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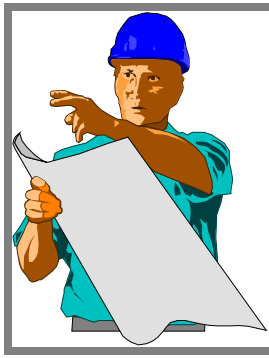
ENGINEERING ECONOMICS
Project Risk Analysis



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Lecture 12

Project Risk

Cash flows are the outcome of several variables such as prices, exchange rates, costs, wages etc.

Hence, forecasts of cash flows are subject to a degree of uncertainty.

We can use the term ***risk*** in describing an investment whose cash flows are not known in advance with absolute certainty, but for which an array of alternative outcomes and their probabilities are known.

If there is greater variability, then the risk is higher and if there is lower variability, then risk is lower.

We use the term ***project risk*** to refer to the variability in a project's NPV.

Methods of describing project risk

1. Sensitivity analysis
2. Breakeven analysis
3. Scenario analysis, and
4. Risk analysis

1. Sensitivity Analysis

It shows how an output variable changes with changes in the input variable when other input variables are taken as constant.

One of the best ways to show the results of sensitivity analysis is to plot sensitivity graphs and find out which input variables affect the output variable most and monitor the most sensitive input variable.

Example

After-tax Cash Flow for WMC's Transmission-Housings Project

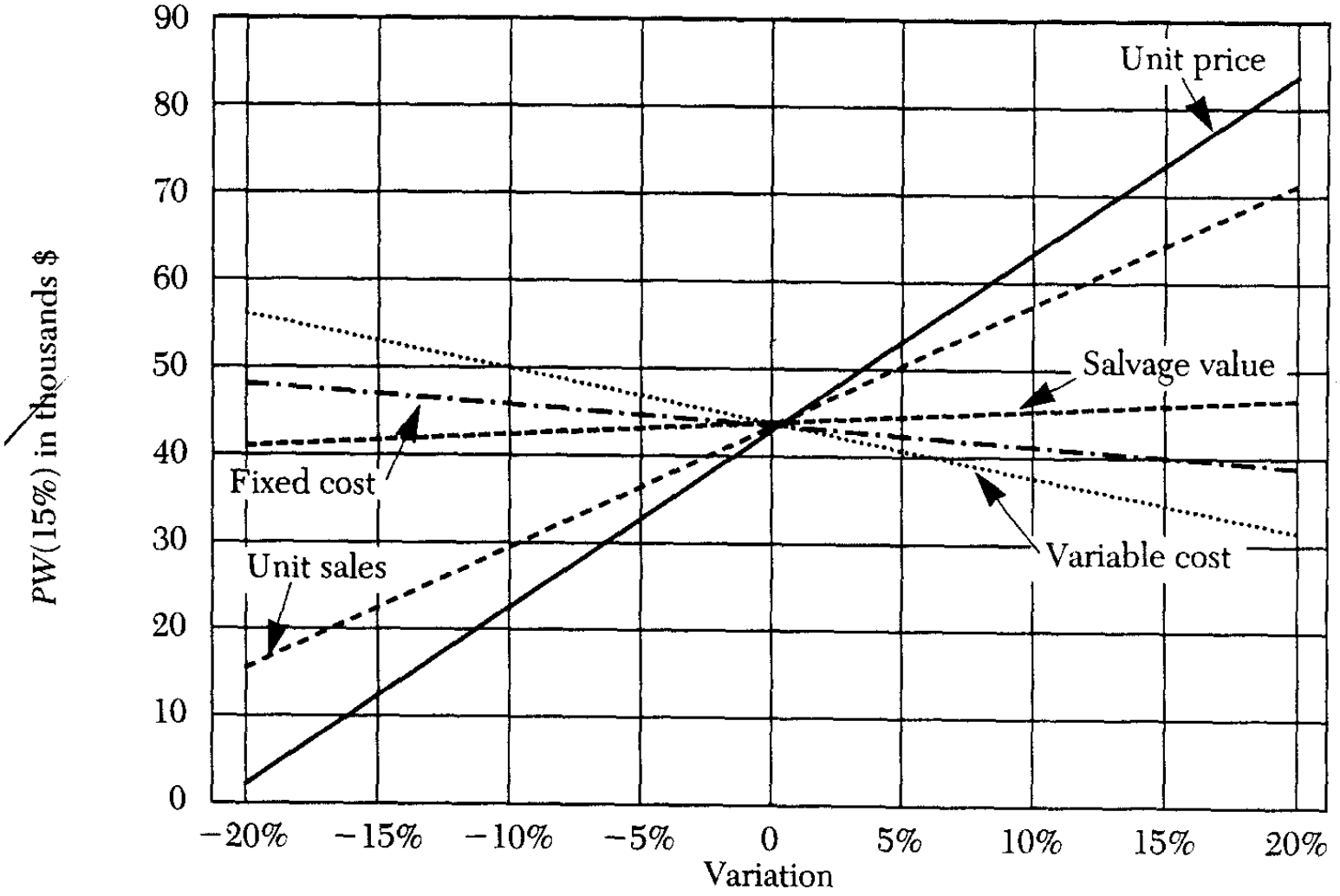
	n					
	0	**1**	**2**	**3**	**4**	**5**
Income Statement						
Revenues		$100,000	$100,000	$100,000	$100,000	$100,000
Variable cost		30,000	30,000	30,000	30,000	30,000
Fixed cost		10,000	10,000	10,000	10,000	10,000
CCA*		18,750	31,875	22,313	15,619	10,933
Taxable income		41,250	28,125	37,688	44,381	49,067
Income taxes		16,500	11,250	15,075	17,753	19,627
Net income		$24,750	$16,875	$22,613	$26,629	$29,440
Cash Flow Statement						
Net income		$24,750	$16,875	$22,613	$26,629	$29,440
CCA		18,750	31,875	22,313	15,619	10,933
Investment/Salvage	($125,000)					50,000
Disposal tax effect						(9,796)
Net cash flow	($125,000)	$43,500	$48,750	$44,925	$42,248	$80,578

