

# ***Supply Chain Engineering Homework #7***

*Ram Prashanth Radha Krishnan*

*NU ID# 001904200*

**Problem #1**

Given:

**Make-to-Stock (No Contract)**

In case there is No Contract between the Manufacturer and Distributor,

Distributor	
Selling Cost/Unit	\$125
Buying Cost/Unit	\$80
Manufacturer	
Fixed Cost	\$100,000
Variable Cost/Unit	\$55
Selling Price to Distributor/Unit	\$80
Selling price to Discount store/unit	\$20

Manufacturer Produces 8,000 Units				
Demand	Probability	Revenue	Cost	Profit
8,000	0.11	\$640,000	\$540,000	\$100,000
10,000	0.11	\$640,000	\$540,000	\$100,000
12,000	0.28	\$640,000	\$540,000	\$100,000
14,000	0.22	\$640,000	\$540,000	\$100,000
16,000	0.18	\$640,000	\$540,000	\$100,000
18,000	0.10	\$640,000	\$540,000	\$100,000
Expected Profit for Manufacturer				\$100,000
Profit for the Distributor = $8000 \times (125 - 80)$				\$360,000

Manufacturer Produces 10,000 Units				
Demand	Probability	Revenue	Cost	Profit
8,000	0.11	\$680,000	\$650,000	\$30,000
10,000	0.11	\$800,000	\$650,000	\$150,000
12,000	0.28	\$800,000	\$650,000	\$150,000
14,000	0.22	\$800,000	\$650,000	\$150,000
16,000	0.18	\$800,000	\$650,000	\$150,000
18,000	0.10	\$800,000	\$650,000	\$150,000
Expected Profit for Manufacturer				\$136,800
Profit for the Distributor = $10000 \times (125 - 80)$				\$450,000

Manufacturer Produces 12,000 Units				
Demand	Probability	Revenue	Cost	Profit
8000	0.11	\$720,000	\$760,000	-\$40,000
10000	0.11	\$840,000	\$760,000	\$80,000
12000	0.28	\$960,000	\$760,000	\$200,000
14000	0.22	\$960,000	\$760,000	\$200,000
16000	0.18	\$960,000	\$760,000	\$200,000
18000	0.1	\$960,000	\$760,000	\$200,000
Expected Profit for Manufacturer				\$160,400
Profit for the Distributor = $12000 \times (125 - 80)$				\$540,000

Manufacturer Produces 14,000 Units				
Demand	Probability	Revenue	Cost	Profit
8000	0.11	\$760,000	\$870,000	-\$110,000
10000	0.11	\$880,000	\$870,000	\$10,000
12000	0.28	\$1,000,000	\$870,000	\$130,000
14000	0.22	\$1,120,000	\$870,000	\$250,000
16000	0.18	\$1,120,000	\$870,000	\$250,000
18000	0.1	\$1,120,000	\$870,000	\$250,000
Expected Profit for Manufacturer				\$150,400
Profit for the Distributor = 14000*(125-80)				\$630,000

Manufacturer Produces 16,000 Units				
Demand	Probability	Revenue	Cost	Profit
8000	0.11	\$800,000	\$980,000	-\$180,000
10000	0.11	\$920,000	\$980,000	-\$60,000
12000	0.28	\$1,040,000	\$980,000	\$60,000
14000	0.22	\$1,160,000	\$980,000	\$180,000
16000	0.18	\$1,280,000	\$980,000	\$300,000
18000	0.1	\$1,280,000	\$980,000	\$300,000
Expected Profit for Manufacturer				\$114,000
Profit for the Distributor = 16000*(125-80)				\$720,000

Manufacturer Produces 18,000 Units				
Demand	Probability	Revenue	Cost	Profit
8000	0.11	\$840,000	\$1,090,000	-\$250,000
10000	0.11	\$960,000	\$1,090,000	-\$130,000
12000	0.28	\$1,080,000	\$1,090,000	-\$10,000
14000	0.22	\$1,200,000	\$1,090,000	\$110,000
16000	0.18	\$1,320,000	\$1,090,000	\$230,000
18000	0.1	\$1,440,000	\$1,090,000	\$350,000
Expected Profit for Manufacturer				\$56,000
Profit for the Distributor = 18000*(125-80)				\$810,000

