MANAGING INVENTORY IN THE FACE OF UNCERTAINTY

The Newsvendor Problem

IE2030

You are the GaTech Barnes & Noble Merchandise Buyer

#BB12 - Final Four tee

100% cotton -shirt with Final Four logo
$21.98.

It’s Sunday, March 28.
The Jackets just made it to the Final Four.

Before heading out to celebrate, you need to call your T-shirt supplier and order Final Four merchandise.

How many do you order?

Georgia Tech Bookstore - Microsoft Internet Explorer

EN English (United States)

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Address http://gatech.bkstore.com/default.asp?m=0302&cat_id=648 Go Links

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BARNES&NOBLE @ Georgia Tech

Your Campus Bookstore - Where a portion of every sale goes back to Georgia Tech!

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STUDENT SERVICES | FACULTY SERVICES

your shopping bag | 0 items total Subtotal: $0.00 | check out

Visit the Georgia Tech website at http://www.gatech.edu.

Privacy | Security | Shipping | Terms of Use | VeriSign

Home > Campus Shop > **Shop by Category**

Shipping Delays

Due to the high demand for Georgia Tech Final Four merchandise, mail orders may be delayed. Orders placed with Next Day Air or Second Day Air shipping will receive priority. We are working day and night, seven days a week to get you your Yellow Jacket merchandise quickly.

Shop by Product Category

- All Gifts
- FINAL FOUR
- Fine Gifts
- Georgia Tech Alumni
- Georgia Tech Baseball
- Golf

Shop by Category

Your Campus Bookstore - Where a portion of every sale goes back to Georgia Tech!

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#BB11 - St. Louis Regional Champs tee

100% cotton with NCAA Division I St. Louis Regional Champions logo

$21.98.

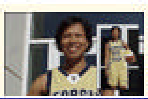
add to cart

#BB12 - Final Four tee

100% cotton t-shirt with Final Four logo

$21.98.

add to cart



#BB2 - Basketball Jersey by Russell

100% Polyester basketball jersey features front chest Georgia Tech "00" and Buzz logos with back "00".

$149.98

add to cart

Georgia Tech aux [search auxiliary services] [auxiliary links] [calendar] [disclaimer] important stuff

Need to think about

Cost and price

Lead time

Uncertainty in demand

What happens to Final Four T-shirt sales if the Jackets

lose the semifinal?

win the semifinal?

win the final?

Value of leftovers after Monday? After this season?

The Newsvendor Framework

- One chance to decide on the stocking quantity for the product you're selling
- Demand for the product is uncertain
- Known marginal profit for each unit sold and known marginal loss for the ones that are bought and not sold
- Goal: Maximize expected profit

Examples where the Newsvendor framework is appropriate

- Perishable goods
  - Meals in a cafeteria
  - Dairy foods
- Short selling season
  - Christmas trees, toys
  - Flowers on Valentine’s day
  - Fashion clothes, seasonal clothes
  - Newspapers

The Newsvendor Problem

- Newsvendor selling the New York Times
- Sells the papers for $1.00
- Buys them for 70 cents
- Leftover papers sold at discount: 20 cents each.
- He will definitely sell at least 35 papers, but no more than 40:
  - 35 papers with probability 0.10
  - 36 papers with probability 0.15
  - 37 papers with probability 0.25
  - 38 papers with probability 0.25
  - 39 papers with probability 0.15
  - 40 papers with probability 0.1

How Many Papers Should He Buy To Maximize His Expected Profit?

Marginal analysis

x	Probabili-ty that demand = x	P = Prob. of selling the xth unit	(1-P)=Prob. of NOT selling the xth unit	P x $0.3 =Expected profit from selling xth unit	(1-P) x $0.5 =Expected loss from NOT selling xth unit	Expected NET profit from stocking xth unit
<35	0					
35	0.1	1.0	0	$0.30	$0	$0.30
36						
37						
38						
39						
40						
>40						

Marginal analysis

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<35	0					
35	0.1	1.0	0	$0.30	$0	$0.30
36	0.15	0.9	0.1	$0.27	$0.05	$0.22
37						
38						
39						
40						
>40						

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35	0.1	1.0	0	\$0.30	\$0	\$0.30
36	0.15	0.9	0.1	\$0.27	\$0.05	\$0.22
37	0.25	0.75	0.25	\$0.225	\$0.125	\$0.10
38						
39						
40						
>40						

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36	0.15	0.9	0.1	\$0.27	\$0.05	\$0.22
37	0.25	0.75	0.25	\$0.225	\$0.125	\$0.10
38	0.25	0.50	0.50	\$0.15	\$0.25	\$-0.10
39	0.15	0.25	0.75	\$0.075	\$0.375	\$-0.30
40	0.1	0.1	0.9	\$0.03	\$0.45	\$-0.42
>40	0	0	1	\$0.0	\$0.50	\$-0.50

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38	0.25	0.50	0.50	$0.15	$0.25	$-0.10
39	0.15	0.25	0.75	$0.075	$0.375	$-0.30
40	0.1	0.1	0.9	$0.03	$0.45	$-0.42
>40	0	0	1	$0.0	$0.50	$-0.50

X=37*

Decreasing marginal returns to each additional unit.

