ABC Inventory Classification

- **ABC classification** is a method for determining level of control and frequency of review of inventory items
- A Pareto analysis can be done to segment items into value categories depending on annual dollar volume
- **A Items** – typically 20% of the items accounting for 80% of the inventory value-use Q system
- **B Items** – typically an additional 30% of the items accounting for 15% of the inventory value-use Q or P
- **C Items** – Typically the remaining 50% of the items accounting for only 5% of the inventory value-use P

EXAMPLE 14.1

ABC System Classification

The maintenance department for a small manufacturing firm has responsibility for maintaining an inventory of spare parts for the machinery it services. The parts inventory, unit cost, and annual usage are as follows:

Part	Unit Cost	Annual Usage
1	$60	90
2	350	40
3	30	130
4	80	60
5	30	100
6	20	180
7	10	170
8	320	50
9	510	60
10	20	120
		1000

The department manager wants to classify the inventory parts according to the ABC system to determine which stocks of parts should most closely be monitored.

First rank the items according to their total value and also compute each item's percentage of total value and quantity.

Part	Total Value	% of Total Value	% of Total Quantity	% Cumulative
9	$30,600	35.9	6.0	6.0
8	16,000	18.7	5.0	11.0
2	14,000	16.4	4.0	15.0
1	5,400	6.3	9.0	24.0
4	4,800	5.6	6.0	30.0
3	3,900	4.6	13.0	43.0
6	3,600	4.2	18.0	61.0
5	3,000	3.5	10.0	71.0
10	2,400	2.8	12.0	83.0
7	1,700	2.0	17.0	100.0
	$85,400			

Class	Items	% of Total Value	% of Total Quantity
A	9, 8, 2	71.0	15.0
B	1, 4, 3	16.5	28.0
C	6, 5, 10, 7	12.5	57.0

ABC ANALYSIS

(ABC = Always Better Control)

- This is based on cost criteria.
- It helps to exercise selective control when confronted with large number of items it rationalizes the number of orders, number of items & reduce the inventory.
- About 10 % of materials consume 70 % of resources
- About 20 % of materials consume 20 % of resources
- About 70 % of materials consume 10 % of resources

‘A’ ITEMS

Small in number, but consume large amount of resources

Must have:

- Tight control
- Rigid estimate of requirements
- Strict & closer watch
- Low safety stocks
- Managed by top management

‘B’ ITEM

Intermediate

Must have:

- Moderate control
- Purchase based on rigid requirements
- Reasonably strict watch & control
- Moderate safety stocks
- Managed by middle level management

‘C’ ITEMS

Larger in number, but consume lesser amount of resources

Must have:

- Ordinary control measures
- Purchase based on usage estimates
- High safety stocks

ABC analysis does not stress on items those are less costly but may be vital

VED ANALYSIS

- Based on critical value & shortage cost of an item
  - It is a subjective analysis.
    - Items are classified into:

Vital:

- Shortage cannot be tolerated.

Essential:

- Shortage can be tolerated for a short period.

Desirable:

- Shortage will not adversely affect but may be using more resources. These must be strictly Scrutinized

	V	E	D		ITEM	COST
A	AV	AE	AD	CATEGORY 1	10	70%
B	BV	BE	BD	CATEGORY 2	20	20%
C	CV	CE	CD	CATEGORY 3	70	10%

CATEGORY 1 - NEEDS CLOSE MONITORING & CONTROL
CATEGORY 2 - MODERATE CONTROL.
CATEGORY 3 - NO NEED FOR CONTROL

SDE ANALYIS

Based on availability

- Scarce
  - Managed by top level management
  - Maintain big safety stocks
- Difficult
  - Maintain sufficient safety stocks
- Easily available
  - Minimum safety stocks

FSN ANALYSIS

Based on utilization.

Fast moving.

Slow moving.

Non-moving.

Non-moving items must be periodically reviewed to prevent expiry & obsolescence

HML ANALYSIS

Based on cost per unit

Highest

Medium

Low

This is used to keep control over consumption at departmental level for deciding the frequency of physical verification.