The Summary of the Calculations is as Follows:

Distributor's Order	Manufacturer's Profit	Distributor's Profit	Total Profit
8,000	\$100,000	\$360,000	\$460,000
10,000	\$136,800	\$450,000	\$586,800
<b>12,000</b>	<b>\$160,400</b>	\$540,000	\$700,400
14,000	\$150,400	\$630,000	\$780,400
16,000	\$114,000	\$720,000	\$834,000
18,000	\$56,000	<b>\$810,000</b>	<b>\$866,000</b>

The **Manufacturer** assumes all the risk of producing excess stock. Hence, he has to limit the production quantity to **12,000 Units** in order to have highest expected profit by selling Ski-Jackets.

**Problem #2**

Given:

**Make-to-Stock (Pay-Back Contract)**

In case there is a Pay-Back Contract between the Manufacturer and Distributor,

Distributor	
Selling Cost/Unit	\$125
Buying Cost/Unit	\$80
Pay-Back Cost/Unit	\$18
Manufacturer	
Fixed Cost	\$100,000
Variable Cost/Unit	\$55
Selling Price to Distributor/Unit	\$80
Selling price to Discount store/unit	\$20

Manufacturer Produces 8,000 Units				
Demand	Probability	Revenue	Cost	Profit
8,000	0.11	\$640,000	\$540,000	\$100,000
10,000	0.11	\$640,000	\$540,000	\$100,000
12,000	0.28	\$640,000	\$540,000	\$100,000
14,000	0.22	\$640,000	\$540,000	\$100,000
16,000	0.18	\$640,000	\$540,000	\$100,000
18,000	0.10	\$640,000	\$540,000	\$100,000
Expected Profit for Manufacturer				<b>\$100,000</b>

Distributor Orders 8,000 Units				
Produced	Probability	Revenue	Cost	Profit
8,000	0.11	\$1,000,000	\$640,000	\$360,000
10,000	0.11	\$1,000,000	\$640,000	\$360,000
12,000	0.28	\$1,000,000	\$640,000	\$360,000
14,000	0.22	\$1,000,000	\$640,000	\$360,000
16,000	0.18	\$1,000,000	\$640,000	\$360,000
18,000	0.10	\$1,000,000	\$640,000	\$360,000
Expected Profit for Distributor				<b>\$360,000</b>

Manufacturer Produces 10,000 Units				
Demand	Probability	Revenue	Cost	Profit
8,000	0.11	\$716,000	\$650,000	\$66,000
10,000	0.11	\$800,000	\$650,000	\$150,000
12,000	0.28	\$800,000	\$650,000	\$150,000
14,000	0.22	\$800,000	\$650,000	\$150,000
16,000	0.18	\$800,000	\$650,000	\$150,000
18,000	0.10	\$800,000	\$650,000	\$150,000
Expected Profit for Manufacturer				<b>\$140,760</b>

Distributor Orders 10,000 Units				
Produced	Probability	Revenue	Cost	Profit
8,000	0.11	\$1,000,000	\$676,000	\$324,000
10,000	0.11	\$1,250,000	\$800,000	\$450,000
12,000	0.28	\$1,250,000	\$800,000	\$450,000
14,000	0.22	\$1,250,000	\$800,000	\$450,000
16,000	0.18	\$1,250,000	\$800,000	\$450,000
18,000	0.10	\$1,250,000	\$800,000	\$450,000
Expected Profit for Distributor				<b>\$436,140</b>

Manufacturer Produces 12,000 Units				
Demand	Probability	Revenue	Cost	Profit
8,000	0.11	\$792,000	\$760,000	\$32,000
10,000	0.11	\$876,000	\$760,000	\$116,000
12,000	0.28	\$960,000	\$760,000	\$200,000
14,000	0.22	\$960,000	\$760,000	\$200,000
16,000	0.18	\$960,000	\$760,000	\$200,000
18,000	0.10	\$960,000	\$760,000	\$200,000
Expected Profit for Manufacturer				<b>\$172,280</b>

