Problem 08

Green Paradise

E217-Inventory Management

SCHOOL OF ENGINEERING

Perishable Goods

- Perishability ≠ Obsolescence
- Perishability refers to physical deterioration or expiry of the product but demand continues.
- Obsolescence implies there is negligible further demand for the SKU. These products are either sold or scraped.
- When demand is uncertain:

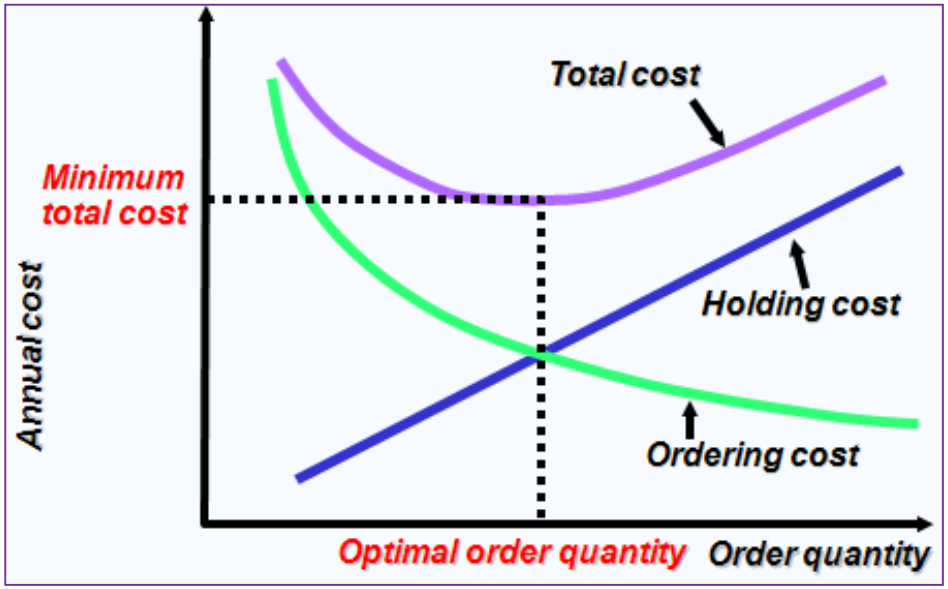
  Order less: cannot satisfy the customer demand

  Order more: over-stock means not just inventory holding cost but the total loss of the products
- Examples of Perishable Commodities
  - Bread, vegetables, fresh meat, flowers, Mini Sushi Bento, magazines, etc

EOQ?

No!

- EOQ is to balance ordering cost and holding cost
- For perishable commodities, inventory holding cost is not a major concern and reorder point is determined by when the perishable 'expires'



Safety Stock?

- Safety stock means that certain amounts of **same** products are always stored for unpredicted demand.
- Perishable commodities cannot have safety stock

No!

Demand Frequency and Probability

- Perishables can have very uncertain demands
- Use historical data to estimate the range of demands and their distribution.

Frequency

- How often a certain demand occurs during a particular period of time.

Demand Probability

- The **chance** of a certain demand occurs during a particular period of time.

Demand	Demand Frequency	Demand Probability
164	1	0.02
165	2	0.03
166	4	0.07
167	5	0.08
168	6	0.10
169	8	0.13
170	8	0.13
171	7	0.12
172	6	0.10
173	5	0.08
174	3	0.05
175	2	0.03
176	2	0.03
177	1	0.02

Cab Fare Question

- In a week (5 days), you take a cab to school every day.
- You pay S$10 on Monday and Thursday, S$12 on Tuesday and Wednesday and S$15 on Friday. What is the frequency of paying the different cab fares?
- What is the probability of you paying each specify amount of the cab fare?

Cab Fare (S$)	Frequency	Probability
10	2	0.4
12	2	0.4
15	1	0.2

Expected cab fare:

E(cab fare) = 0.4x10 + 0.4x12 + 0.2x15 = S$11.8

Payoff Table Analysis

If selling price is $2 and cost price is $0.5, order quantity and demand vary:

If order quantity > demand

- Profit = demand x $2 – order quantity x $0.5

If order quantity ≤ demand

- Profit = order quantity x ($2 - $0.5)

Payoff Table (Example)

	Demand		
Order Quantity	**164**	**165**	**166**
164	**164x1.5**	**164x1.5**	**164x1.5**
165	**164x2-165x0.5**	**165x1.5**	**165x1.5**
166	**164x2-166x0.5**	**165x2-166x0.5**	**166x1.5**