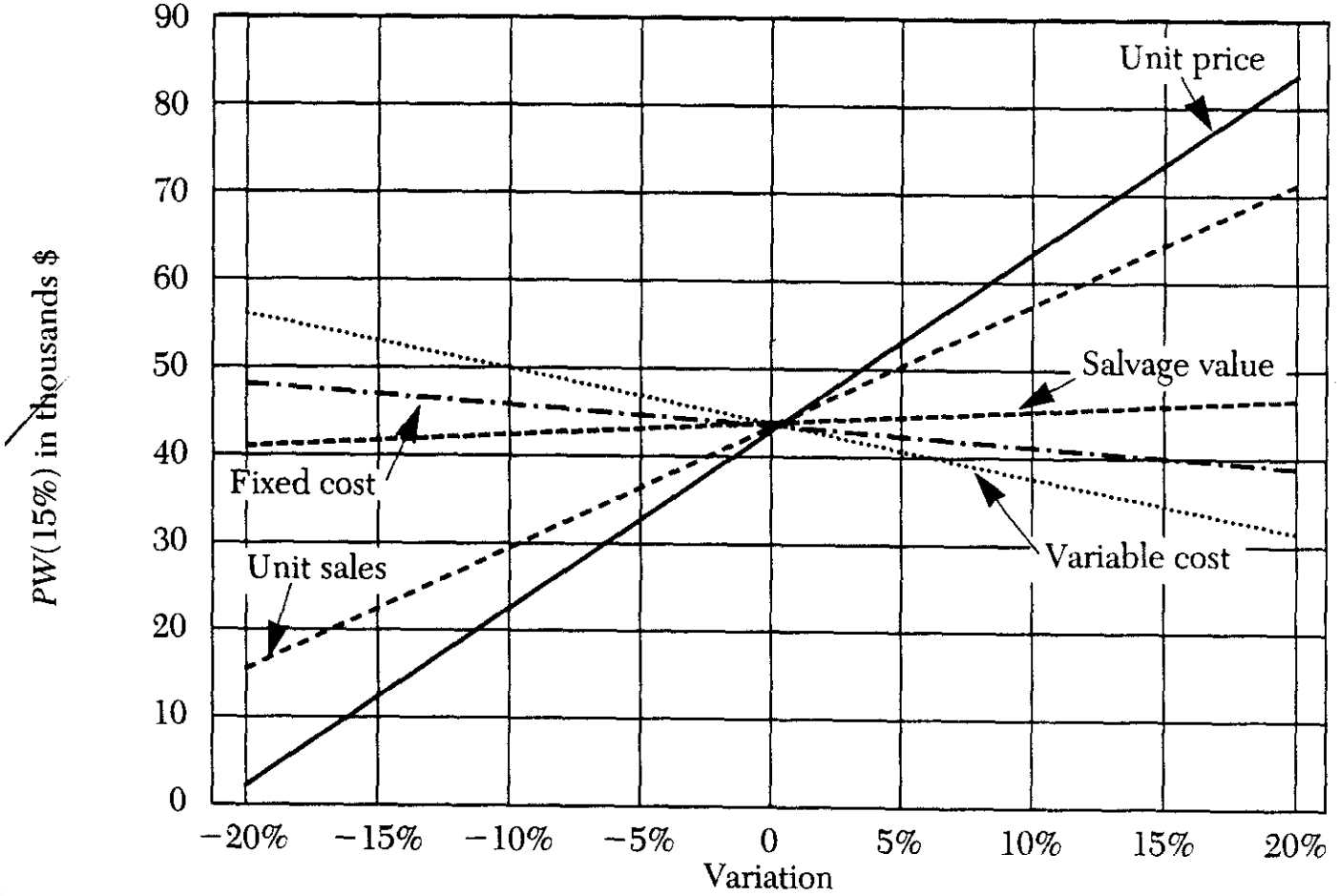
Demand: 2000 units
Unit price: $50 per unit
Unit variable (direct labor, direct material) cost: $15 per unit
Annual fixed cost excluding CCA: $10,000 per year