Distributor Orders 12,000 Units				
Produced	Probability	Revenue	Cost	Profit
8,000	0.11	\$1,000,000	\$712,000	\$288,000
10,000	0.11	\$1,250,000	\$836,000	\$414,000
12,000	0.28	\$1,500,000	\$960,000	\$540,000
14,000	0.22	\$1,500,000	\$960,000	\$540,000
16,000	0.18	\$1,500,000	\$960,000	\$540,000
18,000	0.10	\$1,500,000	\$960,000	\$540,000
Expected Profit for Distributor				<b>\$498,420</b>

Manufacturer Produces 14,000 Units				
Demand	Probability	Revenue	Cost	Profit
8,000	0.11	\$868,000	\$870,000	-\$2,000
10,000	0.11	\$952,000	\$870,000	\$82,000
12,000	0.28	\$1,036,000	\$870,000	\$166,000
14,000	0.22	\$1,120,000	\$870,000	\$250,000
16,000	0.18	\$1,120,000	\$870,000	\$250,000
18,000	0.10	\$1,120,000	\$870,000	\$250,000
Expected Profit for Manufacturer				<b>\$180,280</b>

Distributor Orders 14,000 Units				
Produced	Probability	Revenue	Cost	Profit
8,000	0.11	\$1,000,000	\$748,000	\$252,000
10,000	0.11	\$1,250,000	\$872,000	\$378,000
12,000	0.28	\$1,500,000	\$996,000	\$504,000
14,000	0.22	\$1,750,000	\$1,120,000	\$630,000
16,000	0.18	\$1,750,000	\$1,120,000	\$630,000
18,000	0.10	\$1,750,000	\$1,120,000	\$630,000
Expected Profit for Distributor				<b>\$525,420</b>

Manufacturer Produces 16,000 Units				
Demand	Probability	Revenue	Cost	Profit
8,000	0.11	\$944,000	\$980,000	-\$36,000
10,000	0.11	\$1,028,000	\$980,000	\$48,000
12,000	0.28	\$1,112,000	\$980,000	\$132,000
14,000	0.22	\$1,196,000	\$980,000	\$216,000
16,000	0.18	\$1,280,000	\$980,000	\$300,000
18,000	0.10	\$1,280,000	\$980,000	\$300,000
Expected Profit for Manufacturer				<b>\$169,800</b>

Distributor Orders 16,000 Units				
Produced	Probability	Revenue	Cost	Profit
8,000	0.11	\$1,000,000	\$784,000	\$216,000
10,000	0.11	\$1,250,000	\$908,000	\$342,000
12,000	0.28	\$1,500,000	\$1,032,000	\$468,000
14,000	0.22	\$1,750,000	\$1,156,000	\$594,000
16,000	0.18	\$2,000,000	\$1,280,000	\$720,000
18,000	0.10	\$2,000,000	\$1,280,000	\$720,000
Expected Profit for Distributor				<b>\$524,700</b>

Manufacturer Produces 18,000 Units				
Demand	Probability	Revenue	Cost	Profit
8,000	0.11	\$1,020,000	\$1,090,000	-\$70,000
10,000	0.11	\$1,104,000	\$1,090,000	\$14,000
12,000	0.28	\$1,188,000	\$1,090,000	\$98,000
14,000	0.22	\$1,272,000	\$1,090,000	\$182,000
16,000	0.18	\$1,356,000	\$1,090,000	\$266,000
18,000	0.10	\$1,440,000	\$1,090,000	\$350,000
Expected Profit for Manufacturer				<b>\$144,200</b>

Distributor Orders 18,000 Units				
Produced	Probability	Revenue	Cost	Profit
8,000	0.11	\$1,000,000	\$820,000	\$180,000
10,000	0.11	\$1,250,000	\$944,000	\$306,000
12,000	0.28	\$1,500,000	\$1,068,000	\$432,000
14,000	0.22	\$1,750,000	\$1,192,000	\$558,000
16,000	0.18	\$2,000,000	\$1,316,000	\$684,000
18,000	0.10	\$2,250,000	\$1,440,000	\$810,000
Expected Profit for Distributor				<b>\$501,300</b>

