Yield Management EX SET 1 - solutions

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Theory link

- The yield theory is necessary for companies in order take business decisions faster and decrease the overall costs

- Thanks to this theory, companies can better manage their resources and maximise their profitability

Key messages from the lesson

- Understand how to calculate the protection level for full price customers
- Understand how to manage properly full and discounted tickets
- Calculate the over estimation costs and under estimation costs
- Understand how to manage the no-show phenomena
- Understand how to calculate the break even point

EX1.Futura Spa

The public administration decided to celebrate the renewal of the Giglio theatre with a gala party. The organization of the event is delegated to an important public relations Company named Futura. Futura is in charge of guaranteeing maximum profits by allocating the 500 available seats of the theatre in the best way, through yield management theory. The price agreed to sell the ticket is equal to 1000€/ticket (full price). However, because the probability to sell all tickets at this price is very low, Futura decided to introduce another price. Historical data showed that the probability to sell less than 350 tickets is equal to 90%. Demand for tickets (at 1000€) is distributed as a normal distribution, the average is equal to 200. The second price introduced is 320€/ticket (discounted price). Tickets related to this price must be sold in advance. The manager of Futura knows that if they decided to sell at 320€/tickets, they would sell all the tickets (500) without any problem. However, they decided to sell tickets at two different prices to obtain a higher margin.
To the customer interested in buying tickets at full price, several services are offered:

- Buffet provided by a catering Company, paid in advance (30 days before the event) by Futura. The cost is 15 €/ person.
- A flyer containing the Theatre History. The Flyer is offered by an external sponsor. The cost is 8 €/ flyer.
- Program of the evening printed on high-quality paper. The cost is 40€/program.

To the customer that purchases tickets at a discounted price fewer services are offered:

- A flyer containing the Theatre History. The Flyer is offered by the public administration. The cost is 8 €/ flyer.
- Program of the evening printed on low-quality paper, each costs 25€.

To print flyers and program, 7 days are needed. Tickets at a discounted price are sold up until 20 days before the event. After that date, it is only possible to purchase tickets at full price.

1. You are required to calculate the protection level for full-price tickets.
2. For every event, it happens that some people, those who have not purchased tickets before and are not minded paying full price, try to purchase the ticket directly at the entrance. 15 minutes before the beginning of the events, managers of Futura check how many tickets haven't been sold. So, they decide to sell the remaining tickets at the price of 150 €. Data show that usually, no-shows related to people that have purchased tickets at a discounted price are equal to 10% (The ticket is not refundable under any circumstances).
You are required to comment on the impact of the introduction of this new price on the protection level.

Futura Spa

1) Calculate the protection level for full price tickets

2) What happens to the protection level if company introduces last minute tickets at a price of 150 €?

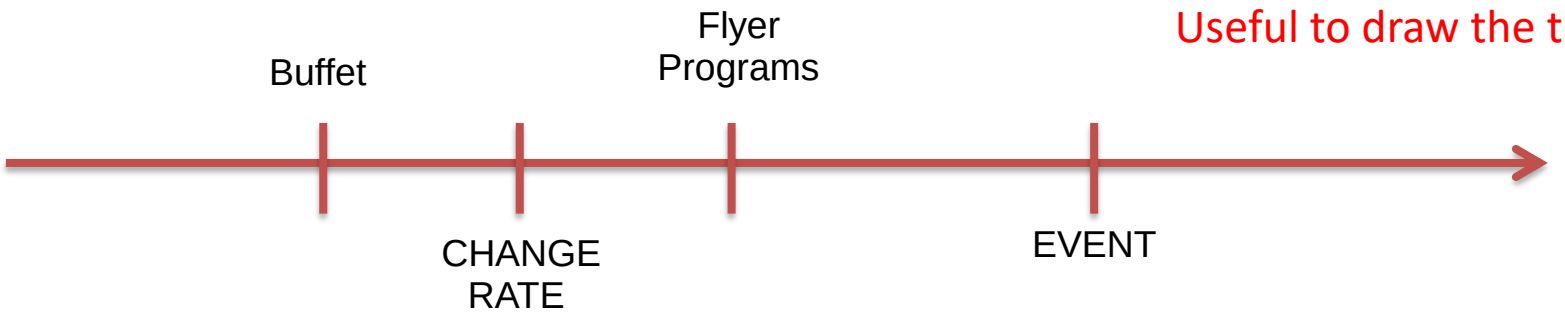
Data shows that usually no-show related to people that have purchased tickets at discounted price is equal to 10% (the ticket is not refoundable)

Futura Spa - Data

Capacity= 500 seats
Demand follows a Normal Distribution N(200, ∂)
P(X<=350) = 90% → σ = ?
Pf=1000, Pd=320

Costs:

- Buffet = 15 €/p → FULL,before the event
- Flyer = 8 €/p → FULL, offered by sponsor
- Program HQ = 40 €/p → FULL, before the event
- Flyer = 8 €/p → DISCOUNTED, offered
- Program LQ = 25 €/p → DISCOUNTED, before the event

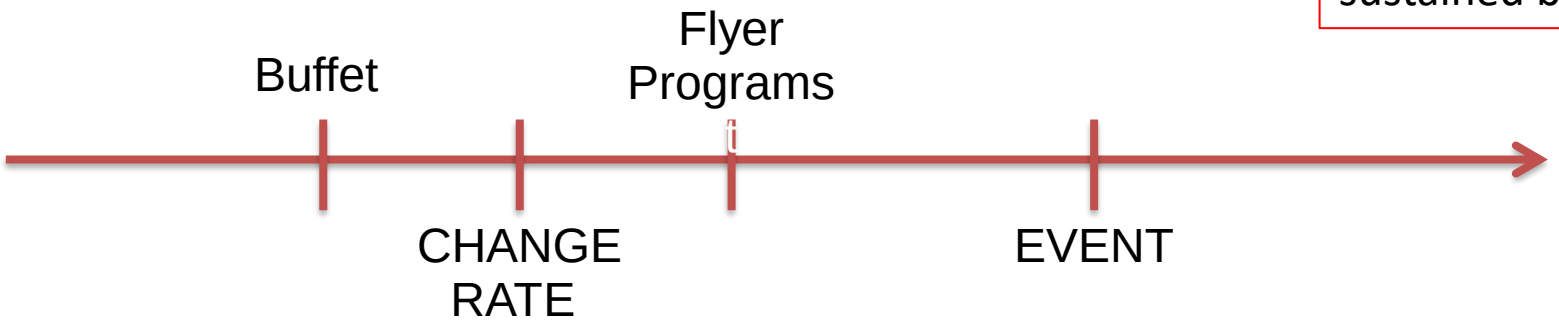


Useful to draw the time frame

Futura Spa - costs

- Buffet = 15 €/p → FULL
- ~~Flyer = 8 €/p~~ → ~~FULL, offered by sponsor~~
- Program HQ = 40 €/p → FULL
- ~~Flyer = 8 €/p~~ → ~~DISCOUNTED, offered~~
- Program LQ = 25 €/p → DISCOUNTED

These costs are not sustained by Futura



Futura Spa → question 1 _ Marginal Analysis

Probability to have underestimated the demand of full price customers

Probability to have overestimated the demand of full price customers

$$P(X_1 \geq S_1) * C_u \geq P(X_1 < S_1) * C_o$$

$$[1 - P(X_1 < S_1)] * C_u \geq P(X_1 < S_1) * C_o$$

$$P(X_1 < S_1) \leq \frac{C_u}{C_u + C_o} \longrightarrow \alpha$$

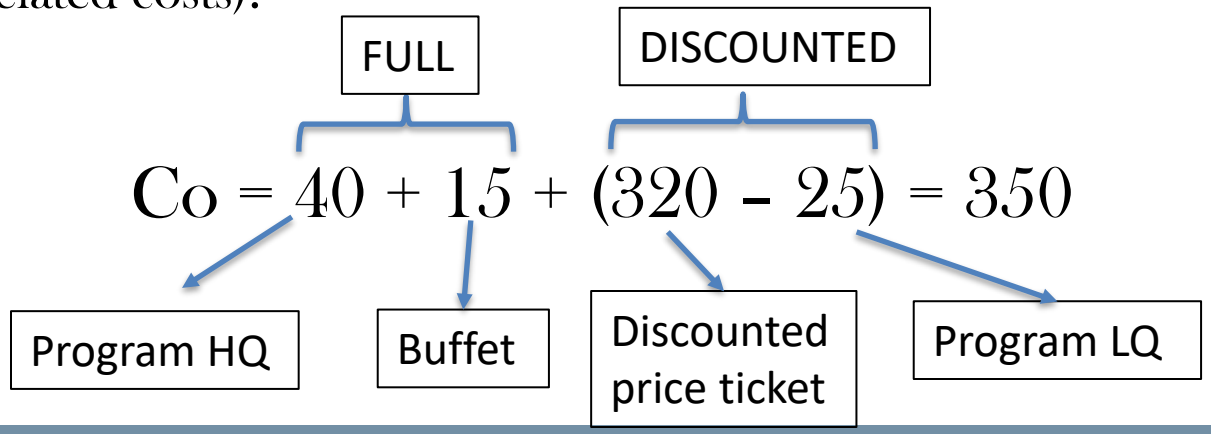
$$pl = \mu + z_\alpha * \sigma$$

Legend
X1 Full price customer demand
S1 (pl) Protection Level
Cu Cost of Underestimation
Co Cost of Overestimation

Futura Spa → question 1 (Overestimation)

