the standard deviation of say

a 50 okay just there

let's see if we can observe any negative equal to count

if count if

the range is here count if in that range

less than 0.

less than z none fortunately all of them are positive

otherwise we needed to write a function here that it is

equal to max of zero and that value to make it at least zero

okay now i have the uh price and the

valuable cost considered to be uh click on that column order

now let's assume um quantity of cells follows

um exponential distribution let's see what is exponential decimal

let's see what is exponential distribution exponential distribution

is a distribution like this probability of small values are high

profility of large values are low

suppose in this situation mu

which is equal to standard deviation in exponential distribution is equal to

um four thousand four thousand units but it has

exponential distribution

in exponential distribution probability of an x to be greater than or equal to a

specific x is equal to e to the power of negative

x divided by mu so this probability is equal to e

to the power of x which we don't know what it is divided by 4 000 in this case

but we know something we know that this probability

is between 0 and 1 and we can

find the random probability by generating a random number

which is between 0 and 1. therefore a random number could be equal to e to the

power of negative x divided by mu

we know that if y is equal to e to the power of z

then

ln of

y is equal to z we know that

so if we have y equal to e to the power of z then ln of y is equal to z

here we have rand

equal to e to the power of negative x divided by mu

therefore ln of

land is equal to

ln of land is equal to

negative x divided by mu and therefore x

is equal to negative mu multiplied by ln of rand

so in order to create an x from this distribution all i need first

to create a round and that is easy

then compute the ln of that rand then multiply it by negative mean and

that is what am i going to do right now

suppose sales has a mean of 4 000

but it has exponential distribution

so i go here i type brand that is my probability

i should compute ln of that line so i go here and i type ln

and ln of that rand okay

and then i multiply it by negative of

mu and lock it because i'm going to copy down

quantum

equal to land then ln of land

and then negative of mu

multiplied by element of rand and then copy down just for simplicity let's

i think i didn't lock this one this one should be locked

and then copy down and just for simplicity

integrate

did i need this one so now these are my

quantity produce sales price variable cost and fixed cost i have these instances

now i should compute my profit

contribution margin that is price minus

variable cost multiplied by quantity minus

fixed cost here enter

and copy down

copy it all paste special paste it by value

these are my profits and this are

sorted profits right and those percentages are still valid

now we go and draw this chart

insert scatter graph

that's it

no probability of loss is much better higher here you cut the

zero at 50 percent if you look at over there

that probability which we had it and it's a valid for the numbers here

it is quite high