Payoff Table Analysis

	Demand	164	165	166	167	168	169	170	171	172	173	174	175	176	177	
	Frequency	1	2	4	5	6	8	8	7	6	5	3	2	2	1	Expected
	Demand Prob	0.02	0.03	0.07	0.08	0.10	0.13	0.13	0.12	0.10	0.08	0.05	0.03	0.03	0.02	Profit
Order Quantity	164	246.0	246.0	246.0	246.0	246.0	246.0	246.0	246.0	246.0	246.0	246.0	246.0	246.0	246.0	$246.00
	165	245.5	247.5	247.5	247.5	247.5	247.5	247.5	247.5	247.5	247.5	247.5	247.5	247.5	247.5	$247.47
	166	245.0	247.0	249.0	249.0	249.0	249.0	249.0	249.0	249.0	249.0	249.0	249.0	249.0	249.0	$248.87
	167	244.5	246.5	248.5	250.5	250.5	250.5	250.5	250.5	250.5	250.5	250.5	250.5	250.5	250.5	$250.13
	168	244.0	246.0	248.0	250.0	252.0	252.0	252.0	252.0	252.0	252.0	252.0	252.0	252.0	252.0	$251.23
	169	243.5	245.5	247.5	249.5	251.5	253.5	253.5	253.5	253.5	253.5	253.5	253.5	253.5	253.5	$252.13
	170	243.0	245.0	247.0	249.0	251.0	253.0	255.0	255.0	255.0	255.0	255.0	255.0	255.0	255.0	$252.77
	171	242.5	244.5	246.5	248.5	250.5	252.5	254.5	256.5	256.5	256.5	256.5	256.5	256.5	256.5	$253.13
	172	242.0	244.0	246.0	248.0	250.0	252.0	254.0	256.0	258.0	258.0	258.0	258.0	258.0	258.0	$253.27
	173	241.5	243.5	245.5	247.5	249.5	251.5	253.5	255.5	257.5	259.5	259.5	259.5	259.5	259.5	$253.20
	174	241.0	243.0	245.0	247.0	249.0	251.0	253.0	255.0	257.0	259.0	261.0	261.0	261.0	261.0	$252.97
	175	240.5	242.5	244.5	246.5	248.5	250.5	252.5	254.5	256.5	258.5	260.5	262.5	262.5	262.5	$252.63
	176	240.0	242.0	244.0	246.0	248.0	250.0	252.0	254.0	256.0	258.0	260.0	262.0	264.0	264.0	$252.23
	177	239.5	241.5	243.5	245.5	247.5	249.5	251.5	253.5	255.5	257.5	259.5	261.5	263.5	265.5	$251.77

Expected Profit

Based on the relative frequency of each demand, Alice can work out the expected daily profit for each order quantity.

E.g. if order quantity = 170,

E(Order qty = 170)