Solution

Start from 35, buy an additional paper only if you expect to make extra profits.

Let's generalize!

c: cost

r: selling price

s: salvage value

MP: marginal profit from selling a stocked unit = r-c

ML: marginal loss from NOT selling a stocked unit = c-s

x: the number of newspapers you buy.

P(x): the probability that the xth newspaper is sold.

Solution

Buy one more unit only if the expected net profit of doing so is positive.

Buying *x* is profitable if

$$P(x)\ MP - (1-P(x))\ ML = 0$$

$$P(x) = ML\ /\ (MP + ML)$$

Critical ratio:

$$Pc = ML\ /\ (MP + ML)$$

Optimal solution: Buy largest *x* such that

$$P(x) = Pc$$

Solution

In this problem:
***MP* = \$1-\$0.70 = \$0.30**
***ML* = \$0.70 -\$0.20 = \$0.50**

Pc=ML / (MP+ML) = 50 / (50+30) = 0.625

Buy largest x such that P(selling xth unit) = Pc

Marginal analysis

x	Probability that demand = x	P= Prob. of selling the xth unit	(1-P)=Prob. of NOT selling the xth unit	P x $0.3 =Expected profit from selling xth unit	(1-P) x $0.5 =Expected loss from NOT selling xth unit	Expected NET profit from stocking xth unit
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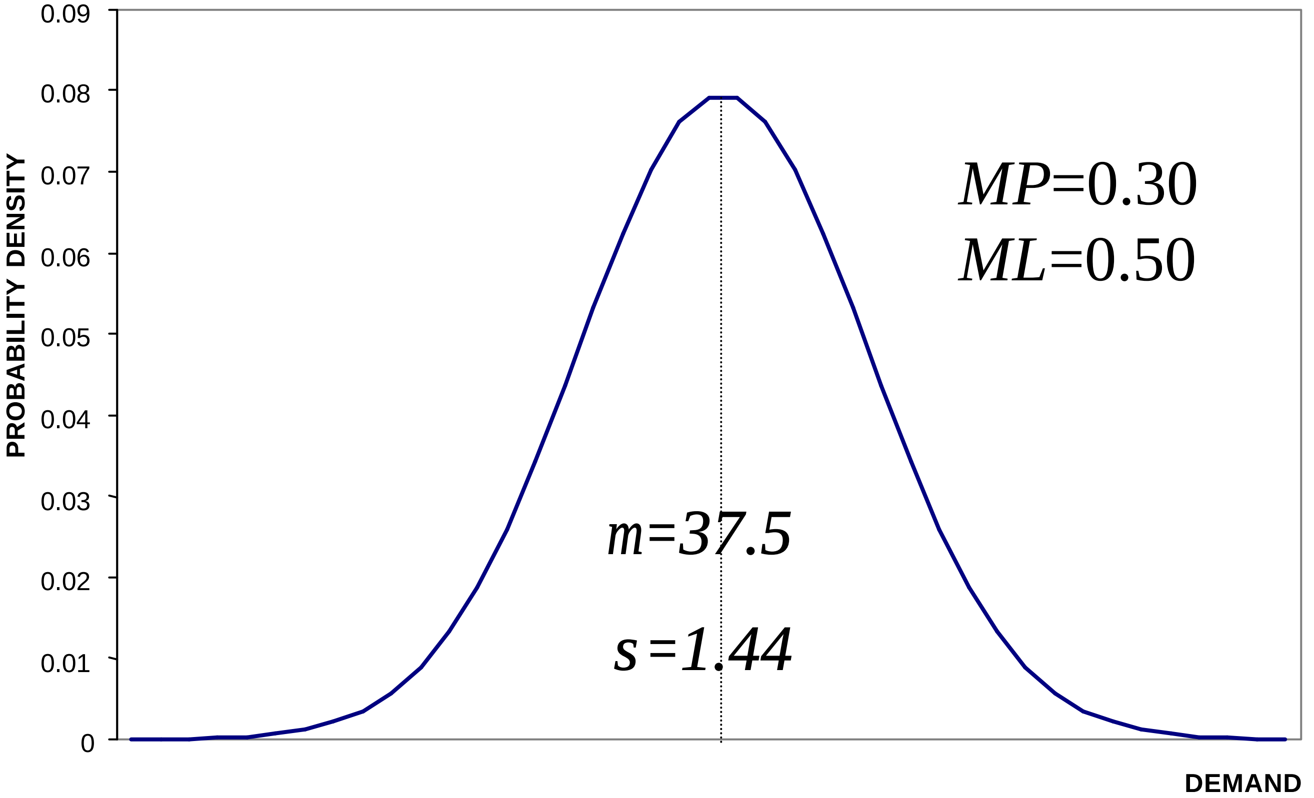
[illegible]	0.15	0.9	0.1	$0.27	$0.05	$0.22
37	0.25	0.75	0.25	$0.225	$0.125	$0.10
38	0.25	0.50	0.50	$0.15	$0.25	$-0.10
39	0.15	0.25	0.75	$0.075	$0.375	$-0.30
40	0.1	0.1	0.9	$0.03	$0.45	$-0.42
>40	0	0	1	$0.0	$0.50	$-0.50

