

Week 3 Review: Risk and the Evaluation of Alternatives

- ◆ Example: Europa Solvent Industries

Europa Solvent Industries: Business Context

- ◆ Europa Solvent Industries (ESI) has a contract to supply one of its customers with 35 tons of a chemical solvent each day, for which it receives a daily payment of 10000€ per ton
- ◆ ESI operates a solvent production line whose processing speed, due to technological reasons, is somewhat unreliable. While its production line is tuned to produce 35 tons of solvent each day on average, on any particular day the actual production may fall below or above this value
- ◆ Analysis of the past data shows that the daily output of the production line, P , can be approximated as a normally distributed random variable with a mean of 35 tons and a standard deviation of 7 tons

Europa Solvent Industries: Business Context

- ◆ ESI's daily production cost is 9500€ per ton of solvent
- ◆ If ESI's daily production exceeds 35 tons, the company must sell the extra solvent it produces to a discount retail chain at a price of 9000€ per ton (i.e., at a loss as compared to ESI's production cost)
- ◆ In the case that the daily production falls short of 35 tons, ESI will sell all of its daily production to its customer at the price of 10000€ per ton, and it must also pay the customer a penalty of 2000€ for each ton below 35. For example, if the daily production happens to be 32.5 tons, ESI will pay the penalty of $(35 - 32.5) \times 2000\text{€} = 5000\text{€}$

Europa Solvent Industries: Questions

- ◆ Suppose that, on a particular day, the daily production P turns out to be 31 tons of solvent. What is the total profit ESI will make on that day?
- ◆ Consider a day when the company's daily production turns out to be 37 tons of solvent. What is the total profit ESI will make on that day?
- ◆ Write down an algebraic expression that calculates the company's total daily profit value V as a function of its daily production P
- ◆ Simulate (using $n=100$ simulation runs and seed = 123) the distribution of the total daily profit that ESI makes, V , and use the simulation results to answer the following questions:
 - What is estimate of the expected value of the total daily profit?
 - What is the estimate of the standard deviation of the total daily profit?

Europa Solvent Industries: Answers

- ◆ Suppose that, on a particular day, the daily production P turns out to be 31 tons of solvent. What is the total profit ESI will make on that day?

Answer: since the production on that day fell short of 35 tons, ESI will a) sell all of it to the customer at the price of 10000€ per ton, and b) will incur the penalty cost of 2000€ for each ton under 35.

ESI's regular revenue on that day is $10000\text{€} \times 31 = 310000\text{€}$

ESI's production cost on that day is $9500\text{€} \times 31 = 294500\text{€}$

ESI's penalty cost on that day is $2000\text{€} \times (35 - 31) = 8000\text{€}$

ESI's total profit on that day is $310000\text{€} - 294500\text{€} - 8000\text{€} = 7500\text{€}$

Europa Solvent Industries: Answers

- ◆ Consider a day when the company's daily production turns out be to 37 tons of solvent. What is the total daily profit ESI will make on that day?

Answer: since the production on that day exceeds 35 tons, ESI will a) sell 35 tons to the customer at the price of 10000€ per ton, and b) will sell 2 tons to the discount chain for 9000€ per ton.

ESI's regular revenue on that day is $10000\text{€} \times 35 = 350000\text{€}$

ESI's discount revenue on that day is $9000\text{€} \times (37 - 35) = 18000\text{€}$

ESI's production cost on that day is $9500\text{€} \times 37 = 351500\text{€}$

ESI's total profit on that day is $350000\text{€} + 18000\text{€} - 351500\text{€} = 16500\text{€}$

Europa Solvent Industries: Answers

- ◆ Write down an algebraic expression that calculates the company's daily profit value V as a function of its daily production P

Answer:

How we calculate ESI's total daily profit depends on whether its daily production is below 35 or at or above that value.

In the case that $P < 35$, ESI

- a) incurs production cost of $9500 * P$,
- b) sells all of its production at the price of 10000€ per ton, obtaining revenue of $10000 * P$ and
- c) incurs penalty cost of $2000 * (35 - P)$

In total, for $P < 35$, ESI's total daily profit is $10000 * P - 9500 * P - 2000 * (35 - P)$
 $= 500 * P - 2000 * (35 - P) = 500 * P - 70000 + 2000 * P = 2500 * P - 70000$

Europa Solvent Industries: Answers

In the case that $P \geq 35$, ESI

- a) incurs production cost of $9500 * P$, and
- b) sells the first 35 tons of its production at the price of 10000€ per ton, and the remaining $P-35$ tons at the discount price of 9000€ per ton, obtaining revenue of $10000 * 35 + 9000 * (P-35)$

In total, for $P \geq 35$, ESI's total daily profit is $10000 * 35 + 9000 * (P-35) - 9500 * P = -500 * P + 35000$.

Combining the two cases, we can write the expression for the total daily profit:

$$V = \text{IF}(P < 35, 2500 * P - 70000, -500 * P + 35000)$$

Europa Solvent Industries: Questions

- ◆ Simulate (using $n=100$ simulation runs and seed = 123) the distribution of the total daily profit that ESI makes, V , and use the simulation results to answer the following questions:
 - What is the estimate of the expected value of the total daily profit?
 - What is the estimate of the standard deviation of the total daily profit?

Europa Solvent Industries: Excel Simulation Set-up

	A	B	C	D	E	F
1	Europa Solvent.xlsx	Europa Solvent Industries Simulation	Simulation Run	Daily Production (tons)	Profit (in €)	
2	Operations Analytics MOOC	$V = \text{IF}(P < 35, 2500 * P - 70000, -500 * P + 35000)$	1	$=\text{IF}(E2 < 35, 2500 * E2 - 70000, -500 * E2 + 35000)$	40.50472022	94420.04600
3			2	30.45357004	10780.21100	
4	Expected Production (tons)	35	3	38.75592663	15622.03669	
5	St. Dev. of Production (tons)	7	4	33.22502218	13062.55545	
6			5	50.726946	9636.526998	
7	Regular Price (€/ton)	10000	6	26.01488356	-4962.791094	
8	Discount Price (€/ton)	9000	7	45.79115464	12104.42268	
9	Production Cost (€/ton)	9500	8	54.46151315	7769.243426	
10	Penalty Cost (€/ton)	2000	9	31.2860602	8215.150489	
11			10	$=\text{AVERAGE}(F2:F101)$	42.4521995	13773.90025
101			100	$=\text{STDEV}(F2:F101)$	34.74554374	9363.85935
102						
103						
104						
105						
106						

Sample Mean

8752.473671

Sample St. Dev.

9414.778914

◆ See Europa Solvent.xlsx

Europa Solvent Industries: Answers

- ◆ Simulate (using $n=100$ simulation runs and seed = 123) the distribution of the total daily profit that ESI makes, V , and use the simulation results to answer the following questions:
 - What is the estimate of the expected value of the total daily profit?
 - What is the estimate of the standard deviation of the total daily profit?

Answer:

Based on a simulation with $n=100$ simulation runs and seed=123, the estimate of the **expected daily profit is about 8752€**, and estimate of the **standard deviation of the daily profit is about 9415€**.