In case of overestimation, Futura losts the opportunity to sell tickets to discounted customers, thus it does not pay for their services but has already spent money to guaratee the services for full price customers (only those to be piad before the event)

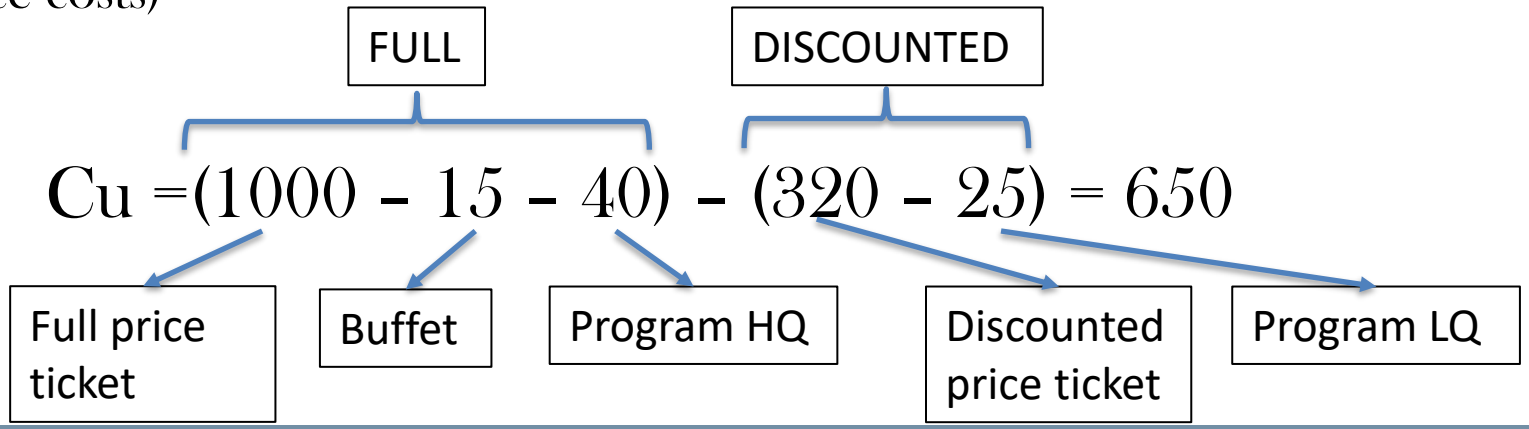
→Co = company paid for h.q. program and buffet for a seat that remains empty. Moreover it lost the opportunity of selling that place at a discounted price (with related costs).



Futura Spa → question 1 (Underestimation)

In case of overestimation, Futura losts the opportunity to sell tickets to full prince customers, thus it does not pay for their services but has already spent money to guarantee the services for discounted price customers (only those to be paid before the event)

→ Cu = company lost the opportunity to sell a ticket at full price (not sustaining also related service costs) but gained the rate of discounted ticket (and paid for its service costs)



Futura Spa → question 1 _ Marginal Analysis

Cu = 650

Co = 350

$$P(X_1 \geq S_1) * C_u \geq P(X_1 < S_1) * C_o$$

$$[1 - P(X_1 < S_1)] * C_u \geq P(X_1 < S_1) * C_o$$

$$P(X_1 < S_1) \leq \frac{C_u}{C_u + C_o}$$

Use the Normal Distribution Table to estimate S1

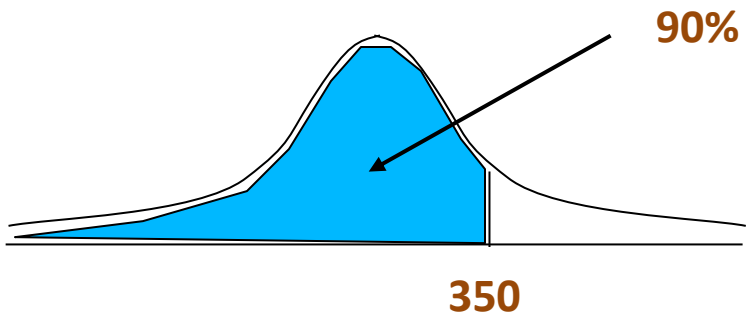
$$P(X_1 < S_1) \leq \frac{650}{650 + 350} = 0{,}65$$

Φ_α	.00	.01	.02	.03	.04	.05	.06	.07	.08	.09
0.0	0,50000	0,50399	0,50798	0,51197	0,51595	0,51994	0,52392	0,52790	0,53188	0,53586
0.1	*0,53983*	*0,54380*	*0,54776*	*0,55172*	*0,55567*	*0,55962*	*0,56356*	*0,56749*	*0,57142*	*0,57535*
0.2	0,57926	0,58317	0,58706	0,59095	0,59483	0,59871	0,60257	0,60642	0,61026	0,61409
0.3	*0,61791*	*0,62172*	*0,62552*	*0,62930*	*0,63307*	*0,63683*	*0,64058*	*0,64431*	*0,64803*	*0,65173*
0.4	0,65542	0,65910	0,66276	0,66640	0,67003	0,67364	0,67724	0,68082	0,68439	0,68793
0.5	*0,69146*	*0,69497*	*0,69847*	*0,70194*	*0,70540*	*0,70884*	*0,71226*	*0,71566*	*0,71904*	*0,72240*
0.6	0,72575	0,72907	0,73237	0,73565	0,73891	0,74215	0,74537	0,74857	0,75175	0,75490
0.7	*0,75804*	*0,76115*	*0,76424*	*0,76730*	*0,77035*	*0,77337*	*0,77637*	*0,77935*	*0,78230*	*0,78524*
0.8	0,78814	0,79103	0,79389	0,79673	0,79955	0,80234	0,80511	0,80785	0,81057	0,81327
0.9	*0,81594*	*0,81859*	*0,82121*	*0,82381*	*0,82639*	*0,82894*	*0,83147*	*0,83398*	*0,83646*	*0,83891*
1.0	0,84134	0,84375	0,84614	0,84849	0,85083	0,85314	0,85543	0,85769	0,85993	0,86214
1.1	*0,86433*	*0,86650*	*0,86864*	*0,87076*	*0,87286*	*0,87493*	*0,87698*	*0,87900*	*0,88100*	*0,88298*
1.2	0,88493	0,88686	0,88877	0,89065	0,89251	0,89435	0,89617	0,89796	0,89973	0,90147
1.3	*0,90320*	*0,90490*	*0,90658*	*0,90824*	*0,90988*	*0,91149*	*0,91308*	*0,91466*	*0,91621*	*0,91774*
1.4	0,91924	0,92073	0,92220	0,92364	0,92507	0,92647	0,92785	0,92922	0,93056	0,93189
1.5	*0,93319*	*0,93448*	*0,93574*	*0,93699*	*0,93822*	*0,93943*	*0,94062*	*0,94179*	*0,94295*	*0,94408*
1.6	0,94520	0,94630	0,94738	0,94845	0,94950	0,95053	0,95154	0,95254	0,95352	0,95449
1.7	*0,95543*	*0,95637*	*0,95728*	*0,95818*	*0,95907*	*0,95994*	*0,96080*	*0,96164*	*0,96246*	*0,96327*
1.8	0,96407	0,96485	0,96562	0,96638	0,96712	0,96784	0,96856	0,96926	0,96995	0,97062
1.9	*0,97128*	*0,97193*	*0,97257*	*0,97320*	*0,97381*	*0,97441*	*0,97500*	*0,97558*	*0,97615*	*0,97670*
2.0	0,97725	0,97778	0,97831	0,97882	0,97932	0,97982	0,98030	0,98077	0,98124	0,98169
2.1	*0,98214*	*0,98257*	*0,98300*	*0,98341*	*0,98382*	*0,98422*	*0,98461*	*0,98500*	*0,98537*	*0,98574*
2.2	0,98610	0,98645	0,98679	0,98713	0,98745	0,98778	0,98809	0,98840	0,98870	0,98899
2.3	*0,98928*	*0,98956*	*0,98983*	*0,99010*	*0,99036*	*0,99061*	*0,99086*	*0,99111*	*0,99134*	*0,99158*
2.4	0,99180	0,99202	0,99224	0,99245	0,99266	0,99286	0,99305	0,99324	0,99343	0,99361
2.5	*0,99379*	*0,99396*	*0,99413*	*0,99430*	*0,99446*	*0,99461*	*0,99477*	*0,99492*	*0,99506*	*0,99520*
2.6	0,99534	0,99547	0,99560	0,99573	0,99585	0,99598	0,99609	0,99621	0,99632	0,99643
2.7	*0,99653*	*0,99664*	*0,99674*	*0,99683*	*0,99693*	*0,99702*	*0,99711*	*0,99720*	*0,99728*	*0,99736*
2.8	0,99744	0,99752	0,99760	0,99767	0,99774	0,99781	0,99788	0,99795	0,99801	0,99807
2.9	*0,99813*	*0,99819*	*0,99825*	*0,99831*	*0,99836*	*0,99841*	*0,99846*	*0,99851*	*0,99856*	*0,99861*

Futura Spa → question 1 (Standard Deviation)

Normal distribution, mean = 200

P(X<=350) = 90% → σ = ?