The Summary of the Calculations is as Follows:

Distributor's Order	Manufacturer's Profit	Distributor's Profit	Total Profit
8,000	\$100,000	\$360,000	\$460,000
10,000	\$140,760	\$436,140	\$576,900
12,000	\$172,280	\$498,420	\$670,700
<b>14,000</b>	<b>\$180,280</b>	<b>\$525,420</b>	<b>\$705,700</b>
16,000	\$169,800	\$524,700	\$694,500
18,000	\$144,200	\$501,300	\$645,500

The **Manufacturer** assumes the risk of producing **14,000 Units** to increasing its profit and the Distributer is will to take the risk of paying back **\$18** for each extra unit manufactured, but not purchased by him, in order to make the manufacturer produce more Ski-Jackets. Hence, for Higher Expected Profit, the Manufacturer produces **14,000 Units** in order to have highest expected Profit and this also benefits the Distributor under **Pay-Back Contract**.

**Problem #3**

Given:

***Make-to-Stock (Cost-Sharing Contract)***

In case there is a Cost-Sharing Contract between the Manufacturer and Distributor,

Distributor	
Selling Cost/Unit	\$125
Buying Cost/Unit	\$62
Cost-Sharing Contract	30% of Manufacturing Cost
Manufacturer	
Fixed Cost	\$100,000
Variable Cost/Unit	\$55
Selling Price to Distributor/Unit	\$62
Selling price to Discount store/unit	\$20

Manufacturer Produces 8,000 Units				
Demand	Probability	Revenue	Cost	Profit
8,000	0.11	\$496,000	\$378,000	\$118,000
10,000	0.11	\$496,000	\$378,000	\$118,000
12,000	0.28	\$496,000	\$378,000	\$118,000
14,000	0.22	\$496,000	\$378,000	\$118,000
16,000	0.18	\$496,000	\$378,000	\$118,000
18,000	0.10	\$496,000	\$378,000	\$118,000
Expected Profit for Manufacturer				<b>\$118,000</b>

Distributor Orders 8,000 Units				
Produced	Probability	Revenue	Cost	Profit
8,000	0.11	\$1,000,000	\$658,000	\$342,000
10,000	0.11	\$1,000,000	\$658,000	\$342,000
12,000	0.28	\$1,000,000	\$658,000	\$342,000
14,000	0.22	\$1,000,000	\$658,000	\$342,000
16,000	0.18	\$1,000,000	\$658,000	\$342,000
18,000	0.10	\$1,000,000	\$658,000	\$342,000
Expected Profit for Distributor				<b>\$342,000</b>

Manufacturer Produces 10,000 Units				
Demand	Probability	Revenue	Cost	Profit
8,000	0.11	\$536,000	\$455,000	\$81,000
10,000	0.11	\$620,000	\$455,000	\$165,000
12,000	0.28	\$620,000	\$455,000	\$165,000
14,000	0.22	\$620,000	\$455,000	\$165,000
16,000	0.18	\$620,000	\$455,000	\$165,000
18,000	0.10	\$620,000	\$455,000	\$165,000
Expected Profit for Manufacturer				<b>\$155,760</b>

Distributor Orders 10,000 Units				
Produced	Probability	Revenue	Cost	Profit
8,000	0.11	\$1,000,000	\$731,000	\$269,000
10,000	0.11	\$1,250,000	\$815,000	\$435,000
12,000	0.28	\$1,250,000	\$815,000	\$435,000
14,000	0.22	\$1,250,000	\$815,000	\$435,000
16,000	0.18	\$1,250,000	\$815,000	\$435,000
18,000	0.10	\$1,250,000	\$815,000	\$435,000
Expected Profit for Distributor				<b>\$416,740</b>

Manufacturer Produces 12,000 Units				
Demand	Probability	Revenue	Cost	Profit
8000	0.11	\$576,000	\$532,000	\$44,000
10000	0.11	\$660,000	\$532,000	\$128,000
12000	0.28	\$744,000	\$532,000	\$212,000
14000	0.22	\$744,000	\$532,000	\$212,000
16000	0.18	\$744,000	\$532,000	\$212,000
18000	0.1	\$744,000	\$532,000	\$212,000
Expected Profit for Manufacturer				<b>\$184,280</b>