$= \sum_{d} f_d P_d$

= 0.02*243+0.03*245+0.07*247+…….+0.03*255+0.03*255+0.02*255

= $252.77

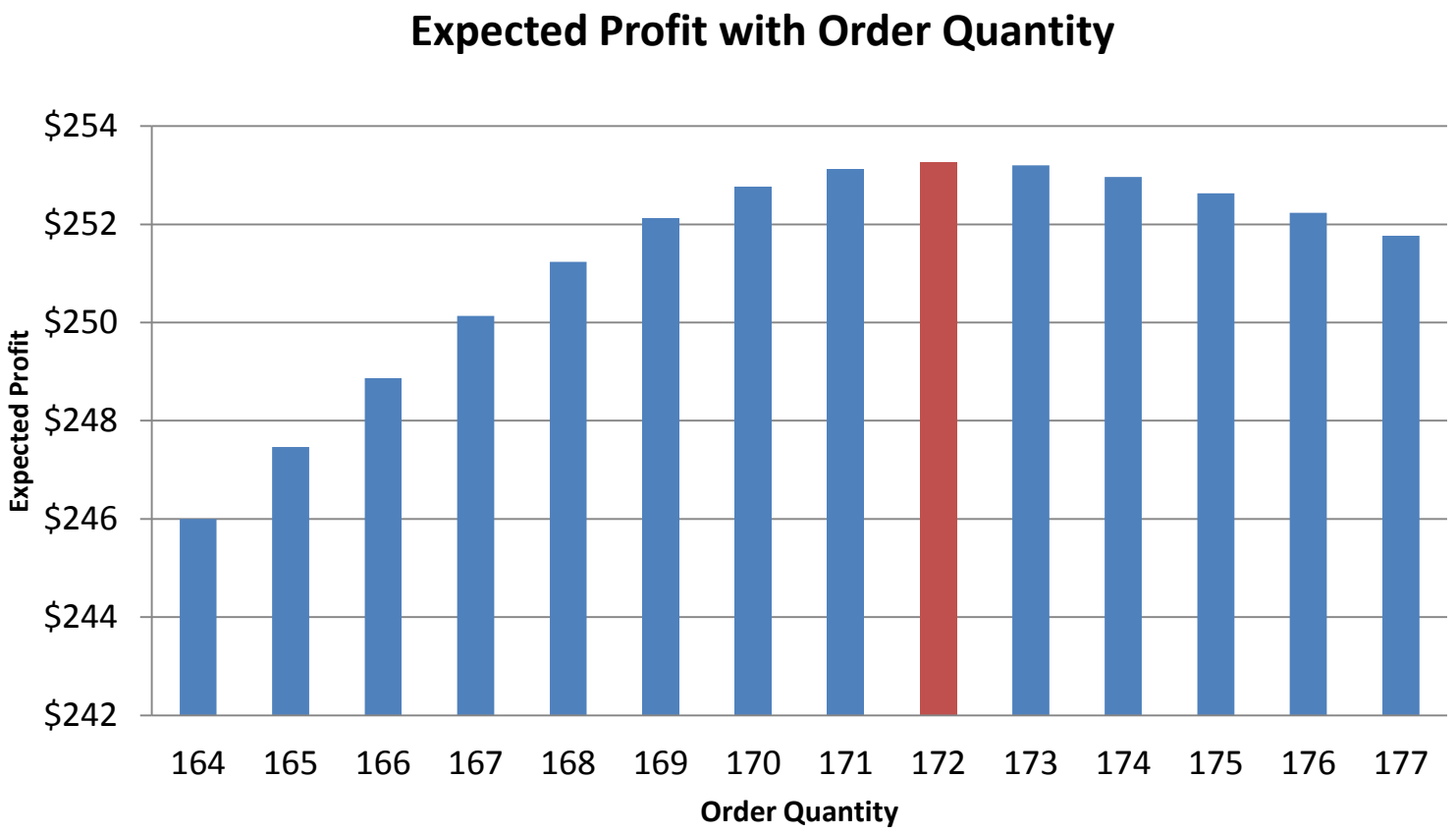
Where f_d = Probability of demand d happening,

P_d = Profit if demand is d

Expected Profit

	Demand	164	165	166	167	168	169	170	171	172	173	174	175	176	177	
	Frequency	1	2	4	5	6	8	8	7	6	5	3	2	2	1	Expected
	Demand Prob	0.02	0.03	0.07	0.08	0.10	0.13	0.13	0.12	0.10	0.08	0.05	0.03	0.03	0.02	Profit
Order Quantity	164	246.0	246.0	246.0	246.0	246.0	246.0	246.0	246.0	246.0	246.0	246.0	246.0	246.0	246.0	$246.00
	165	245.5	247.5	247.5	247.5	247.5	247.5	247.5	247.5	247.5	247.5	247.5	247.5	247.5	247.5	$247.47
	166	245.0	247.0	249.0	249.0	249.0	249.0	249.0	249.0	249.0	249.0	249.0	249.0	249.0	249.0	$248.87
	167	244.5	246.5	248.5	250.5	250.5	250.5	250.5	250.5	250.5	250.5	250.5	250.5	250.5	250.5	$250.13
	168	244.0	246.0	248.0	250.0	252.0	252.0	252.0	252.0	252.0	252.0	252.0	252.0	252.0	252.0	$251.23
	169	243.5	245.5	247.5	249.5	251.5	253.5	253.5	253.5	253.5	253.5	253.5	253.5	253.5	253.5	$252.13
	170	243.0	245.0	247.0	249.0	251.0	253.0	255.0	255.0	255.0	255.0	255.0	255.0	255.0	255.0	$252.77
	171	242.5	244.5	246.5	248.5	250.5	252.5	254.5	256.5	256.5	256.5	256.5	256.5	256.5	256.5	$253.13
	172	242.0	244.0	246.0	248.0	250.0	252.0	254.0	256.0	258.0	258.0	258.0	258.0	258.0	258.0	$253.27
	173	241.5	243.5	245.5	247.5	249.5	251.5	253.5	255.5	257.5	259.5	259.5	259.5	259.5	259.5	$253.20
	174	241.0	243.0	245.0	247.0	249.0	251.0	253.0	255.0	257.0	259.0	261.0	261.0	261.0	261.0	$252.97
	175	240.5	242.5	244.5	246.5	248.5	250.5	252.5	254.5	256.5	258.5	260.5	262.5	262.5	262.5	$252.63
	176	240.0	242.0	244.0	246.0	248.0	250.0	252.0	254.0	256.0	258.0	260.0	262.0	264.0	264.0	$252.23
	177	239.5	241.5	243.5	245.5	247.5	249.5	251.5	253.5	255.5	257.5	259.5	261.5	263.5	265.5	$251.77