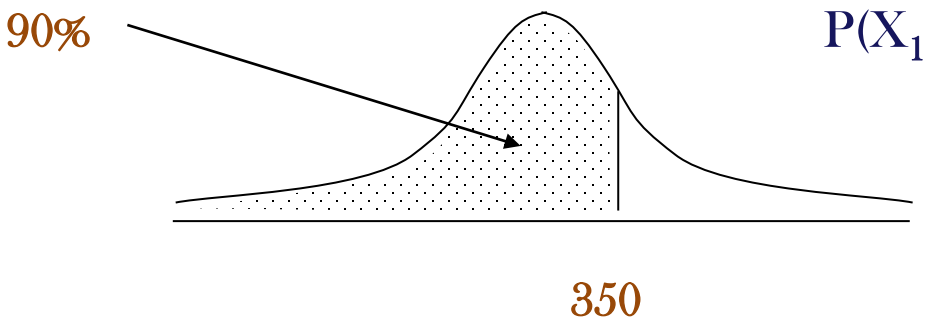


How much is the standard deviation?
Conversion to a standard normal distribution N(0,1):

$$P(X_1 \le K) = P(\frac{X_1 - \mu}{\sigma} \le \frac{K - \mu}{\sigma})$$

Futura Spa → question 1 (Standard Deviation)

- Probability of demand lower or equal to 350:



$P(X_1 \leq 350) = 0,9$

Conversion to a standard normal distribution N(0,1):

$$P\left(\frac{X_1 - \mu}{\sigma} \leq \frac{350 - 200}{\sigma}\right) = 0,9$$

$F(Z\alpha)=0,9$
$Z\alpha=1,28$

$$\frac{350 - 200}{\sigma} = 1,28 \rightarrow \sigma = \frac{150}{1,28} = 117,2$$

Futura Spa → question 1

$F(Z\alpha) = 0{,}65$

$Z\alpha = 0{,}39$

Full price tickets Protection level:

$$S_1 = 200 + 0{,}39 * 117{,}2 = 245{,}7$$

From the Normal Distribution Table

Company has to reserve 246 seats for Full price customers

How many tickets at discounted price could company sell?
(Capacity – Protection Level)
500 – 246 = 254

1) Calculate the protection level for full price tickets

2) What happens to the protection level if company introduces last minute tickets at a price of 150 €?

Data shows that usually no-show related to people that have purchased tickets at discounted price is equal to 10% (the ticket is not refoundable)

Futura Spa → question 2 (No-Show phenomena)

Futura sells the empty seats:

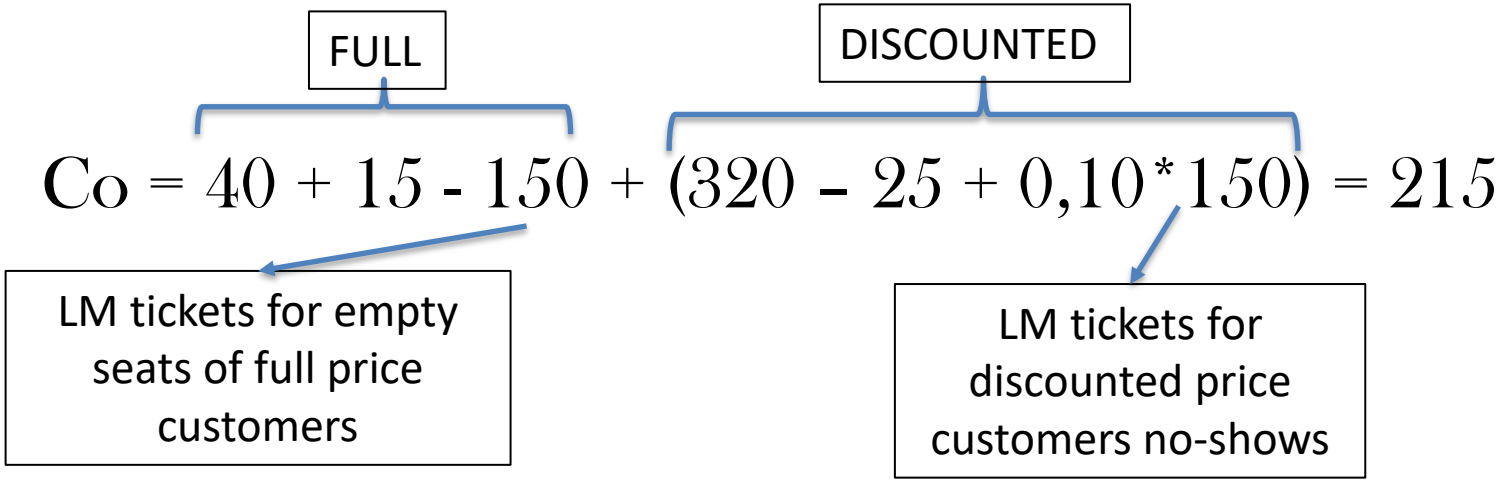
- Due to discounted customers no-shows (10% of probability that who bought discounted ticket doesn't turn-up)
- Due to remaining empty seats because not sold to full price customers

Introduction of last-minute ticket, price = 150 €

Futura Spa → question 2

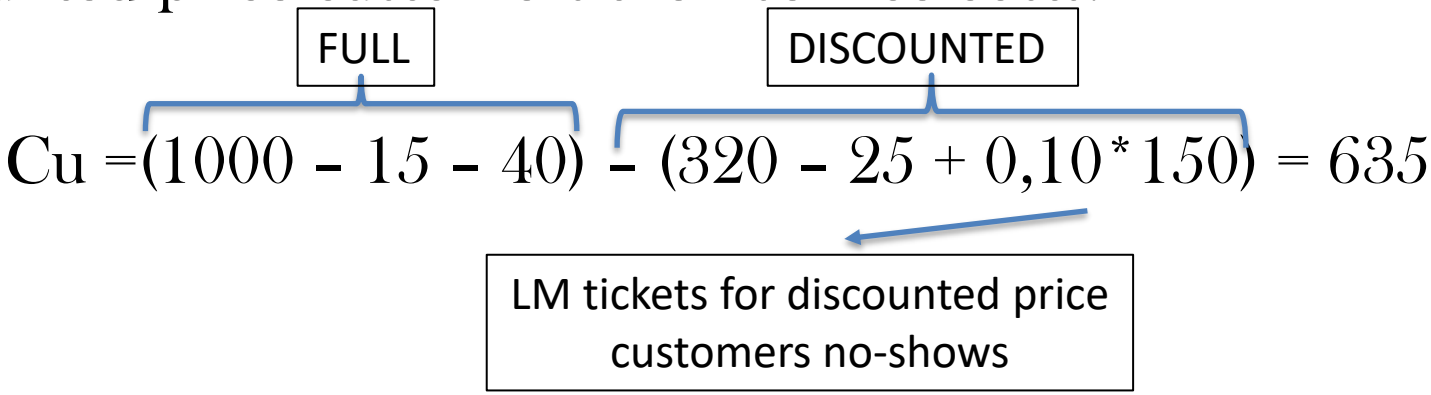
Co = company paid for h.q. program and buffet for a seat that remains empty. The empty seats of full price customers can be covered by selling the last minutes tickets.

Moreover it lost the opportunity of selling that place at a discounted price and in case of their no-shows, the company would have lost the opportunity sell the last-minute price tickets. Nevertheless, it does not pay for the discounted price customers'services.



Futura Spa → question 2

Cu = company lost the opportunity to sell a ticket at full price (without sustaining related service costs) but gained the rate of discounted ticket and the selling of last-minutes tickets in case of their no-shows phenomena. Moreover, the company pays for discounted price customers their service costs.



N.B. In this case, there are no empty seats due to not selling tickets, because discounted customers will purchase all the tickets available for them

Futura Spa → question 2

$$Co = 40 + 15 + (320 - 25 + 0{,}10 * 150) - 150 = 215$$

$$Cu = (1000 - 15 - 40) - (320 - 25 + 0{,}10 * 150) = 635$$

When company sells a discounted ticket in 10% of the cases it has an additional revenue of 150 € by last minute ticket