Distributor Orders 12,000 Units				
Produced	Probability	Revenue	Cost	Profit
8,000	0.11	\$1,000,000	\$804,000	\$196,000
10,000	0.11	\$1,250,000	\$888,000	\$362,000
12,000	0.28	\$1,500,000	\$972,000	\$528,000
14,000	0.22	\$1,500,000	\$972,000	\$528,000
16,000	0.18	\$1,500,000	\$972,000	\$528,000
18,000	0.10	\$1,500,000	\$972,000	\$528,000
Expected Profit for Distributor				<b>\$473,220</b>

Manufacturer Produces 14,000 Units				
Demand	Probability	Revenue	Cost	Profit
8000	0.11	\$616,000	\$609,000	\$7,000
10000	0.11	\$700,000	\$609,000	\$91,000
12000	0.28	\$784,000	\$609,000	\$175,000
14000	0.22	\$868,000	\$609,000	\$259,000
16000	0.18	\$868,000	\$609,000	\$259,000
18000	0.1	\$868,000	\$609,000	\$259,000
Expected Profit for Manufacturer				<b>\$189,280</b>

Distributor Orders 14,000 Units				
Produced	Probability	Revenue	Cost	Profit
8,000	0.11	\$1,000,000	\$877,000	\$123,000
10,000	0.11	\$1,250,000	\$961,000	\$289,000
12,000	0.28	\$1,500,000	\$1,045,000	\$455,000
14,000	0.22	\$1,750,000	\$1,129,000	\$621,000
16,000	0.18	\$1,750,000	\$1,129,000	\$621,000
18,000	0.10	\$1,750,000	\$1,129,000	\$621,000
Expected Profit for Distributor				<b>\$483,220</b>

Manufacturer Produces 16,000 Units				
Demand	Probability	Revenue	Cost	Profit
8000	0.11	\$656,000	\$686,000	-\$30,000
10000	0.11	\$740,000	\$686,000	\$54,000
12000	0.28	\$824,000	\$686,000	\$138,000
14000	0.22	\$908,000	\$686,000	\$222,000
16000	0.18	\$992,000	\$686,000	\$306,000
18000	0.1	\$992,000	\$686,000	\$306,000
Expected Profit for Manufacturer				<b>\$175,800</b>

Distributor Orders 16,000 Units				
Produced	Probability	Revenue	Cost	Profit
8,000	0.11	\$1,000,000	\$950,000	\$50,000
10,000	0.11	\$1,250,000	\$1,034,000	\$216,000
12,000	0.28	\$1,500,000	\$1,118,000	\$382,000
14,000	0.22	\$1,750,000	\$1,202,000	\$548,000
16,000	0.18	\$2,000,000	\$1,286,000	\$714,000
18,000	0.10	\$2,000,000	\$1,286,000	\$714,000
Expected Profit for Distributor				<b>\$456,700</b>

Manufacturer Produces 18,000 Units				
Demand	Probability	Revenue	Cost	Profit
8000	0.11	\$696,000	\$763,000	-\$67,000
10000	0.11	\$780,000	\$763,000	\$17,000
12000	0.28	\$864,000	\$763,000	\$101,000
14000	0.22	\$948,000	\$763,000	\$185,000
16000	0.18	\$1,032,000	\$763,000	\$269,000
18000	0.1	\$1,116,000	\$763,000	\$353,000
Expected Profit for Manufacturer				<b>\$147,200</b>

Distributor Orders 18,000 Units				
Produced	Probability	Revenue	Cost	Profit
8,000	0.11	\$1,000,000	\$1,023,000	-\$23,000
10,000	0.11	\$1,250,000	\$1,107,000	\$143,000
12,000	0.28	\$1,500,000	\$1,191,000	\$309,000
14,000	0.22	\$1,750,000	\$1,275,000	\$475,000
16,000	0.18	\$2,000,000	\$1,359,000	\$641,000
18,000	0.10	\$2,250,000	\$1,443,000	\$807,000
Expected Profit for Distributor				<b>\$400,300</b>

