Math 251/Buad427 **ACTIVITY 10:** Inventory Management Perishable Goods, Uncertain Demand

Why

The single-period, uncertain demand case extends many of the basic principles of inventory control and of operations research generally into a different situation. It also provides an opportunity to recall the use of expected value in decision-making.

LEARNING OBJECTIVES

1. Work as a team, using the team roles
2. Understand and be able to apply the single period, uncertain demand inventory model

CITERIA

1. Success in working as a team and in fulfilling the team roles.
2. Understanding of the material by all team members
3. Success in completing the exercises.

RESOURCES

1. Class notes from Wednesday 11/18
2. Your text – section 8.8
3. Microsoft Excel on the campus network and the inventory.xls workbook
4. 50 minutes

PLAN

1. Select roles, if you have not already done so, and decide how you will carry out steps 2 and 3
2. Work through the exercises given below you will submit one (team) copy of the work, with the usual reports [see the syllabus]
3. Assess the team's work and roles performances and prepare the Reflector's and Recorder's reports including team grade.
4. Be prepared to discuss your results

DISCUSSION

We are dealing with a situation in which a perishable item is being sold in a fixed time period (souvenir t-shirts at a concert, newspapers from a newsstand – daily, etc.). We must decide ahead of time how many items to order (Q). Only one order can be placed for each time period (each day), and we must pay for items ordered, whether they sell or not. Unsold items may have a salvage value (certainly less than our cost – possibly even negative, if disposal costs something) but cannot be held and sold in the next period. Demand D is uncertain, but we assume that we know the probability distribution for D (that is, we can can find $P(D \leq d)$ for any value d). The main components of the decision process are

1. Bayes decision rule: Under conditions of uncertainty, select the alternative that gives the best expected value when the whole range of possible situations is considered.[There are other rules used in other situations]
2. Marginal analysis: The process of making decisions of "what level to work/order/spend " based on the marginal cost (or profit – but here we'll use profit) – the *change* in profit for increasing effort/order size/spending. The general rule – we obtain the highest profit by looking at the point at which our marginal cost changes from positive to negative.
3. The *service level* attained by a given ordering policy. Most simply stated, it is the probability that all the demand is met [note: its not the percent of the demand that is met, but how often – on what proportion of the days – the demand is fully met.]. That is, the service level from ordering Q items is $P[D \leq Q]$.

The analysis: What happens when we add one more item to our order size Q?
If the order size is no larger than the demand (If $Q+1 \leq D$) we add one more sale (add p to income), pay for one more item (add c to costs) and avoid one irritated customer (subtract g from costs) – profit increases by $p-c+g$. The probability this happens is exactly $P[D \geq Q+1] = 1 - P[D \leq Q]$.
If the (new) order size is greater than demand ($Q+1 > D$), we don't sell any more items, but we do pay for one more item (cost increases by c) and we have one more item to sell for salvage (profit increases by s) – change in profit is $-c+s$. The probability of this is $Pr[D < Q+1) = Pr[D \leq Q]$

Notice that the probability here– $P[D \leq Q]$– is the *service level* – the probability (percent of the time) that the demand is met.

So our marginal change in *expected* profit is $(p-c+g)(1-P[D \leq Q])+(-c+s)P[D \leq Q]$. We can play algebra and rewrite this as $(p+g-c)-(p+g-s)P[D \leq Q]$. We want to increase Q as long as this is positive and stop increasing Q when this is negative. So we want to keep increasing Q as long as $P[D \leq Q] < \dfrac{p+g-c}{p+g-s}$ and stop as soon as $P[D \leq Q] \geq \dfrac{p+g-c}{p+g-s}$.

CONCLUSION We should select, as Q^*, the *smallest order size* for which $P[D \leq Q]$ (the *service level*) is at least $\dfrac{p+g-c}{p+g-s}$

MODEL

Harveys Newsstand sells "Whats New at ND". It costs Harvey's \$1.50 for each copy, and they sell the paper for \$2.50. Unsold papers can be returned to the publisher for a credit of \$.50, and the manager believes that customer goodwill (if customers who want the paper can't get it) costs about \$.25 for each disappointed customer. The demand each day is 9, 10, or 11 papers, with probability .3, .4, .3,

The expected value from ordering 10 papers per day is P(D=9)(10-9)(\$1.00) + P(D = 10)(0) + P(D=11)(11-10)(\$1.25) = \$.675 and we can calculate expected values for other plans similarly. With so few options, we could calculate the expected profit for each possible order level and apply Bayes decision rule to choose the best..

On the other hand, we can immediately calculate the optimal service level. Harveys optimal service level is $\dfrac{2.50+.25-1.50}{2.50+.25-.50} = .55.5\%$ (order enough papers that demand is satisfied 55.5% of the time– we could use of either of the single-period templates to confirm this). This is achieved by ordering 10 papers a day (demand is 10 or fewer papers per day 70% of the time, but is 9 or fewer only 30% of the time).

EXERCISES

1. Jennifers Donut House serves a large variety of doughnuts, including a specialty – a large-size, blueberry-filled chocolate-covered doughnut with sprinkles (intended to be shared). Preparation must begin by 4:00 am, so a decision must be made ahead of time on the number of these doughnuts to make. The cost for materials and labor is \$1 per doughnut, and the sale price is \$3. Any doughnuts not sold during the day are sold to a local discount grocery store for \$.25 each. Some families make a special trip to the shop just for this special doughnut, so the manager believes there is a goodwill cost, which he estimates at \$.75 per unmet request. The setup cost for making any size batch of the special is \$1.50. Over time, Jennifers has developed the following distribution of number of doughnuts requested per day (at the shop):

# doughnuts	0	1	2	3	4	5
% of days	10	15	20	30	15	10

   (a) What is the profit on a day when 3 special doughnuts are made and 2 are sold?
   (b) What is the profit on a day when 3 special doughnuts are made and 5 customers want to buy them?
   (c) What is the expected profit (it might be negative, indicating a loss) of a policy of making 3 of these doughnuts each day?
   (d) What is the optimal service level [use formula or template]?
   (e) What is the optimal number of doughnuts to make per day? [You need to decide this – template gives correct service level, but doesn't give quantity calculation for this probability distribution]

2. Text - exercise #12 for chapter 8 [Use template]

SKILL EXERCISES:(hand in - individually - at next class meeting)

p.492 # 6, 25, 26 (goodwill cost is *negative* because the company feels it benefits. Watch out for five plates/ per plate differences), 44 (note the salvage value is *negative* – they have to *pay* to dispose of unsold trees)