The AAU Corp. is considering doing an ABC analysis on its entire inventory but has decided to test the technique on a small sample of 15 of its SKU's. The annual usage and unit cost of each item is shown below

ABC Problem Data

Item	Unit $ Value	Annual Usage (in units)
101	12.00	80
102	50.00	10
103	15.00	50
104	50.00	40
105	40.00	80
106	75.00	220
107	4.00	250
108	1.50	400
109	2.00	250
110	25.00	500
111	5.00	450
112	7.50	80
113	3.50	250
114	1.00	1200
115	15.00	300

(A) First calculate the annual dollar volume for each item

- **Solution**

(a)

ABC Annual Usage Values

Item	Unit $ Value	Annual Usage (in units)	Annual Usage ($)
101	12.00	80	960
102	50.00	10	500
103	15.00	50	750
104	50.00	40	2000
105	40.00	80	3200
106	75.00	220	16,500
107	4.00	250	1000
108	1.50	400	600
109	2.00	250	500
110	25.00	500	12,500
111	5.00	450	2250
112	7.50	80	600
113	3.50	250	875
114	1.00	1200	1200
115	15.00	300	4500
		Total	$47,935

B) List the items in descending order based on annual dollar volume. (C) Calculate the cumulative annual dollar volume as a percentage of total dollars. (D) Classify the items into groups

(b, c, and d)

ABC Solution

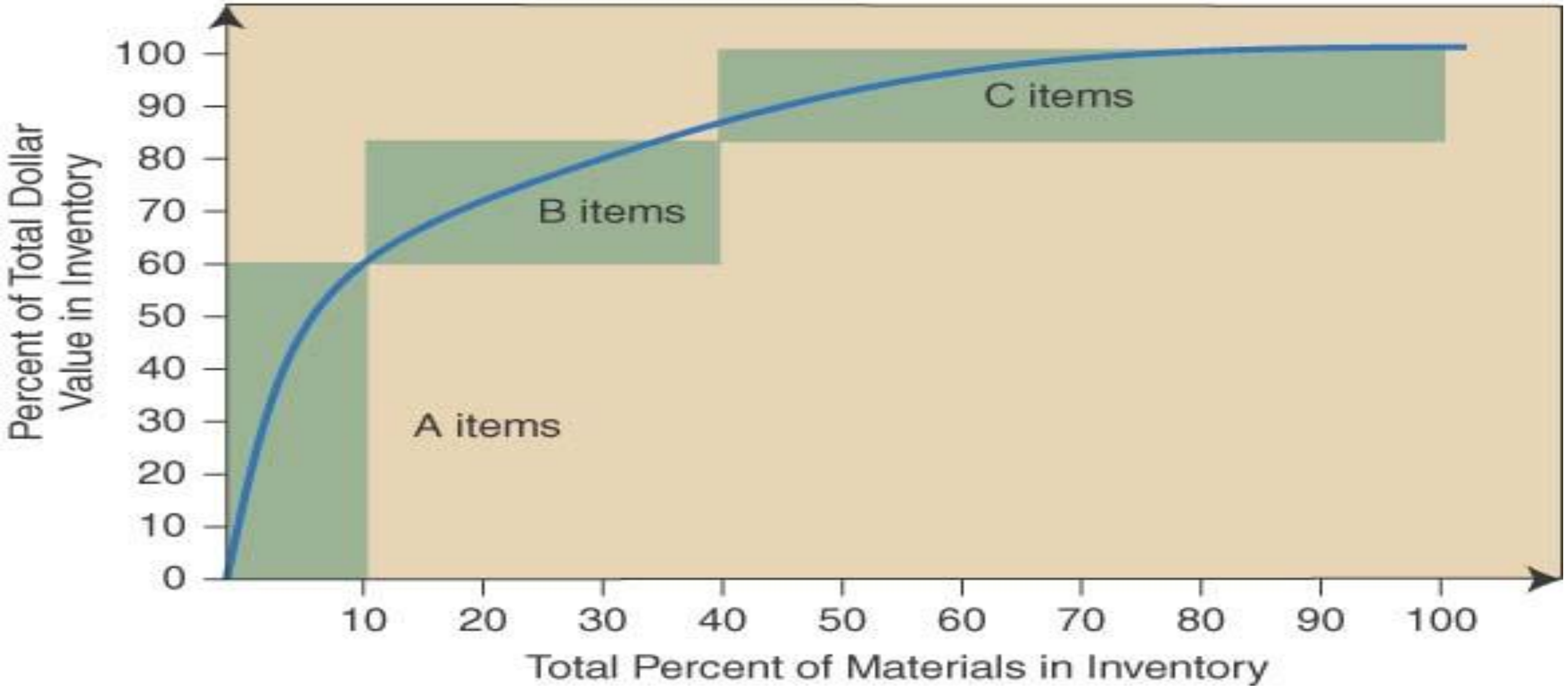
Item	Annual Usage ($)	Percentage of Total Dollars	Cumulative Percentage of Total Dollars	Item Classification
106	16,500	34.4	34.4	A
110	12,500	26.1	60.5	A
115	4500	9.4	69.9	B
105	3200	6.7	76.6	B
111	2250	4.7	81.3	B
104	2000	4.2	85.5	B
114	1200	2.5	88.0	C
107	1000	2.1	90.1	C
101	960	2.0	92.1	C
113	875	1.8	93.9	C
103	750	1.6	95.5	C
108	600	1.3	96.8	C
112	600	1.3	98.1	C
102	500	1.0	99.1	C
109	500	1.0	100.1*	C
Total	**$47,935**			