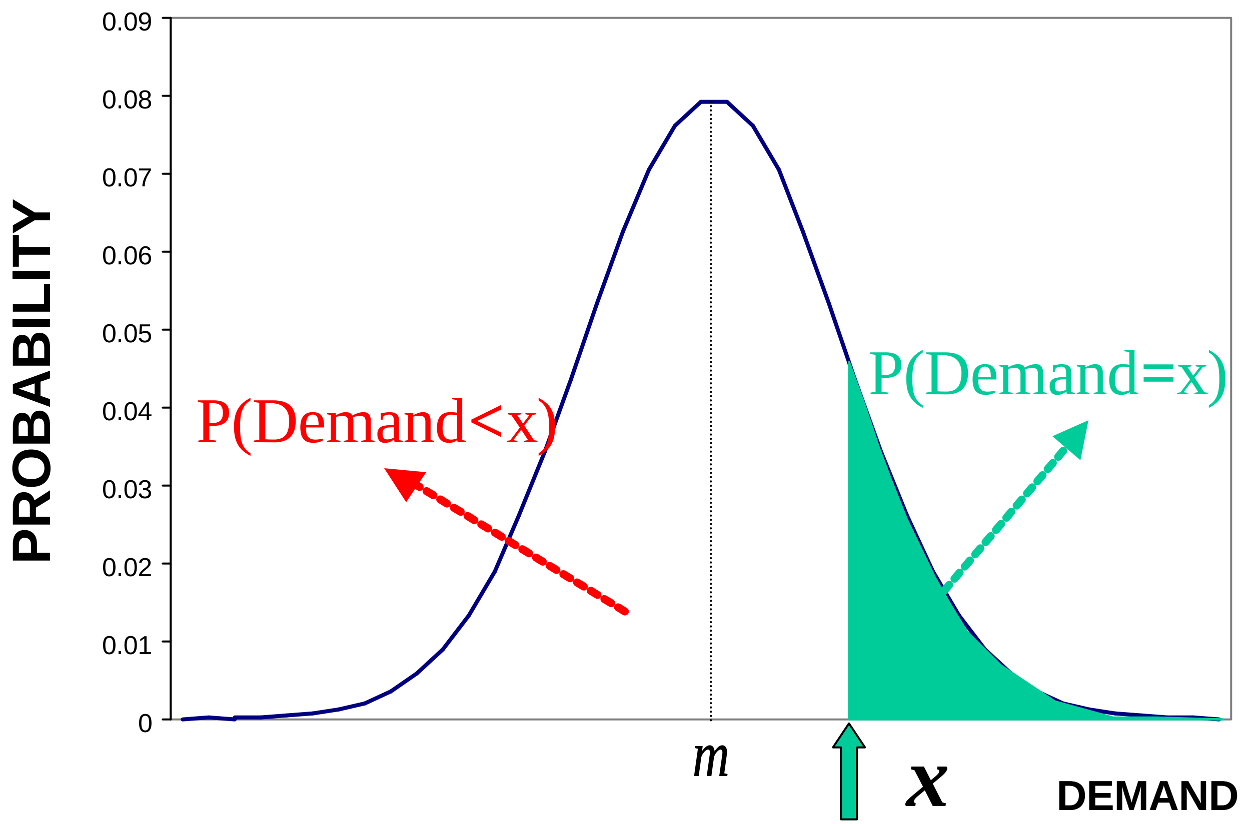
X*=37

Pc = 0.625

Now Let's Assume that Demand is Normally