Futura Spa → question 2

Cu = 635

Co = 215

$$P(X_1 \geq S_1) * C_u \geq P(X_1 < S_1) * C_o$$

$$[1 - P(X_1 < S_1)] * C_u \geq P(X_1 < S_1) * C_o$$

$$P(X_1 < S_1) \leq \frac{C_u}{C_u + C_o}$$

Use the Normal Distribution Table to estimate S1

$$P(X_1 < S_1) \leq \frac{635}{635 + 215} = 0{,}747$$

Φ_α	.00	.01	.02	.03	.04	.05	.06	.07	.08	.09
0.0	0,50000	0,50399	0,50798	0,51197	0,51595	0,51994	0,52392	0,52790	0,53188	0,53586
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1.0	0,84134	0,84375	0,84614	0,84849	0,85083	0,85314	0,85543	0,85769	0,85993	0,86214
1.1	*0,86433*	*0,86650*	*0,86864*	*0,87076*	*0,87286*	*0,87493*	*0,87698*	*0,87900*	*0,88100*	*0,88298*
1.2	0,88493	0,88686	0,88877	0,89065	0,89251	0,89435	0,89617	0,89796	0,89973	0,90147
1.3	*0,90320*	*0,90490*	*0,90658*	*0,90824*	*0,90988*	*0,91149*	*0,91308*	*0,91466*	*0,91621*	*0,91774*
1.4	0,91924	0,92073	0,92220	0,92364	0,92507	0,92647	0,92785	0,92922	0,93056	0,93189
1.5	*0,93319*	*0,93448*	*0,93574*	*0,93699*	*0,93822*	*0,93943*	*0,94062*	*0,94179*	*0,94295*	*0,94408*
1.6	0,94520	0,94630	0,94738	0,94845	0,94950	0,95053	0,95154	0,95254	0,95352	0,95449
1.7	*0,95543*	*0,95637*	*0,95728*	*0,95818*	*0,95907*	*0,95994*	*0,96080*	*0,96164*	*0,96246*	*0,96327*
1.8	0,96407	0,96485	0,96562	0,96638	0,96712	0,96784	0,96856	0,96926	0,96995	0,97062
1.9	*0,97128*	*0,97193*	*0,97257*	*0,97320*	*0,97381*	*0,97441*	*0,97500*	*0,97558*	*0,97615*	*0,97670*
2.0	0,97725	0,97778	0,97831	0,97882	0,97932	0,97982	0,98030	0,98077	0,98124	0,98169
2.1	*0,98214*	*0,98257*	*0,98300*	*0,98341*	*0,98382*	*0,98422*	*0,98461*	*0,98500*	*0,98537*	*0,98574*
2.2	0,98610	0,98645	0,98679	0,98713	0,98745	0,98778	0,98809	0,98840	0,98870	0,98899
2.3	*0,98928*	*0,98956*	*0,98983*	*0,99010*	*0,99036*	*0,99061*	*0,99086*	*0,99111*	*0,99134*	*0,99158*
2.4	0,99180	0,99202	0,99224	0,99245	0,99266	0,99286	0,99305	0,99324	0,99343	0,99361
2.5	*0,99379*	*0,99396*	*0,99413*	*0,99430*	*0,99446*	*0,99461*	*0,99477*	*0,99492*	*0,99506*	*0,99520*
2.6	0,99534	0,99547	0,99560	0,99573	0,99585	0,99598	0,99609	0,99621	0,99632	0,99643
2.7	*0,99653*	*0,99664*	*0,99674*	*0,99683*	*0,99693*	*0,99702*	*0,99711*	*0,99720*	*0,99728*	*0,99736*
2.8	0,99744	0,99752	0,99760	0,99767	0,99774	0,99781	0,99788	0,99795	0,99801	0,99807
2.9	*0,99813*	*0,99819*	*0,99825*	*0,99831*	*0,99836*	*0,99841*	*0,99846*	*0,99851*	*0,99856*	*0,99861*

Futura Spa → question 2

$F(Z\alpha) = 0{,}747$

$Z\alpha = 0{,}67$

Full price tickets Protection level:

$$S_1 = 200 + 0{,}67 * 117{,}2 = 278{,}5$$

Company has to reserve 279 seats

From the Normal Distribution Table

How many tickets at discounted fare could company sell?

500 – 279 = 221

Practice the same exercise with the excel file

Exercise 2

The organizers of the Operations management world conference are excited for the opportunity to organize the best event in the operations management field. So, they want to obtain the maximum profit from the event.

They have to pay the rental rate of the conference room, which can host 1000 participants, and it costs 80€/participant. They decide to propose two different prices: one discounted and one full.

With the discounted price (600 €/participant) they are sure to sell out all the tickets, but they want to earn more from the event. So, they decided to sell tickets at a discounted price in advance and to sell also tickets at full price (1200 €/participant). Historical data showed that with the price of 1200€/ participant it would be possible to sell less than 400 tickets with an 80% probability. Demand for tickets (at 1200€) is distributed as a normal distribution, average =250.

They decide to print the proceedings for all the participants (both full and discounted price). That cost 50 €/participant. They have to communicate the number of proceedings copies 20 days before the event.

The organizers also decided to offer a coffee break to all the participants (both full and discounted price), and they have to pay the catering Company 90 days before the event (10 €/participant).

Moreover, they decided to offer a gala dinner to the participants that purchase the ticket at full price. They agreed with the restaurant the price of 50 €/participant, and that cost is paid directly by the organizers to the restaurant after the dinner. Historical data showed that on average 70% of the participants (full price) will attend the dinner.

Sales are organized as follow:

- From 80 days before the event until 30 days before the event: tickets at a discounted price.
- From 30 days before the event until 1 day before the event: tickets at full price.

1. You are required to calculate the protection level for full-price tickets.
2. How the protection level will be modified if they decided to introduce a last-minute price of 300€/participant, to sell during the event day.
3. Calculate the break-even point of the two different scenarios.

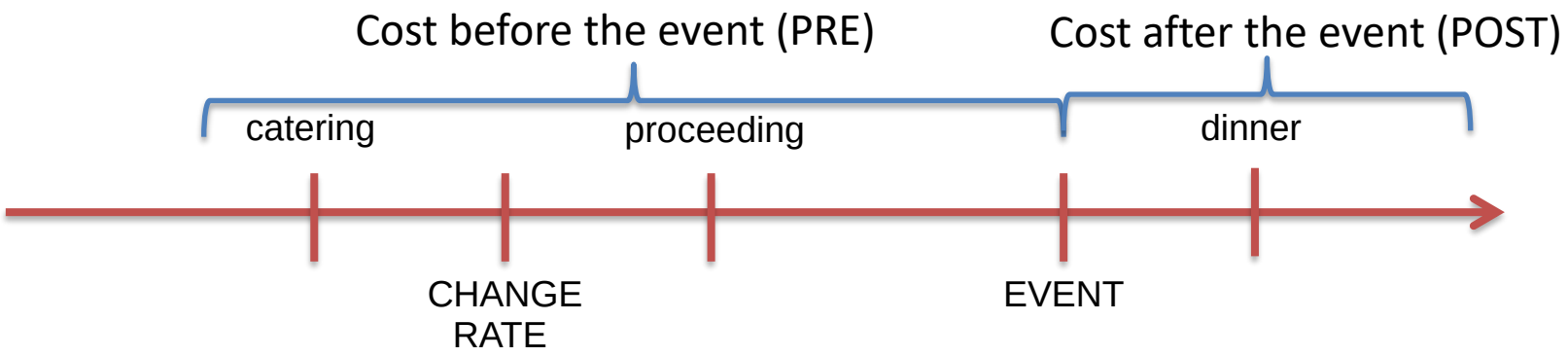
Exercise 2 → question 1

Capacity= 1000 seats
Demand follows a Normal Distribution N(200, ∂)
P(X<=400) = 80% → σ = ?
Pf=1200, Pd=600

Costs:

- Rental of the room = 80 €/p → BOTH (PRE)
- Proceedings = 50 €/p → BOTH (PRE)
- Catering = 10 €/p → BOTH, (PRE)
- Dinner = 50 €/p → FULL (POST, only for the70%)

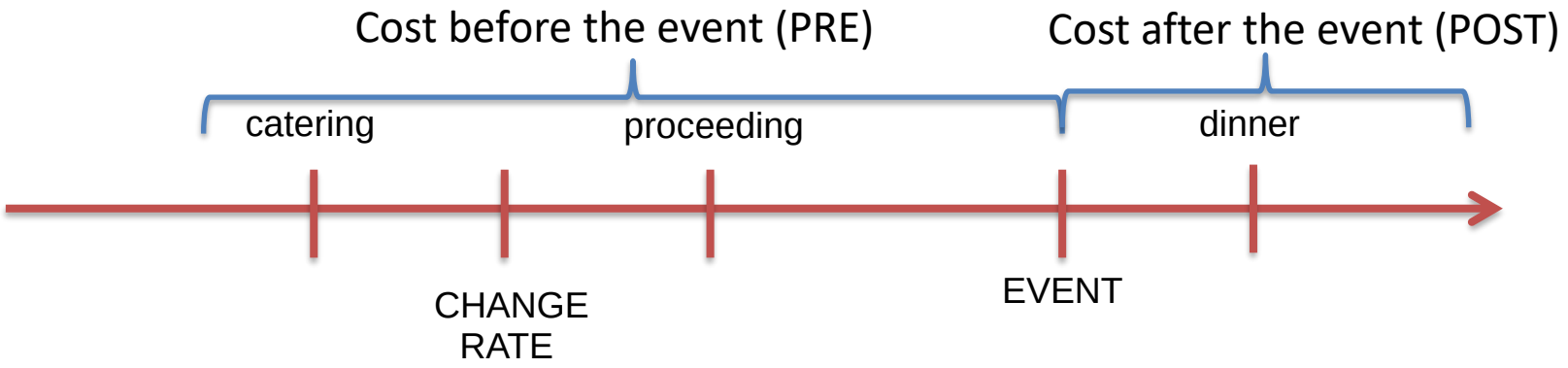
These costs are not differential!



Exercise 2 → question 1

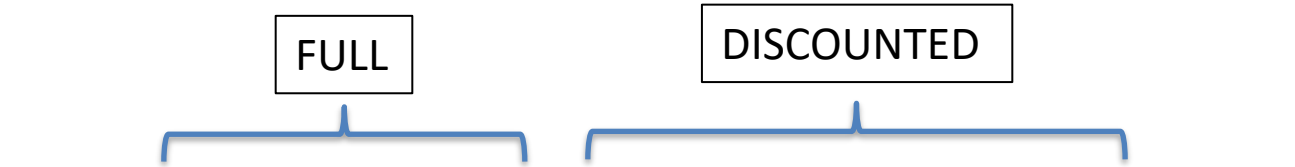
Costs:

- ~~Rental of the room = 80 €/p~~ → ~~BOTH (PRE)~~
- ~~Proceedings = 50 €/p~~ → ~~BOTH (PRE)~~
- ~~Catering = 10 €/p~~ → ~~BOTH, (PRE)~~
- Dinner = 40 €/p → FULL (POST, only for the70%)



Exercise 2 → question 1

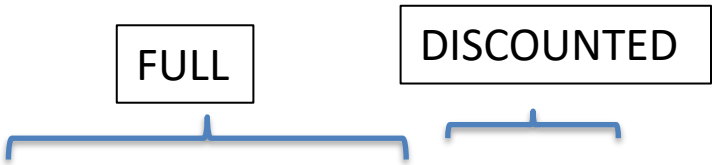
Co = company losts the opportunity to sell discounted tickets. The costs of the two classess are not differential. The only cost indeed refers to the opportunity cost



$$Co = 80 + 50 + 10 + 600 - 80 - 50 - 10 = 600$$

Exercise 2 → question 1

Cu = company losts the opportunity to sell a ticket at full price (without sustaining related service costs) but gained the rate of discounted ticket.