*Total exceeds 100% due to rounding.

Remember that these are not absolute rules for classifying items. Your company wants to group their more valuable items together to make sure that they get the most control.

Graphical solution

- The A items (106 and 110) account for 60.5% of the value and 13.3% of the items
- The B items (115,105,111,and 104) account for 25% of the value and 26.7% of the items
- The C items make up the last 14.5% of the value and 60% of the items
- How might you control each item classification? Different ordering rules for each?



Decision Tree Analysis for outsourcing decision

- A decision tree is a graphic device used to evaluate decisions under uncertainty.
- Decision trees with DCFs can be used to evaluate supply chain design decisions given uncertainty in prices, demand, exchange rates, and inflation.
- The probability on an arrow is referred to as the transition probability and is the probability of transitioning from the origin node in Period i to the end node in Period i + 1.
- The analysis is based on Bellman's principle, which states that for any choice of strategy in a given state, the optimal strategy in the next period is the one that is selected if the entire analysis is assumed to begin in the next period.

Trips Logistics problem

- The manager must decide whether to lease warehouse space for the coming three years and the quantity to lease.
- The manager anticipates uncertainty in demand and spot prices for warehouse space over the coming three years.
- The long-term lease is cheaper but the space could go unused if demand is lower than anticipated.
- The long-term lease may also end up being more expensive if future spot market prices come down. The manager is considering three options:

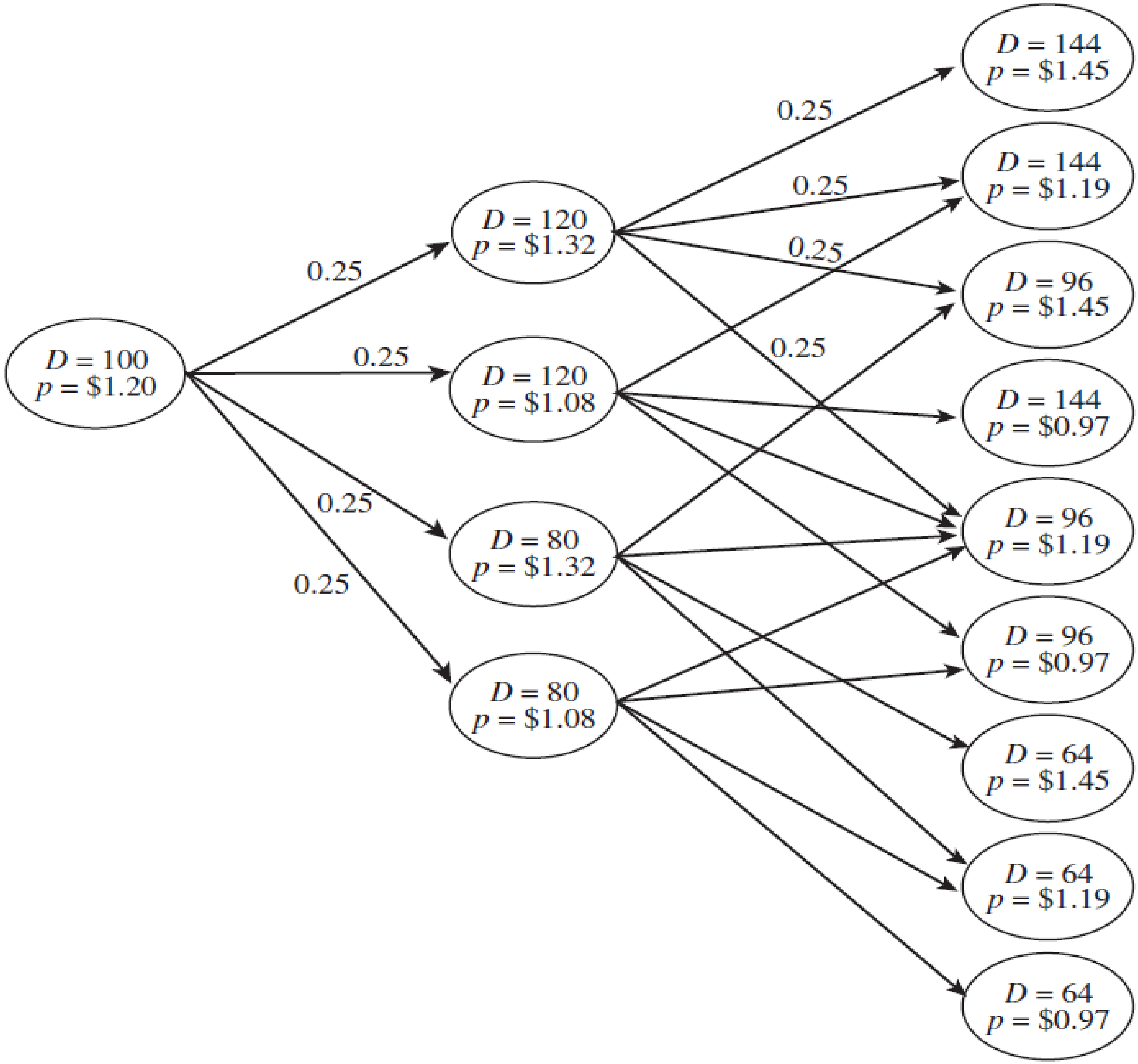
1. Get all warehousing space from the spot market as needed.
2. Sign a three-year lease for a fixed amount of warehouse space and get additional requirements from the spot market.
3. Sign a flexible lease with a minimum charge that allows variable usage of warehouse space up to a limit, with additional requirements from the spot market

- We now discuss how the manager can evaluate each decision, taking uncertainty into account.
- One thousand square feet of warehouse space is required for every 1,000 units of demand, and the current demand at Trips Logistics is for 100,000 units per year.
- The manager forecasts that from one year to the next, demand may go up by 20 percent, with a probability of 0.5, or go down by 20 percent, with a probability of 0.5.
- The probabilities of the two outcomes are independent and unchanged from one year to the next.
- The general manager can sign a three-year lease at a price of $1 per square foot per year. Warehouse space is currently available on the spot market for $1.20 per square foot per year.