Distributed

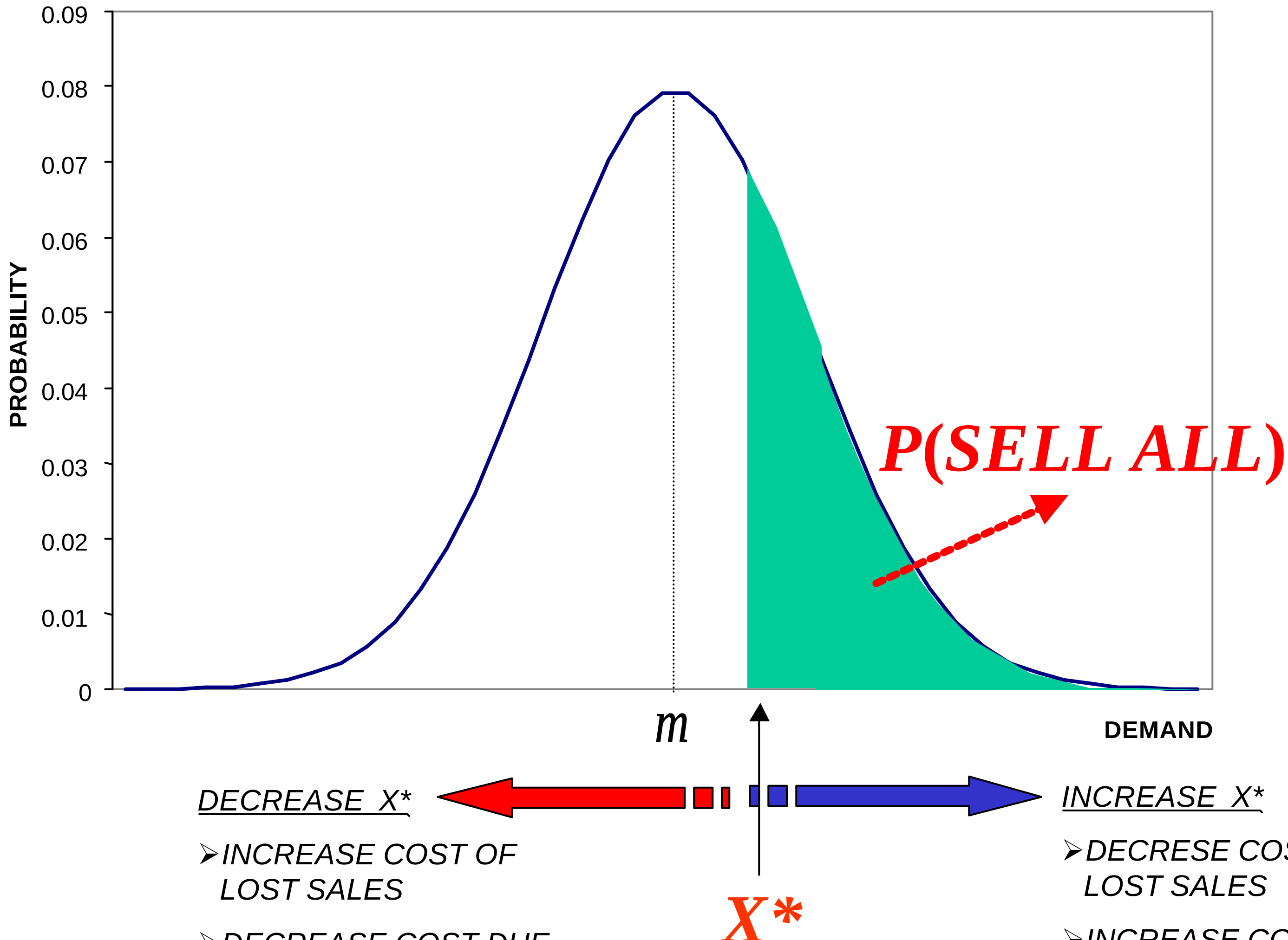


How do we find order quantity X*?