Expected Profit



Maximum profit of $253.27 can be achieved with an order quantity of 172 packets

Marginal Analysis

- Useful for discrete demand distribution, continuous demand distribution, seasonal or perishable goods
- Let :

p = probability of selling at least one more (the marginal) unit

(1-p) = probability of not selling one more unit

MP = profit realized from selling that additional unit (marginal profit)

ML = loss realized if the additional unit is not sold (marginal loss)

Marginal Analysis

- Compare the gain/loss for ordering one more item:
- Expected Profit = Expected Loss

p x MP = (1-p) x ML

p= ML/(MP+ML)

p = margin loss / (marginal loss + marginal profit)

Hence,

Critical Ratio = ML / (MP + ML)

Today's Problem (Q12)

- ML = purchase price = 0.5
- MP = selling price – purchase price = 2 – 0.5 = 1.5
- **Critical Ratio = ML/ (MP+ML) = 0.5 / (1.5+0.5) = 0.25**

The probability of selling 172 or more is 0.32 (this is **more than** 0.25 !!)

The probability of selling 173 or more is 0.22 (this is **less than** 0.25 !!)

- Recommendations: order **172** packets of the organic lettuce.

Demand (D)	Demand Prob	Prob. Of selling D or MORE
164	0.02	1.00
165	0.03	0.98
166	0.07	0.95
167	0.08	0.88
168	0.10	0.80
169	0.13	0.70
170	0.13	0.57
171	0.12	0.43
172	0.10	0.32
173	0.08	0.22
174	0.05	0.13
175	0.03	0.08
176	0.03	0.05
177	0.02	0.02

Today's Problem (Q13)

If Salvage value is $0.40

- ML = purchase price – salvage value = 0.5 – 0.4= 0.1
- MP = selling price – purchase price = 2 – 0.5 = 1.5

- **Critical Ratio = ML/ (MP+ML) =0.1/(0.1+1.5) = 0.06**

The probability of selling 175 or more is 0.08 (this is **more than** 0.06 !!)

The probability of selling 176 or more is 0.05 (this is **less than** 0.06 !!)

With salvage value for the organic lettuce per packet, the recommended order quantity will be **175** packets.

Demand (D)	Demand Prob	Prob. Of selling D or MORE
164	0.02	1.00
165	0.03	0.98
166	0.07	0.95
167	0.08	0.88
168	0.10	0.80
169	0.13	0.70
170	0.13	0.57
171	0.12	0.43
172	0.10	0.32
173	0.08	0.22
174	0.05	0.13
175	0.03	0.08
176	0.03	0.05
177	0.02	0.02

Today's Problem (Q14) – Return Policy

- Most of suppliers or manufacturers offer a return policy to their customers for perishable products. It states that customers can return the unsold products with a minimal price.
- This policy will give more confidence to customers to buy more at the beginning. Thus, it is a win-win situation for both supplier and customer
- The return price offered by the supplier is normally very low, but it still saves the effort for companies to find their own way to recover the costs.
- Of course, if companies can sell the unwanted products at a higher price, they will do that first before they return to suppliers eventually

Learning Objectives

- Describe the characteristics of perishables
- Describe why the EOQ model is not an appropriate inventory management model for perishables
- Describe why carrying safety stock is not appropriate for perishables
- Apply the Payoff Table Analysis to a given business case-study
- Apply the Marginal Analysis to a given business case-study
- Calculate the optimal order quantity and profits for a given business case-study