The Summary of the Calculations is as Follows:

Distributor's Order	Manufacturer's Profit	Distributor's Profit	Total Profit
8,000	\$118,000	\$342,000	\$460,000
10,000	\$155,760	\$416,740	\$572,500
12,000	\$184,280	\$473,220	\$657,500
<b>14,000</b>	<b>\$189,280</b>	<b>\$483,220</b>	<b>\$672,500</b>
16,000	\$175,800	\$456,700	\$632,500
18,000	\$147,200	\$400,300	\$547,500

The **Manufacturer** assumes the risk of producing **14,000 Units** for increasing his profit and the Distributer is will to take the risk of paying 30% of the production cost to the manufacturer in order to make the manufacturer reduce the selling price of the Ski-Jackets from **\$80** to **\$62**. Hence, for Higher Expected Profit, the Manufacturer produces **14,000 Units** in order to have highest expected Profit and this also benefits the Distributor under **Cost-Sharing Contract**.

#### Problem #4

Given:

The Weekly Demand for a certain type of Transformers at the Utility Company is normally distributed,

Mean	$D$	100
Standard Deviation	$\sigma_D$	50
Holding Cost	$I$	25%
Cycle Service Level	CSL	95%

Quote of the Two Suppliers:

Reliable Components	
Selling Price	\$5,000
Minimum Order Quantity	100
Lead Time, $L$	1
SD of Lead Time, $s_L$	0.1

Value Electric	
Selling Price	\$4,800
Minimum Order Quantity	1000
Lead Time, $L$	5
SD of Lead Time, $s_L$	4

#### Cost Analysis of Reliable Components

Annual Cost of Transformer =  $100 * 52 * \$5,000 = \$26,000,000$

Average Cycle Inventory =  $\frac{(100+0)}{2} = 50$

Annual Cost of Holding Cycle Inventory =  $50 * \$5,000 * 0.25 = \$62,500$

Standard Deviation of Demand during Lead Time,

$$\sigma_L = \sqrt{L * \sigma_D^2 + D^2 * s_L^2} = \sqrt{1 * 50^2 + 100^2 * 0.1^2} = \sqrt{2600} = 50.99 \approx 51$$

Safety Inventory required  $F_S^{-1}(CSL) * \sigma_L = F_S^{-1}(0.95) * 51 = 1.645 * 51 = 83.895 \approx 84$

Annual Cost of Holding Safety Inventory =  $84 * \$5,000 * 0.25 = \$105,000$

Total Annual Cost of the Supplier, Reliable Components

= Annual Cost of Transformer + Annual Cost of Holding Cycle Inventory + Annual Cost of Holding Safety Inventory

=  $\$26,000,000 + \$62,500 + \$105,000 = \$26,167,500$

#### Cost Analysis of Value Electric

Annual Cost of Transformer =  $100 * 52 * \$4,800 = \$24,960,000$

Average Cycle Inventory =  $\frac{(1000+0)}{2} = 500$

Annual Cost of Holding Cycle Inventory =  $500 * \$4,800 * 0.25 = \$600,000$

Standard Deviation of Demand during Lead Time,

$$\sigma_L = \sqrt{L * \sigma_D^2 + D^2 * s_L^2} = \sqrt{5 * 50^2 + 100^2 * 4^2} = \sqrt{172500} = 415.331 \approx 415$$

Safety Inventory required  $F_S^{-1}(CSL) * \sigma_L = F_S^{-1}(0.95) * 415 = 1.645 * 415 = 682.675 \approx 683$

Annual Cost of Holding Safety Inventory =  $683 * \$4,800 * 0.25 = \$819,600$

Total Annual Cost of the Supplier, Value Electric

= Annual Cost of Transformer + Annual Cost of Holding Cycle Inventory + Annual Cost of Holding Safety Inventory

=  $\$24,960,000 + \$600,000 + \$819,600 = \$26,379,600$

Even though the *Cost of the transformer* is low for *Value Electric*, the *Total Annual cost* of using *Value Electric* as supplier is higher than *Reliable Components*.

***The Utility Company should Reliable Components for this type of Transformer.***