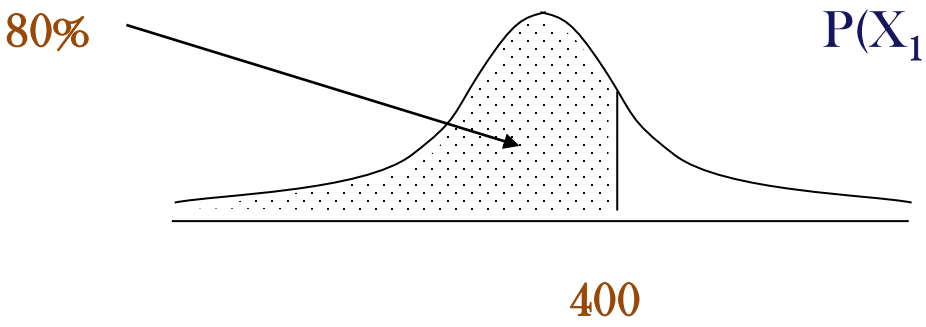


$$Cu = (1200 - 0{,}7 * 50) - (600) = 565$$

N.B the cost post the event for full price customers must be considered. Indeed, this cost is really differential because the company does not give to full price customers the possibility to purchase the tickets, thus it does not spend money for their services. Moreover, in case they would have purchased the ticket, only the 70% would have participated to the dinner

Exercise 2 → question 1

- Probability of demand lower or equal to 400:



$P(X_1 \leq 400) = 0,8$

Conversion to a standard normal distribution N(0,1):

$$P\left(\frac{X_1 - \mu}{\sigma} \leq \frac{400 - 250}{\sigma}\right) = 0,8$$

$F(Z\alpha)=0,8$
$Z\alpha=0,84$ → From the Normal Distribution Table

$$\frac{400 - 250}{\sigma} = 0,84 \rightarrow \sigma = \frac{150}{0,84} = 178.57$$

Φ_α	.00	.01	.02	.03	.04	.05	.06	.07	.08	.09
0.0	0,50000	0,50399	0,50798	0,51197	0,51595	0,51994	0,52392	0,52790	0,53188	0,53586
0.1	*0,53983*	*0,54380*	*0,54776*	*0,55172*	*0,55567*	*0,55962*	*0,56356*	*0,56749*	*0,57142*	*0,57535*
0.2	0,57926	0,58317	0,58706	0,59095	0,59483	0,59871	0,60257	0,60642	0,61026	0,61409
0.3	*0,61791*	*0,62172*	*0,62552*	*0,62930*	*0,63307*	*0,63683*	*0,64058*	*0,64431*	*0,64803*	*0,65173*
0.4	0,65542	0,65910	0,66276	0,66640	0,67003	0,67364	0,67724	0,68082	0,68439	0,68793
0.5	*0,69146*	*0,69497*	*0,69847*	*0,70194*	*0,70540*	*0,70884*	*0,71226*	*0,71566*	*0,71904*	*0,72240*
0.6	0,72575	0,72907	0,73237	0,73565	0,73891	0,74215	0,74537	0,74857	0,75175	0,75490
0.7	*0,75804*	*0,76115*	*0,76424*	*0,76730*	*0,77035*	*0,77337*	*0,77637*	*0,77935*	*0,78230*	*0,78524*
0.8	0,78814	0,79103	0,79389	0,79673	0,79955	0,80234	0,80511	0,80785	0,81057	0,81327
0.9	*0,81594*	*0,81859*	*0,82121*	*0,82381*	*0,82639*	*0,82894*	*0,83147*	*0,83398*	*0,83646*	*0,83891*
1.0	0,84134	0,84375	0,84614	0,84849	0,85083	0,85314	0,85543	0,85769	0,85993	0,86214
1.1	*0,86433*	*0,86650*	*0,86864*	*0,87076*	*0,87286*	*0,87493*	*0,87698*	*0,87900*	*0,88100*	*0,88298*
1.2	0,88493	0,88686	0,88877	0,89065	0,89251	0,89435	0,89617	0,89796	0,89973	0,90147
1.3	*0,90320*	*0,90490*	*0,90658*	*0,90824*	*0,90988*	*0,91149*	*0,91308*	*0,91466*	*0,91621*	*0,91774*
1.4	0,91924	0,92073	0,92220	0,92364	0,92507	0,92647	0,92785	0,92922	0,93056	0,93189
1.5	*0,93319*	*0,93448*	*0,93574*	*0,93699*	*0,93822*	*0,93943*	*0,94062*	*0,94179*	*0,94295*	*0,94408*
1.6	0,94520	0,94630	0,94738	0,94845	0,94950	0,95053	0,95154	0,95254	0,95352	0,95449
1.7	*0,95543*	*0,95637*	*0,95728*	*0,95818*	*0,95907*	*0,95994*	*0,96080*	*0,96164*	*0,96246*	*0,96327*
1.8	0,96407	0,96485	0,96562	0,96638	0,96712	0,96784	0,96856	0,96926	0,96995	0,97062
1.9	*0,97128*	*0,97193*	*0,97257*	*0,97320*	*0,97381*	*0,97441*	*0,97500*	*0,97558*	*0,97615*	*0,97670*
2.0	0,97725	0,97778	0,97831	0,97882	0,97932	0,97982	0,98030	0,98077	0,98124	0,98169
2.1	*0,98214*	*0,98257*	*0,98300*	*0,98341*	*0,98382*	*0,98422*	*0,98461*	*0,98500*	*0,98537*	*0,98574*
2.2	0,98610	0,98645	0,98679	0,98713	0,98745	0,98778	0,98809	0,98840	0,98870	0,98899
2.3	*0,98928*	*0,98956*	*0,98983*	*0,99010*	*0,99036*	*0,99061*	*0,99086*	*0,99111*	*0,99134*	*0,99158*
2.4	0,99180	0,99202	0,99224	0,99245	0,99266	0,99286	0,99305	0,99324	0,99343	0,99361
2.5	*0,99379*	*0,99396*	*0,99413*	*0,99430*	*0,99446*	*0,99461*	*0,99477*	*0,99492*	*0,99506*	*0,99520*
2.6	0,99534	0,99547	0,99560	0,99573	0,99585	0,99598	0,99609	0,99621	0,99632	0,99643
2.7	*0,99653*	*0,99664*	*0,99674*	*0,99683*	*0,99693*	*0,99702*	*0,99711*	*0,99720*	*0,99728*	*0,99736*
2.8	0,99744	0,99752	0,99760	0,99767	0,99774	0,99781	0,99788	0,99795	0,99801	0,99807
2.9	*0,99813*	*0,99819*	*0,99825*	*0,99831*	*0,99836*	*0,99841*	*0,99846*	*0,99851*	*0,99856*	*0,99861*

Exercise 2 → question 1

$$P(X_1 < S_1) \leq \frac{Cu}{Co + Cu} = \frac{565}{600 + 565} = 0{,}485$$

F(Zα)= 0,485 → It is lower than 0,5
Use the complementary value of 0,485 in the table
1-0,485= 0,515 → Zα = -0,04

Full price tickets Protection level:

$$S_1 = 250 - 0{,}04 * 178{,}57 = 242{,}85 >> 243$$

seats

Φ_α	.00	.01	.02	.03	.04	.05	.06	.07	.08	.09
0.0	0,50000	0,50399	0,50798	0,51197	0,51595	0,51994	0,52392	0,52790	0,53188	0,53586
0.1	*0,53983*	*0,54380*	*0,54776*	*0,55172*	*0,55567*	*0,55962*	*0,56356*	*0,56749*	*0,57142*	*0,57535*
0.2	0,57926	0,58317	0,58706	0,59095	0,59483	0,59871	0,60257	0,60642	0,61026	0,61409
0.3	*0,61791*	*0,62172*	*0,62552*	*0,62930*	*0,63307*	*0,63683*	*0,64058*	*0,64431*	*0,64803*	*0,65173*
0.4	0,65542	0,65910	0,66276	0,66640	0,67003	0,67364	0,67724	0,68082	0,68439	0,68793
0.5	*0,69146*	*0,69497*	*0,69847*	*0,70194*	*0,70540*	*0,70884*	*0,71226*	*0,71566*	*0,71904*	*0,72240*
0.6	0,72575	0,72907	0,73237	0,73565	0,73891	0,74215	0,74537	0,74857	0,75175	0,75490
0.7	*0,75804*	*0,76115*	*0,76424*	*0,76730*	*0,77035*	*0,77337*	*0,77637*	*0,77935*	*0,78230*	*0,78524*
0.8	0,78814	0,79103	0,79389	0,79673	0,79955	0,80234	0,80511	0,80785	0,81057	0,81327
0.9	*0,81594*	*0,81859*	*0,82121*	*0,82381*	*0,82639*	*0,82894*	*0,83147*	*0,83398*	*0,83646*	*0,83891*
1.0	0,84134	0,84375	0,84614	0,84849	0,85083	0,85314	0,85543	0,85769	0,85993	0,86214
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1.2	0,88493	0,88686	0,88877	0,89065	0,89251	0,89435	0,89617	0,89796	0,89973	0,90147
1.3	*0,90320*	*0,90490*	*0,90658*	*0,90824*	*0,90988*	*0,91149*	*0,91308*	*0,91466*	*0,91621*	*0,91774*
1.4	0,91924	0,92073	0,92220	0,92364	0,92507	0,92647	0,92785	0,92922	0,93056	0,93189
1.5	*0,93319*	*0,93448*	*0,93574*	*0,93699*	*0,93822*	*0,93943*	*0,94062*	*0,94179*	*0,94295*	*0,94408*
1.6	0,94520	0,94630	0,94738	0,94845	0,94950	0,95053	0,95154	0,95254	0,95352	0,95449
1.7	*0,95543*	*0,95637*	*0,95728*	*0,95818*	*0,95907*	*0,95994*	*0,96080*	*0,96164*	*0,96246*	*0,96327*
1.8	0,96407	0,96485	0,96562	0,96638	0,96712	0,96784	0,96856	0,96926	0,96995	0,97062
1.9	*0,97128*	*0,97193*	*0,97257*	*0,97320*	*0,97381*	*0,97441*	*0,97500*	*0,97558*	*0,97615*	*0,97670*
2.0	0,97725	0,97778	0,97831	0,97882	0,97932	0,97982	0,98030	0,98077	0,98124	0,98169
2.1	*0,98214*	*0,98257*	*0,98300*	*0,98341*	*0,98382*	*0,98422*	*0,98461*	*0,98500*	*0,98537*	*0,98574*
2.2	0,98610	0,98645	0,98679	0,98713	0,98745	0,98778	0,98809	0,98840	0,98870	0,98899
2.3	*0,98928*	*0,98956*	*0,98983*	*0,99010*	*0,99036*	*0,99061*	*0,99086*	*0,99111*	*0,99134*	*0,99158*
2.4	0,99180	0,99202	0,99224	0,99245	0,99266	0,99286	0,99305	0,99324	0,99343	0,99361
2.5	*0,99379*	*0,99396*	*0,99413*	*0,99430*	*0,99446*	*0,99461*	*0,99477*	*0,99492*	*0,99506*	*0,99520*
2.6	0,99534	0,99547	0,99560	0,99573	0,99585	0,99598	0,99609	0,99621	0,99632	0,99643
2.7	*0,99653*	*0,99664*	*0,99674*	*0,99683*	*0,99693*	*0,99702*	*0,99711*	*0,99720*	*0,99728*	*0,99736*
2.8	0,99744	0,99752	0,99760	0,99767	0,99774	0,99781	0,99788	0,99795	0,99801	0,99807
2.9	*0,99813*	*0,99819*	*0,99825*	*0,99831*	*0,99836*	*0,99841*	*0,99846*	*0,99851*	*0,99856*	*0,99861*

Exercise 2→ question 2

Introduction of last-minute ticket for not sold tickets, price = 300 €

Co = opportunity cost to sell a discounted ticket but at the same time, company sells a last minute ticket for the unsold

$$Co = 600 - 300 = 300$$

LM tickets for empty seats of full price customers

Cu = company lost the opportunity to sell a ticket at full price (without sustaining related service costs) but gained the rate of discounted ticket

$$Cu = (1200 - 0{,}7 * 50) - 600 = 565$$

N.B. The Cu remains the same since there are no differences in respect to the first situation

Exercise 2 → question 2

$$P(X_1 < S_1) \leq \frac{Cu}{Co + Cu} = \frac{565}{300 + 565} = 0{,}653$$

F(Zα)= 0,653

Zα = 0,39

Full price tickets Protection level:

$$S_1 = 250 + 0{,}39 * 176{,}57 = 318{,}86 >> 319 \text{ seats}$$

Exercise 2 → question 3

Break-even point → Revenue = Costs

1) Rental rate = 80000 €
   Standard situation
   No-shows

2) Rental rate = 66000 €
   Standard situation
   No-shows

Exercise 2 → question 3 (Standard situation)

$$\text{Revenue} = X*1200 + (1000 - 243)*600 = 1200*X + 454200$$

- Real demand of full price customers
- Full customers price ticket
- Capacity
- Protection Level
- Discounted customers price ticket

$$\text{Costs} = 1000*50 + 1000*10 + 0{,}7*50*X + 80000 = 35*X + 140000$$

- Capacity
- Proceedings
- Catering
- Dinner
- Real demand of full price customers
- Rental Rate

Rental Rate = 80000 euros

Exercise 2 → question 3 (Standard situation)

Break-even point → Revenue = Costs

Revenues: $1200*X + 454200$

Costs: $35*X + 140000$

$1200*X + 454200 = 35*X + 140000$ → X= -1904,24

→ X= negative → company is sure to reach the breakeven point

Exercise 2 → question 3 (No-show phenomena)

Empty seats

$$\text{Revenues} = X*1200 + (1000 - 319)*600 + (319\text{-}X)*300 = 900*X + 504300$$

- Real demand of full price customers
- Full customers price ticket
- Capacity
- Protection Level with No-phenomena
- Discounted customers price ticket
- Last minute price

$$\text{Costs} = 1000*50 + 1000*10 + 0{,}7*50*X + 80000 = 35*X + 140000$$

- Capacity
- Proceedings
- Catering
- Dinner for the 70% of full customers
- Real demand of full price customers
- Rental Fee

Rental Rate = 80000 euros

Exercise 2 → question 3 (Last minute)

Break-even point → Revenues = Costs

Revenues: $900*X + 504300$

Costs: $35*X + 140000$

$900*X + 504300 = 35*X + 140000$ → $X = -421{,}156$

→ X= negative → company is sure to reach the breakeven point

Exercise 2 → question 3

Break-even point with the new rental rate 600000 €

Revenue = X*1200 + (1000 – 243)*600
= 1200*X + 454200

Costs = 1000*50 +1000*10 + 0,7*50*X +600000
= 35*X + 660000

R=C

1200*X + 454200 = 35*X + 660000

→ X= 177 company has to sell 177 full price tickets to reach the break-even point

Exercise 2 → question 3

Break-even point with the new rental rate 600000 € and No-Shows

Revenue = X*1200 + (1000 – 319)*600 + (319-X)*300
= 900*X + 504300

Costs = 1000*50 +1000*10 + 0,7*50*X +600000
= 35*X + 660000

R=C

900*X + 504300 = 35*X + 660000

→ X= 180 full price tickets

Exercise 3

The Sales Manager of a Company decides to apply Yield Management for an important sports event. If the customers will book in advance (40 days before the event), they can buy tickets at a special price of 200 €. The manager, based on historical data, knows that if he decides to sell all the tickets at this special price, he will not have any problem selling all the 500 tickets. But he knows also that the yield management strategy can help to reach more profit from the event. So, he decides to introduce another price, 400 €, from 40 days before the event till the day before the event. The demand for tickets sold at 400 € is distributed as a normal distribution with an average of 300 and a probability of 80% to sell less or equal 400 tickets.

Both the typologies (discounted and full) are characterized by no-show phenomena. Data shows that usually, no-show related to people that have purchased tickets both at discounted and full price is equal to 10% (The ticket is not refundable under any circumstances).

The manager decides to print a flyer to promote the event. He will print the flyer 2 months and a half before the event. The cost for each flyer is 3 €.

Moreover, he has to hire a security service for the day of the event. He has to communicate to the security service Company (and pay) the right number of stewards that he needs, 35 days before the event. The cost for this service is calculated as 6 €/ticket. Also, there is a fixed cost of 3000€ for the stipulation of the contract.

He decides to offer a buffet after the event, just to the full-price customers. It will cost 12 €/ person, and it will be paid after the event. The historical data show that only 60 % of the full-price tickets sold will attend the buffet after the event.

a) You are required to calculate the protection level for the full price.

b) The manager promised to his Company to reach at lead a net profit of 45000. The rent for the sporting arena is 50000 €. Do you think that the manager will reach this net profit with a probability of 95%?

c) He decides to introduce a last-minute price (175€) to sell just the day of the event. How does the protection level change? Comment on it.

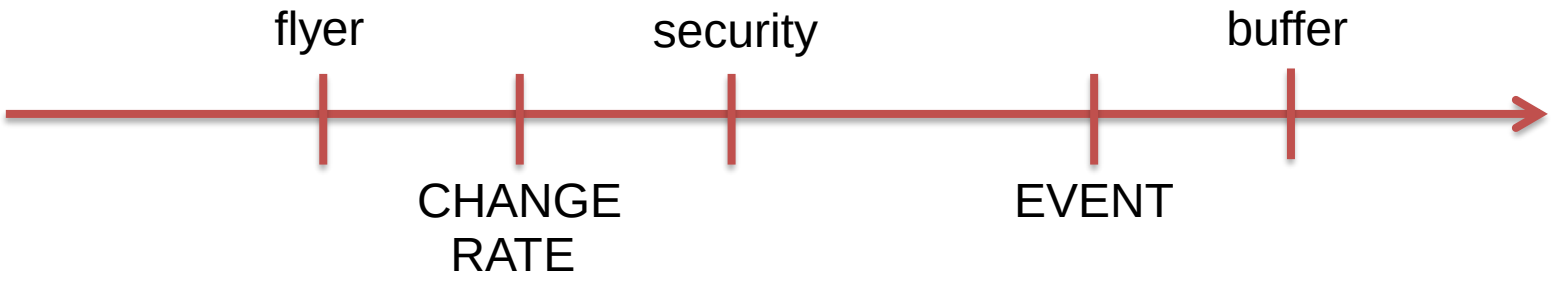
Exercise 3 → Data

Capacity= 500 seats
Demand follows a Normal Distribution N(300, ð)
P(X<=400) = 80% → σ = ?
Pf=400, Pd=200

These costs are not differential!