Data given

1000 sq. ft. of warehouse space needed for 1000 units of demand

- Current demand = 100,000 units per year
- Binomial uncertainty: Demand can go up by 20% with $p = 0.5$ or down by 20% with $1 - p = 0.5$
- Lease price = \$1.00 per sq. ft. per year
- Spot market price = \$1.20 per sq. ft. per year
- Spot prices can go up by 10% with $p = 0.5$ or down by 10% with $1 - p = 0.5$
- Revenue = \$1.22 per unit of demand
- $k = 0.1$



D = 100
p = $1.20
0.25
0.25
0.25
0.25
D = 120
p = $1.32
D = 120
p = $1.08
D = 80
p = $1.32
D = 80
p = $1.08
0.25
0.25
0.25
0.25
D = 144
p = $1.45
D = 144
p = $1.19
D = 96
p = $1.45
D = 144
p = $0.97
D = 96
p = $1.19
D = 96
p = $0.97
D = 64
p = $1.45
D = 64
p = $1.19
D = 64
p = $0.97

Evaluating the Spot Market Option

- Analyze the option of not signing a lease and using the spot market
- Start with last period and calculate the profit at each node

For D = 144, p = \$1.45, in Period 2:

$$C(D = 144, p = 1.45, 2) = 144{,}000 \times 1.45$$
$$= \$208{,}800$$
$$P(D = 144, p = 1.45, 2) = 144{,}000 \times 1.22$$
$$- C(D = 144, p = 1.45, 2)$$
$$= 175{,}680 - 208{,}800$$

Net = −\$33,120

Evaluating the Spot Market Option

Period 2 Calculations for Spot Market Option

	Revenue	Cost $C(D =, p =, 2)$	Profit $P(D =, p =, 2)$
$D = 144, p = 1.45$	144,000 × 1.22	144,000 × 1.45	–$33,120
$D = 144, p = 1.19$	144,000 × 1.22	144,000 × 1.19	$4,320
$D = 144, p = 0.97$	144,000 × 1.22	144,000 × 0.97	$36,000
$D = 96, p = 1.45$	96,000 × 1.22	96,000 × 1.45	–$22,080
$D = 96, p = 1.19$	96,000 × 1.22	96,000 × 1.19	$2,880
$D = 96, p = 0.97$	96,000 × 1.22	96,000 × 0.97	$24,000
$D = 64, p = 1.45$	64,000 × 1.22	64,000 × 1.45	–$14,720
$D = 64, p = 1.19$	64,000 × 1.22	64,000 × 1.19	$1,920
$D = 64, p = 0.97$	64,000 × 1.22	64,000 × 0.97	$16,000

Evaluating the Spot Market Option

- Expected profit at each node in Period 1 is the profit during Period 1 plus the present value of the expected profit in Period 2
- Expected profit E P(*D* =, *p* =, 1) at a node is the expected profit over all four nodes in Period 2 that may result from this node
- Present value E P(*D* =, *p* =, 1) is the present value of this expected profit and *P*(*D* =, *p* =, 1), and the total expected profit, is the sum of the profit in Period 1 and the present value of the expected profit in Period 2.

Evaluating the Spot Market Option

- From node $D = 120$, $p = \$1.32$ in Period 1, there are four possible states in Period 2
- Evaluate the expected profit in Period 2 over all four states possible from node $D = 120$, $p = \$1.32$ in Period 1 to be

$$
\begin{aligned}
E\,P(D = 120, p = 1.32, 1) = 0.25 \times [&P(D = 144, p = 1.45, 2) \\
&+ P(D = 144, p = 1.19, 2) \\
&+ P(D = 96, p = 1.45, 2) \\
&+ P(D = 96, p = 1.19, 2)
\end{aligned}
$$

$$= 0.25 \times [-33{,}120 + 4{,}320$$

$$- 22{,}080 + 2{,}880]$$

$$= -\$12{,}000$$

Evaluating the Spot Market Option

The present value of this expected value in Period 1 is

$$PVEP(D=120, p=1.32, 1) = \frac{EP(D=120, p=1.32, 1)}{(1+k)}$$

$$= \frac{-\$12{,}000}{(1.1)}$$

$$= -\$10{,}909$$

Evaluating the Spot Market Option

The total expected profit $P(D = 120, p = 1.32,1)$ at node $D = 120$, $p = 1.32$ in Period 1 is the sum of the profit in Period 1 at this node, plus the present value of future expected profits possible from this node

$$
\begin{aligned}
&P(D=120, p=1.32,1) = (120{,}000 \times 1.22) - (120{,}000 \times 1.32) \\
&+PVEP(D=120, p=1.32,1) \\
&= -\$12{,}000 - \$10{,}909 = -\$22{,}909
\end{aligned}
$$