P(Demand = x) = P(ALL x newspapers are sold)

Choose X* such that
P (Demand = X)* = Pc



<u>*DECREASE X**</u>

- *INCREASE COST OF LOST SALES*
- *DECREASE COST DUE TO UNSOLD ITEMS*

<u>*INCREASE X**</u>

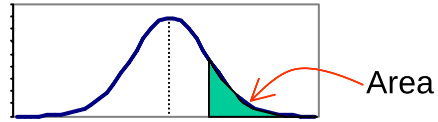
- *DECRESE COST OF LOST SALES*
- *INCREASE COST DUE UNSOLD ITEMS*

Newsvendor: Solution with Normal Distribution

- Remember: $MP = 0.30; ML = 0.50$
- Then Pc is

  $$Pc=ML / (MP+ML)=50/(50+30)=0.625$$

- *Look at the z table to find the z corresponding to Pc*
- $X^*=m + z\ s$



Area	z	Area	z	Area	z	Area	z	Area	z	Area	z	Area	z	Area	z
0.005	2.576	0.130	1.126	0.255	0.659	0.380	0.305	0.505	-0.013	0.630	-0.332	0.755	-0.690	0.880	-1.175
0.010	2.326	0.135	1.103	0.260	0.643	0.385	0.292	0.510	-0.025	0.635	-0.345	0.760	-0.706	0.885	-1.200
0.015	2.170	0.140	1.080	0.265	0.628	0.390	0.279	0.515	-0.038	0.640	-0.358	0.765	-0.722	0.890	-1.227
0.020	2.054	0.145	1.058	0.270	0.613	0.395	0.266	0.520	-0.050	0.645	-0.372	0.770	-0.739	0.895	-1.254
0.025	1.960	0.150	1.036	0.275	0.598	0.400	0.253	0.525	-0.063	0.650	-0.385	0.775	-0.755	0.900	-1.282
0.030	1.881	0.155	1.015	0.280	0.583	0.405	0.240	0.530	-0.075	0.655	-0.399	0.780	-0.772	0.905	-1.311
0.035	1.812	0.160	0.994	0.285	0.568	0.410	0.228	0.535	-0.088	0.660	-0.412	0.785	-0.789	0.910	-1.341
0.040	1.751	0.165	0.974	0.290	0.553	0.415	0.215	0.540	-0.100	0.665	-0.426	0.790	-0.806	0.915	-1.372
0.045	1.695	0.170	0.954	0.295	0.539	0.420	0.202	0.545	-0.113	0.670	-0.440	0.795	-0.824	0.920	-1.405
0.050	1.645	0.175	0.935	0.300	0.524	0.425	0.189	0.550	-0.126	0.675	-0.454	0.800	-0.842	0.925	-1.440
0.055	1.598	0.180	0.915	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	-1.476
0.060	1.555	0.185	0.896	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	-1.514
0.065	1.514	0.190	0.878	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	-1.555
0.070	1.476	0.195	0.860	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	-1.598
0.075	1.440	0.200	0.842	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	-1.645
0.080	1.405	0.205	0.824	0.330	0.440	0.455	0.113	0.580	-0.202	[illegible]	-0.539	0.830	-0.954	0.955	-1.695
0.085	1.372	0.210	0.806	0.335	0.426	0.460	0.100	0.585	-0.215	0.710	-0.553	0.835	-0.974	0.960	-1.751
0.090	1.341	0.215	0.789	0.340	0.412	0.465	0.088	0.590	-0.228	0.715	-0.568	0.840	-0.994	0.965	-1.812
0.095	1.311	0.220	0.772	0.345	0.399	0.470	0.075	0.595	-0.240	0.720	-0.583	0.845	-1.015	0.970	-1.881
0.100	1.282	0.225	0.755	0.350	0.385	0.475	0.063	0.600	-0.253	0.725	-0.598	0.850	-1.036	0.975	-1.960
0.105	1.254	0.230	0.739	0.355	0.372	0.480	0.050	0.605	-0.266	0.730	-0.613	0.855	-1.058	0.980	-2.054
0.110	1.227	0.235	0.722	0.360	0.358	0.485	0.038	0.610	-0.279	0.735	-0.628	0.860	-1.080	0.985	-2.170
0.115	1.200	0.240	0.706	0.365	0.345	0.490	0.025	0.615	-0.292	0.740	-0.643	0.865	-1.103	0.990	-2.326
0.120	1.175	0.245	0.690	0.370	0.332	0.495	0.013	0.620	-0.305	0.745	-0.659	0.870	-1.126	0.995	-2.576
0.125	1.150	0.250	0.674	0.375	0.319	0.500	0.000	0.625	-0.319	0.750	-0.674	0.875	-1.150		

Area = $Pc=0.625$

z = -0.32

$X^*=m + z\ s = 37.5 + (-0.32)\ 1.44 = 37.04$

What Do We Learn from the Newsvendor?

- Forecasts are always wrong. A demand estimate that only gives the mean is too simple, you also need the standard deviation.
- The optimal order quantity depends on the relative cost of stocking too much and stocking too little.
- The smaller the standard deviation, the closer will be the order to the mean.