Costs

- Flyer= 3 €/p → BOTH (PRE)
- Security = 6 €/p → BOTH, (PRE)
- Security fixed cost = 3000 €
- Buffet = 12 €/p → FULL (POST for the 60%)



NO-SHOW phenomenon affects both ticket classes (10% of the cases)

Exercise 3 → question 1 Marginal Analysis

Co = opportunity cost to sell a discounted ticket (the other costs are not differential)

$$Co = 200$$

Cu = company lost the opportunity to sell a ticket at full price (without sustaining related service costs) but gained the rate of discounted ticket.

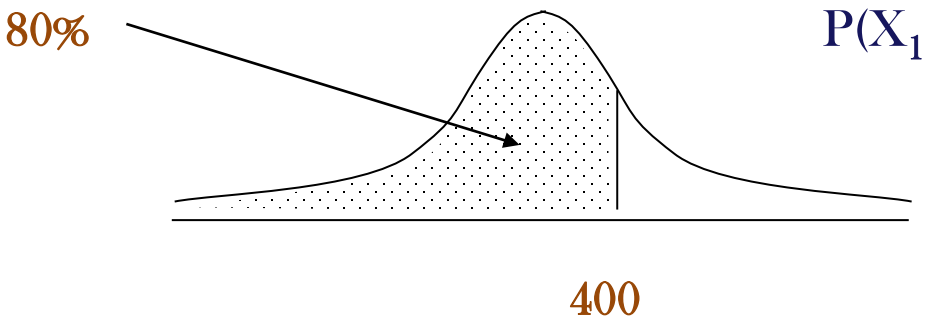
Only the 60% of the full price customers takes part to the buffet

$$Cu = (400 - 0{,}6 * 0{,}9 * 12) - 200 = 193{,}52$$

N.B. 10% of no-shows of full price customers→ only the 90% will participate and will have the have the buffet

Exercise 3 → question 1 Marginal Analysis

- Probability of demand lower or equal to 400:



$P(X_1 \leq 400) = 0,8$

Conversion to a standard normal distribution N(0,1):

$$P\left(\frac{X_1 - \mu}{\sigma} \leq \frac{400-300}{\sigma}\right) = 0,8$$

F(Zα)=0,8
Zα=0,84

$$\frac{400-300}{\sigma} = 0,84 \rightarrow \sigma = \frac{100}{0,84} = 119,05$$

Exercise 3 → question 3.1

$F(Z\alpha) = 0{,}80 \rightarrow Z\alpha = 0{,}84$ → Use the linear interpolation

$$\frac{y - y1}{y2 - y1} = \frac{x - x1}{x2 - x1}$$

$$\frac{y - 0{,}84}{0{,}85 - 0{,}84} = \frac{0{,}80 - 0{,}79955}{0{,}80234 - 0{,}79955}$$

$$Y = 0{,}842 = 0{,}84$$

Φ_α	.00	.01	.02	.03	.04	.05	.06	.07	.08	.09
0.0	0,50000	0,50399	0,50798	0,51197	0,51595	0,51994	0,52392	0,52790	0,53188	0,53586
0.1	*0,53983*	*0,54380*	*0,54776*	*0,55172*	*0,55567*	*0,55962*	*0,56356*	*0,56749*	*0,57142*	*0,57535*
0.2	0,57926	0,58317	0,58706	0,59095	0,59483	0,59871	0,60257	0,60642	0,61026	0,61409
0.3	*0,61791*	*0,62172*	*0,62552*	*0,62930*	*0,63307*	*0,63683*	*0,64058*	*0,64431*	*0,64803*	*0,65173*
0.4	0,65542	0,65910	0,66276	0,66640	0,67003	0,67364	0,67724	0,68082	0,68439	0,68793
0.5	*0,69146*	*0,69497*	*0,69847*	*0,70194*	*0,70540*	*0,70884*	*0,71226*	*0,71566*	*0,71904*	*0,72240*
0.6	0,72575	0,72907	0,73237	0,73565	0,73891	0,74215	0,74537	0,74857	0,75175	0,75490
0.7	*0,75804*	*0,76115*	*0,76424*	*0,76730*	*0,77035*	*0,77337*	*0,77637*	*0,77935*	*0,78230*	*0,78524*
0.8	0,78814	0,79103	0,79389	0,79673	0,79955	0,80234	0,80511	0,80785	0,81057	0,81327
0.9	*0,81594*	*0,81859*	*0,82121*	*0,82381*	*0,82639*	*0,82894*	*0,83147*	*0,83398*	*0,83646*	*0,83891*
1.0	0,84134	0,84375	0,84614	0,84849	0,85083	0,85314	0,85543	0,85769	0,85993	0,86214
1.1	*0,86433*	*0,86650*	*0,86864*	*0,87076*	*0,87286*	*0,87493*	*0,87698*	*0,87900*	*0,88100*	*0,88298*
1.2	0,88493	0,88686	0,88877	0,89065	0,89251	0,89435	0,89617	0,89796	0,89973	0,90147
1.3	*0,90320*	*0,90490*	*0,90658*	*0,90824*	*0,90988*	*0,91149*	*0,91308*	*0,91466*	*0,91621*	*0,91774*
1.4	0,91924	0,92073	0,92220	0,92364	0,92507	0,92647	0,92785	0,92922	0,93056	0,93189
1.5	*0,93319*	*0,93448*	*0,93574*	*0,93699*	*0,93822*	*0,93943*	*0,94062*	*0,94179*	*0,94295*	*0,94408*
1.6	0,94520	0,94630	0,94738	0,94845	0,94950	0,95053	0,95154	0,95254	0,95352	0,95449
1.7	*0,95543*	*0,95637*	*0,95728*	*0,95818*	*0,95907*	*0,95994*	*0,96080*	*0,96164*	*0,96246*	*0,96327*
1.8	0,96407	0,96485	0,96562	0,96638	0,96712	0,96784	0,96856	0,96926	0,96995	0,97062
1.9	*0,97128*	*0,97193*	*0,97257*	*0,97320*	*0,97381*	*0,97441*	*0,97500*	*0,97558*	*0,97615*	*0,97670*
2.0	0,97725	0,97778	0,97831	0,97882	0,97932	0,97982	0,98030	0,98077	0,98124	0,98169
2.1	*0,98214*	*0,98257*	*0,98300*	*0,98341*	*0,98382*	*0,98422*	*0,98461*	*0,98500*	*0,98537*	*0,98574*
2.2	0,98610	0,98645	0,98679	0,98713	0,98745	0,98778	0,98809	0,98840	0,98870	0,98899
2.3	*0,98928*	*0,98956*	*0,98983*	*0,99010*	*0,99036*	*0,99061*	*0,99086*	*0,99111*	*0,99134*	*0,99158*
2.4	0,99180	0,99202	0,99224	0,99245	0,99266	0,99286	0,99305	0,99324	0,99343	0,99361
2.5	*0,99379*	*0,99396*	*0,99413*	*0,99430*	*0,99446*	*0,99461*	*0,99477*	*0,99492*	*0,99506*	*0,99520*
2.6	0,99534	0,99547	0,99560	0,99573	0,99585	0,99598	0,99609	0,99621	0,99632	0,99643
2.7	*0,99653*	*0,99664*	*0,99674*	*0,99683*	*0,99693*	*0,99702*	*0,99711*	*0,99720*	*0,99728*	*0,99736*
2.8	0,99744	0,99752	0,99760	0,99767	0,99774	0,99781	0,99788	0,99795	0,99801	0,99807
2.9	*0,99813*	*0,99819*	*0,99825*	*0,99831*	*0,99836*	*0,99841*	*0,99846*	*0,99851*	*0,99856*	*0,99861*

Exercise 3 → question 1 Marginal Analysis

$$P(X_1 < S_1) \leq \frac{Cu}{Co + Cu} = \frac{193{,}52}{200 + 193{,}52} = 0{,}4918$$