Present worth = $43,443
Annual worth = $12,960
Internal ROR = 27.8%

CCA= Capital Cost Allowance

Sensitivity graph-WMC's transmission-housings project





Deviation	−20%	−15%	−10%	−5%	0	5%	10%	15%	20%
Unit sales	1,600	1,700	1,800	1,900	2,000	2,100	2,200	2,300	2,400
PW(15%)	$15,285	$22,325	$29,364	$36,404	$43,443	$50,483	$57,523	$64,562	$71,602
Price ($)	40	42.5	45	47.5	50	52.5	55	57.5	60
PW(15%)	$ 3,218	$13,274	$23,331	$33,387	$43,443	$53,500	$63,556	$73,613	$83,669
Variable cost	12	12.75	13.5	14.25	15	15.75	16.5	17.25	18
PW(15%)	$55,511	$52,494	$49,477	$46,460	$43,443	$40,426	$37,410	$34,392	$31,376
Fixed cost	8,000	8,500	9,000	9,500	10,000	10,500	11,000	11,500	12,000
PW(15%)	$47,466	$46,460	$45,455	$44,449	$43,443	$42,438	$41,432	$40,427	$39,421
Salvage	40,000	42,500	45,000	47,500	50,000	52,500	55,000	57,500	60,000
PW(15%)	$40,460	$41,206	$41,952	$42,698	$43,443	$44,189	$44,935	$45,681	$46,426

2. Breakeven Analysis

Managers sometimes want to know at what sales volume the project begins to lose money or NPV becomes negative.

This kind of analysis is called ***breakeven analysis***.