Evaluating the Spot Market Option

Period 1 Calculations for Spot Market Option

Node	*EP*(*D* =, *p* =, 1)	*P*(*D* =, *p* =, 1) = *D* × 1.22 – *D* x *p* + start fraction E P at left parenthesis D =, p =, 1 right parenthesis over left parenthesis 1 + k right parenthesis end fraction $\frac{EP(D =, p =, 1)}{(1+k)}$
D = 120, *p* = 1.32	−\$12,000	−\$22,909
D = 120, *p* = 1.08	\$16,000	\$32,073
D = 80, *p* = 1.32	−\$8,000	−\$15,273
D = 80, *p* = 1.08	\$11,000	\$21,382

Evaluating the Spot Market Option

For Period 0, the total profit $P(D = 100, p = 120,0)$ is the sum of the profit in Period 0 and the present value of the expected profit over the four nodes in Period 1

$$
\begin{aligned}
EP(D = 100, p = 1.20,0) = 0.25 \times [&P(D = 120, p = 1.32,1) \\
&+ P(D = 120, p = 1.08,1) \\
&+ P(D = 96, p = 1.32,1) \\
&+ P(D = 96, p = 1.08,1)]
\end{aligned}
$$

$$= 0.25 \times [-22,909 + 32,073$$

$$- 15,273) + 21,382]$$

$$= \$3,818$$

Evaluating the Spot Market Option

$$PVEP(D = 100, p = 1.20,1) = \frac{EP(D = 100, p = 1.20,0)}{(1 + k)}$$

$$= \frac{\$3,818}{(1.1)} = \$3,471$$

$$P(D = 100, p = 1.20,0) = (100,000 \times 1.22) - (100,000 \times 1.20) + PV\ EP(D = 100, p = 1.20,0)$$

$$= \$2,000 + \$3,471 = \$5,471$$

Therefore, the expected N P V of not signing the lease and obtaining all warehouse space from the spot market is given by N P V (Spot Market) = $5,471

Evaluating the Fixed Lease Option

Period 2 Profit Calculations at Trips Logistics for Fixed Lease Option

Node	Leased Space	Warehouse Space at Spot Price (*S*)	Profit *P*(*D* =, *p* =, 2) = *D* × 1.22 – (100,000 × 1 + *S* x *p*)
D = 144, *p* = 1.45	100,000 sq. ft. (aval. For 100k)	44,000 sq. ft.	$11,880
D = 144, *p* = 1.19	100,000 sq. ft.	44,000 sq. ft.	$23,320
D = 144, *p* = 0.97	100,000 sq. ft.	44,000 sq. ft.	$33,000
D = 96, *p* = 1.45	100,000 sq. ft.	0 sq. ft.	$17,120
D = 96, *p* = 1.19	100,000 sq. ft.	0 sq. ft.	$17,120
D = 96, *p* = 0.97	100,000 sq. ft.	0 sq. ft.	$17,120
D = 64, *p* = 1.45	100,000 sq. ft.	0 sq. ft.	–$21,920
D = 64, *p* = 1.19	100,000 sq. ft.	0 sq. ft.	–$21,920
D = 64, *p* = 0.97	100,000 sq. ft.	0 sq. ft.	–$21,920

Evaluating the Fixed Lease Option

Period 1 Profit Calculations at Trips Logistics for Fixed Lease Option

Node	***EP*(*D* =, *p* =, 1)**	**Warehouse Space at Spot Price (*S*)**	***P*(*D* =, *p* =, 1) = *D* x 1.22–(100,000 x 1 + *S* x *p*) + *EP*(*D* =, *p* = ,1)(1 + *k*)**
D = 120, *p* = 1.32	0.25 × [*P*(*D* = 144, *p* = 1.45,2) + *P*(*D* = 144, *p* = 1.19,2) + *P*(*D* = 96, *p* = 1.45,2) + *P*(*D* = 96, *p* = 1.19,2)] = 0.25 × (11,880 + 23,320 + 17,120 + 17,120) = $17,360	20,000	$35,782
D = 120, *p* = 1.08	0.25 × (23,320 + 33,000 + 17,120 + 17,120) = $22,640	20,000	$45,382
D = 80, *p* = 1.32	0.25 × (17,120 + 17,120−21,920 − 21,920) = −$2,400	0	−$4,582
D = 80, *p* = 1.08	0.25 × (17,120 + 17,120 − 21,920 −21,920) = −$2,400	0	−$4,582