F(Zα)= 0,4918 → 0,4918< 0,5

Use the complementary value of 0,4918 in the table
1-0,4918= 0,5082 → Zα = -0,02

Full price tickets Protection level:

$$S_1 = 300 - 0{,}02 * 119{,}05 = 297{,}6 >> 298 seats$$

Exercise 3 → question 2 Breakeven point

Revenue – Costs = Target Profit

rent of arena = 50000 €

profit target = 45000 €

Revenues = X*400 + (500 – 298)*200

= 400*X + 40400

Costs = 500*3 +500*6 + 0,6*0,9*12*X +3000+50000

= 6,48*X + 57500

Exercise 3 → question 2 Breakeven point

R-C=Target Profit

$400*X + 40400 - (6{,}48*X + 57500) = 45000$

$X=157{,}8 \rightarrow 158$ (Minimum number of full price customers ticket)

$$P(X_1 \geq 158) = P\left(\frac{X_1 - \mu}{\sigma} \geq \frac{158 - \mu}{\sigma}\right) = P\left(Z_1 \geq \frac{158 - 300}{119{,}05}\right) =$$

$$P(Z_1 \geq -1{,}193) = 1 - P(Z_1 \leq -1{,}193) = 1 - 0{,}117 =$$

$$= 0{,}883$$

The probability to reach profit target is lower than 95%

Exercise 3→ question 3 Last Minute Ticket

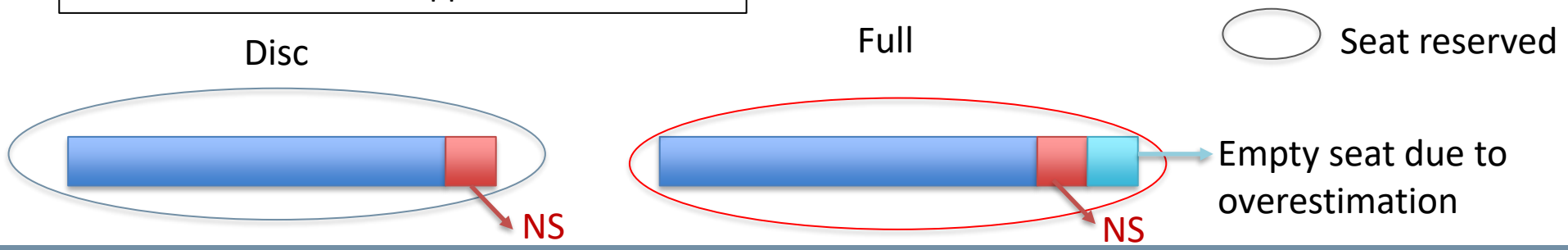
Introduction of last-minute ticket, price = 175 €

Co = opportunity cost to sell a discounted ticket (and additional last minute revenue in 10% of cases) but at the same time, company sells a last minute ticket for the not sold tickets

$$Co = (200 + 0{,}1 * 175) - 175 = 42{,}5$$

LM tickets for no-shows of discounted price customers that happens for 10%

LM tickets for empty seats of full price customers



Exercise 3→ question 3 Last Minute Ticket

Introduction of last-minute ticket, price = 175 €

Cu = company losts the opportunity to sell a ticket at full price (without sustaining related service costs) but gained the rate of discounted ticket (for both tickets there is an additional last minute revenue from no-show phenomenon)

$Cu = (400 - 0{,}6 * 0{,}9 * 12 + 0{,}1 * 175) - (200 + 0{,}1 * 175) = 193{,}52$

LM tickets for no-shows of full price customers that happens for 10%

LM tickets for no-shows of discounted price customers that happens for 10%

Exercise 3 → question 3.1

$$P(X_1 < S_1) \leq \frac{Cu}{Co + Cu} = \frac{193{,}52}{42{,}5 + 193{,}52} = 0{,}819$$

$F(Z\alpha) = 0{,}819$

$Z\alpha = 0{,}92$ → From the Normal Distribution Table

Full price tickets Protection level:

$$S_1 = 300 + 0{,}92 * 119{,}05 = 409{,}5 >> 410 seats$$

Φ_α	.00	.01	.02	.03	.04	.05	.06	.07	.08	.09
0.0	0,50000	0,50399	0,50798	0,51197	0,51595	0,51994	0,52392	0,52790	0,53188	0,53586
0.1	*0,53983*	*0,54380*	*0,54776*	*0,55172*	*0,55567*	*0,55962*	*0,56356*	*0,56749*	*0,57142*	*0,57535*
0.2	0,57926	0,58317	0,58706	0,59095	0,59483	0,59871	0,60257	0,60642	0,61026	0,61409
0.3	*0,61791*	*0,62172*	*0,62552*	*0,62930*	*0,63307*	*0,63683*	*0,64058*	*0,64431*	*0,64803*	*0,65173*
0.4	0,65542	0,65910	0,66276	0,66640	0,67003	0,67364	0,67724	0,68082	0,68439	0,68793
0.5	*0,69146*	*0,69497*	*0,69847*	*0,70194*	*0,70540*	*0,70884*	*0,71226*	*0,71566*	*0,71904*	*0,72240*
0.6	0,72575	0,72907	0,73237	0,73565	0,73891	0,74215	0,74537	0,74857	0,75175	0,75490
0.7	*0,75804*	*0,76115*	*0,76424*	*0,76730*	*0,77035*	*0,77337*	*0,77637*	*0,77935*	*0,78230*	*0,78524*
0.8	0,78814	0,79103	0,79389	0,79673	0,79955	0,80234	0,80511	0,80785	0,81057	0,81327
0.9	*0,81594*	*0,81859*	*0,82121*	*0,82381*	*0,82639*	*0,82894*	*0,83147*	*0,83398*	*0,83646*	*0,83891*
1.0	0,84134	0,84375	0,84614	0,84849	0,85083	0,85314	0,85543	0,85769	0,85993	0,86214
1.1	*0,86433*	*0,86650*	*0,86864*	*0,87076*	*0,87286*	*0,87493*	*0,87698*	*0,87900*	*0,88100*	*0,88298*
1.2	0,88493	0,88686	0,88877	0,89065	0,89251	0,89435	0,89617	0,89796	0,89973	0,90147
1.3	*0,90320*	*0,90490*	*0,90658*	*0,90824*	*0,90988*	*0,91149*	*0,91308*	*0,91466*	*0,91621*	*0,91774*
1.4	0,91924	0,92073	0,92220	0,92364	0,92507	0,92647	0,92785	0,92922	0,93056	0,93189
1.5	*0,93319*	*0,93448*	*0,93574*	*0,93699*	*0,93822*	*0,93943*	*0,94062*	*0,94179*	*0,94295*	*0,94408*
1.6	0,94520	0,94630	0,94738	0,94845	0,94950	0,95053	0,95154	0,95254	0,95352	0,95449
1.7	*0,95543*	*0,95637*	*0,95728*	*0,95818*	*0,95907*	*0,95994*	*0,96080*	*0,96164*	*0,96246*	*0,96327*
1.8	0,96407	0,96485	0,96562	0,96638	0,96712	0,96784	0,96856	0,96926	0,96995	0,97062
1.9	*0,97128*	*0,97193*	*0,97257*	*0,97320*	*0,97381*	*0,97441*	*0,97500*	*0,97558*	*0,97615*	*0,97670*
2.0	0,97725	0,97778	0,97831	0,97882	0,97932	0,97982	0,98030	0,98077	0,98124	0,98169
2.1	*0,98214*	*0,98257*	*0,98300*	*0,98341*	*0,98382*	*0,98422*	*0,98461*	*0,98500*	*0,98537*	*0,98574*
2.2	0,98610	0,98645	0,98679	0,98713	0,98745	0,98778	0,98809	0,98840	0,98870	0,98899
2.3	*0,98928*	*0,98956*	*0,98983*	*0,99010*	*0,99036*	*0,99061*	*0,99086*	*0,99111*	*0,99134*	*0,99158*
2.4	0,99180	0,99202	0,99224	0,99245	0,99266	0,99286	0,99305	0,99324	0,99343	0,99361
2.5	*0,99379*	*0,99396*	*0,99413*	*0,99430*	*0,99446*	*0,99461*	*0,99477*	*0,99492*	*0,99506*	*0,99520*
2.6	0,99534	0,99547	0,99560	0,99573	0,99585	0,99598	0,99609	0,99621	0,99632	0,99643
2.7	*0,99653*	*0,99664*	*0,99674*	*0,99683*	*0,99693*	*0,99702*	*0,99711*	*0,99720*	*0,99728*	*0,99736*
2.8	0,99744	0,99752	0,99760	0,99767	0,99774	0,99781	0,99788	0,99795	0,99801	0,99807
2.9	*0,99813*	*0,99819*	*0,99825*	*0,99831*	*0,99836*	*0,99841*	*0,99846*	*0,99851*	*0,99856*	*0,99861*

Exercise 3 → question 3.2

Profit → Revenue – Costs = Profit

rent of arena = 50000 €

profit target = 45000 €

1) Revenue = X*400 + (500 – 410)*200 +

+0,1*[X+(500 – 410)]*175 + (410 – X)*175 =

= 242,5*X + 91325

Costs = 500*3 +500*6 + 0,6*0,9*12*X +3000+50000

= 6,48*X + 57500

Exercise 3 → question 3.2

R-C=Pr

$$242{,}5*X + 91325 - (6{,}48*X + 57500) = 45000$$

$$X=47{,}3 \rightarrow 48$$

$$P(X_1 \geq 48) = P(\frac{X_1 - \mu}{\sigma} \geq \frac{48 - \mu}{\sigma}) = P(Z_1 \geq \frac{48 - 300}{119{,}05}) =$$

$$P(Z_1 \geq -2{,}12) = 1 - P(Z_1 \leq -2{,}12) = 1 - 0{,}017 =$$

$$= 0{,}983$$

The probability to reach profit target by introducing last minute ticket is greater than 95%!!

Some examples – How to shape the following systems?

1. The tickets sold for a concert are more than the available places. The day of the concert, some people do not show up and thus some places remain empty. Map the situation and try to think about what would you do.

2. Alitalia have sold all the flight tickets and thus the crew have prepared the meal for all the passengers who have purchased the tickets. Moreover, they have purchased some gadgets for those people flying in the first class, but these gadgets can be reused for the next flight in case of no show-up of some passenger.

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