Example

Breakeven Analysis with Unknown Annual Sales X

Items	0	1	2	3	4	5
Cash inflow						
Net salvage:						$40,204
Revenue:						
$X(1 - 0.4)50$		$30X$	$30X$	$30X$	$30X$	$30X$
CCA credit:						
+0.4 (CCA)		$7,500	$12,750	$8,925	$6,248	$4,373
Cash outflow						
Investment:	−$125,000					
Variable cost:						
$-X(1 - 0.4)15$		$-9X$	$-9X$	$-9X$	$-9X$	$-9X$
Fixed cost:						
−0.6(10,000)		−$6,000	−$6,000	−$6,000	−$6,000	−$6,000
Net cash flow	−$125,000	$21X + $1,500	$21X + $6,750	$21X + $2,925	$21X + $248	$21X + $38,577

PW of cash inflows = (PW of after-tax net revenue)

+ (PW of net salvage value)

+ (PW of tax savings from CCA)

$$PW(15\%)_{\text{inflow}} = 30X(P/A, 15\%, 5) + \$40{,}204(P/F, 15\%, 5)$$
$$+ \$7500(P/F, 15\%, 1) + \$12{,}750(P/F, 15\%, 2)$$
$$+ \$8925(P/F, 15\%, 3) + \$6248(P/F, 15\%, 4)$$
$$+ \$4373(P/F, 15\%, 5)$$
$$= 30X(P/A, 15\%, 5) + \$47{,}766$$
$$= 100.566X + \$47{,}766$$

PW of cash outflows = (PW of capital expenditure)

+ (PW of after-tax expenses)

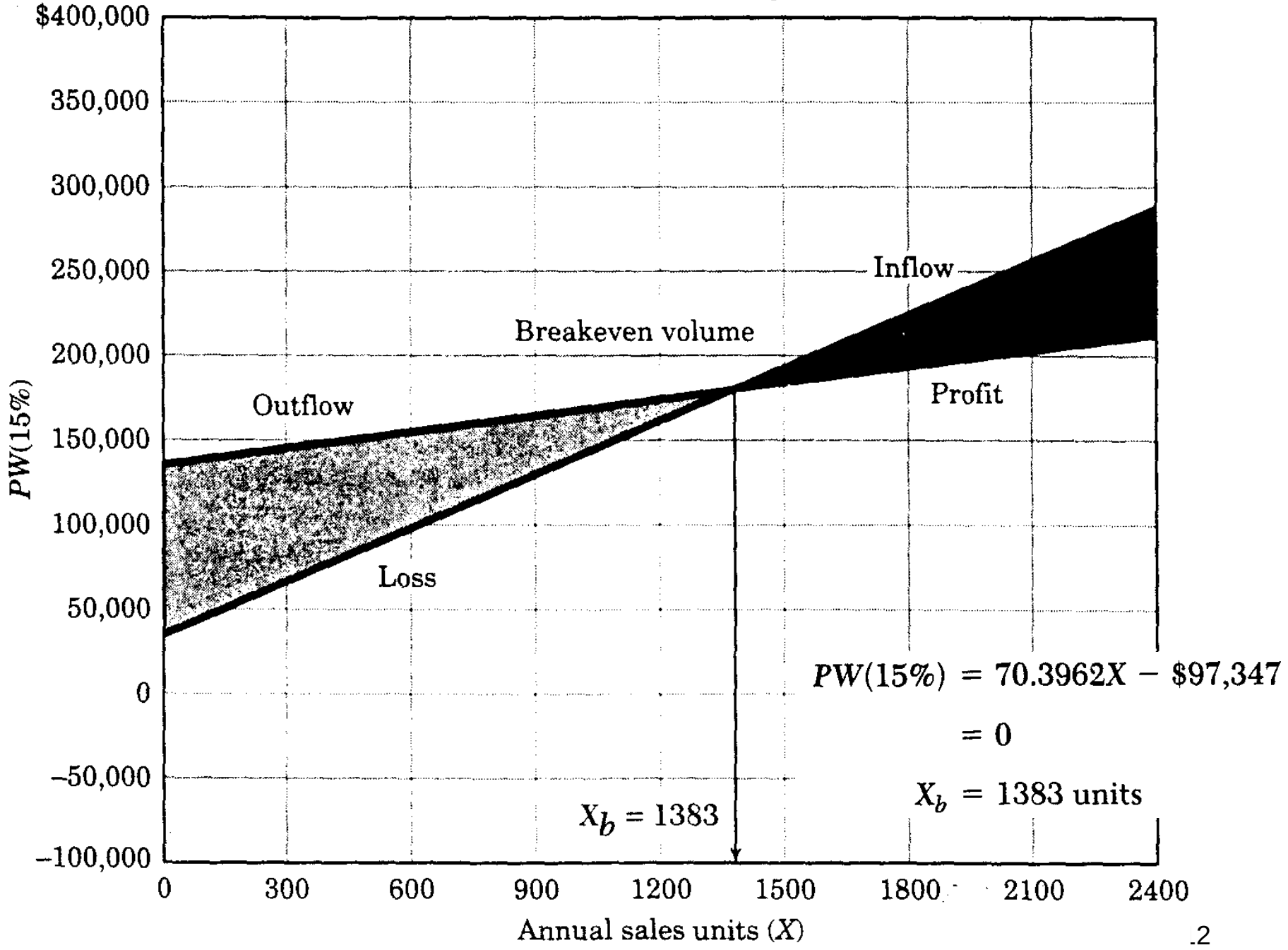
$$PW(15\%)_{\text{outflow}} = \$125{,}000 + (9X + \$6000)(P/A, 15\%, 5)$$
$$= 30.1694X + \$145{,}113$$