Evaluating the Fixed Lease Option

Using the same approach for the lease option, NPV (Lease) = $38,364

$EP(D = 100, p = 1.20,0) = 0.25 \times [P(D = 120, p = 1.32,1) + P(D = 120, p = 1.08,1) + P(D = 80, p = 1.32,1) + P(D = 80, p = 1.08,1)]$

$= 0.25 \times [35{,}782 + 45{,}382 - 4{,}582 - 4{,}582]$

$= \$18{,}000$

Evaluating the Fixed Lease Option

$$PVEP(D = 100, p = 1.20,1) = \frac{EP\left(D = 100, p = 1.20,1\right)}{\left(1 + k\right)}$$

$$= \frac{\$18{,}000}{\left(1.1\right)} = \$16{,}364$$

$$P(D = 100,\ p = 1.20,0) = (100{,}000 \times 1.22) - (100{,}000 \times 1) + PVEP(D = 100,\ p = 1.20,0)$$

$$= \$22{,}000 + \$16{,}364 = \$38{,}364$$

Evaluating the Fixed Lease Option

- Recall that when uncertainty was ignored, the N P V for the lease option was $60,182
- However, the manager would probably still prefer to sign the three-year lease for 100,000 sq. ft. because this option has the higher expected profit

Evaluating the Flexible Lease Option

Period 2 Profit Calculations at Trips Logistics with Flexible Lease Contract

Node	Warehouse Space at \$1 (*W*)	Warehouse Space at Spot Price (*S*)	Profit $P(D =, p =, 2) = D \times 1.22 - (W \times 1 + S \times p)$
$D = 144, p = 1.45$	100,000 sq. ft.	44,000 sq. ft.	\$11,880
$D = 144, p = 1.19$	100,000 sq. ft.	44,000 sq. ft.	\$23,320
$D = 144, p = 0.97$	100,000 sq. ft.	44,000 sq. ft.	\$33,000
$D = 96, p = 1.45$	96,000 sq. ft.	0 sq. ft.	\$21,120
$D = 96, p = 1.19$	96,000 sq. ft.	0 sq. ft.	\$21,120
$D = 96, p = 0.97$	96,000 sq. ft.	0 sq. ft.	\$21,120
$D = 64, p = 1.45$	64,000 sq. ft.	0 sq. ft.	\$14,080
$D = 64, p = 1.19$	64,000 sq. ft.	0 sq. ft.	\$14,080
$D = 64, p = 0.97$	64,000 sq. ft.	0 sq. ft.	\$14,080

Evaluating the Flexible Lease Option

Period 1 Profit Calculations at Trips Logistics with Flexible Lease Contract

Node	$EP(D =, p =, 1)$	Warehouse Space at $1 ($W$)	Warehouse Space at Spot Price (S)	$P(D =, p =, 1) = D \times 1.22 - (W \times 1 + S \times p) + EP(D =, p = ,1)(1 + k)$
D = 120, p = 1.32	0.25 × (11,880 + 23,320 + 21,120 + 21,120) = $19,360	100,000	20,000	$37,600
D = 120, p = 1.08	0.25 × (23,320 + 33,000 + 21,120 + 21,120) = $24,640	100,000	20,000	$47,200
D = 80, p = 1.32	0.25 × (21,120 + 21,120 + 14,080 + 14,080) = $17,600	80,000	0	$33,600
D = 80, p = 1.08	0.25 × (21,920 + 21,920 + 14,080 +	80,000	0	$33,600

Decision Tree – Trips Logistics

Option	Value
All warehouse space from the spot market	$5,471
Lease 100,000 sq. ft. for three years	$38,364
Flexible lease to use between 60,000 and 100,000 sq. ft.	$46,545