The NPW of all cash flows for the WMC is thus

NPW(15%) **= PW of cash inflow – PW of cash outflow**

$$= 70.3962X - \$97{,}347$$

Units (X)	PW of Inflow (100.566X + $47,766)	PW of Outflow (30.1694X + $145,113)	NPW (70.3962X − $97,347)
0	$ 47,766	$145,113	($97,347)
500	98,049	160,198	(62,149)
1000	148,332	175,282	(26,951)
1500	198,615	190,367	8,247
2000	248,898	205,452	43,443
2500	299,181	220,537	78,643


$400,000
350,000
300,000
250,000
200,000
150,000
100,000
50,000
0
−50,000
−100,000
PW(15%)
Inflow
Breakeven volume
Outflow
Profit
Loss
X_b = 1383
PW(15%) = 70.3962X − $97,347
= 0
X_b = 1383 units
0
300
600
900
1200
1500
1800
2100
2400
Annual sales units (X)

3. Scenario Analysis

Both the sensitivity and breakeven analyses have limitations, they cannot give the right relations, when input variables are interdependent.

A scenario analysis shows the sensitivity of NPV with regard to changes in important variables to the range of likely values of the input variables.

The decision-maker can have the worst case scenario, most likely scenario, and the best case scenario.

Then these scenarios are compared to the base case value of NPV.

Example

Scenario Analysis for WMC

Variable Considered	Worst-case Scenario	Most-likely-case Scenario	Best-case Scenario
Unit demand	1600	2000	2200
Unit price ($)	48	50	53
Variable cost ($)	17	15	12
Fixed cost ($)	11,000	10,000	8,000
Salvage value ($)	30,000	50,000	60,000
PW(15%)	($5,564)	$43,443	$91,077

Risk Analysis (Risk Simulation)

Risk simulation, in general, is the process of modeling reality to observe and weigh the likelihood of possible outcomes of a risky undertaking.

Monte Carlo Simulation is specific type of randomized sampling method in which a random sample of outcomes is generated for specified probability distributions of values of random input variables.

Simulation output analysis

Through the descriptive statistics and histogram of the values of the output variable, we can determine and analyze the probability distribution of the output variable such as net profit, NPV, IRR etc.

Example

Assessments of Conditional and joint Probabilities

Unit price Y	Probability	Unit Sales X	Conditional Probability	Joint Probability
\$48	0.30	1600	0.10	0.030
		2000	0.64	0.192
		2400	0.26	0.078
50	0.50	1600	0.17	0.085
		2000	0.66	0.330
		2400	0.17	0.085
53	0.20	1600	0.50	0.100
		2000	0.40	0.080
		2400	0.10	0.020

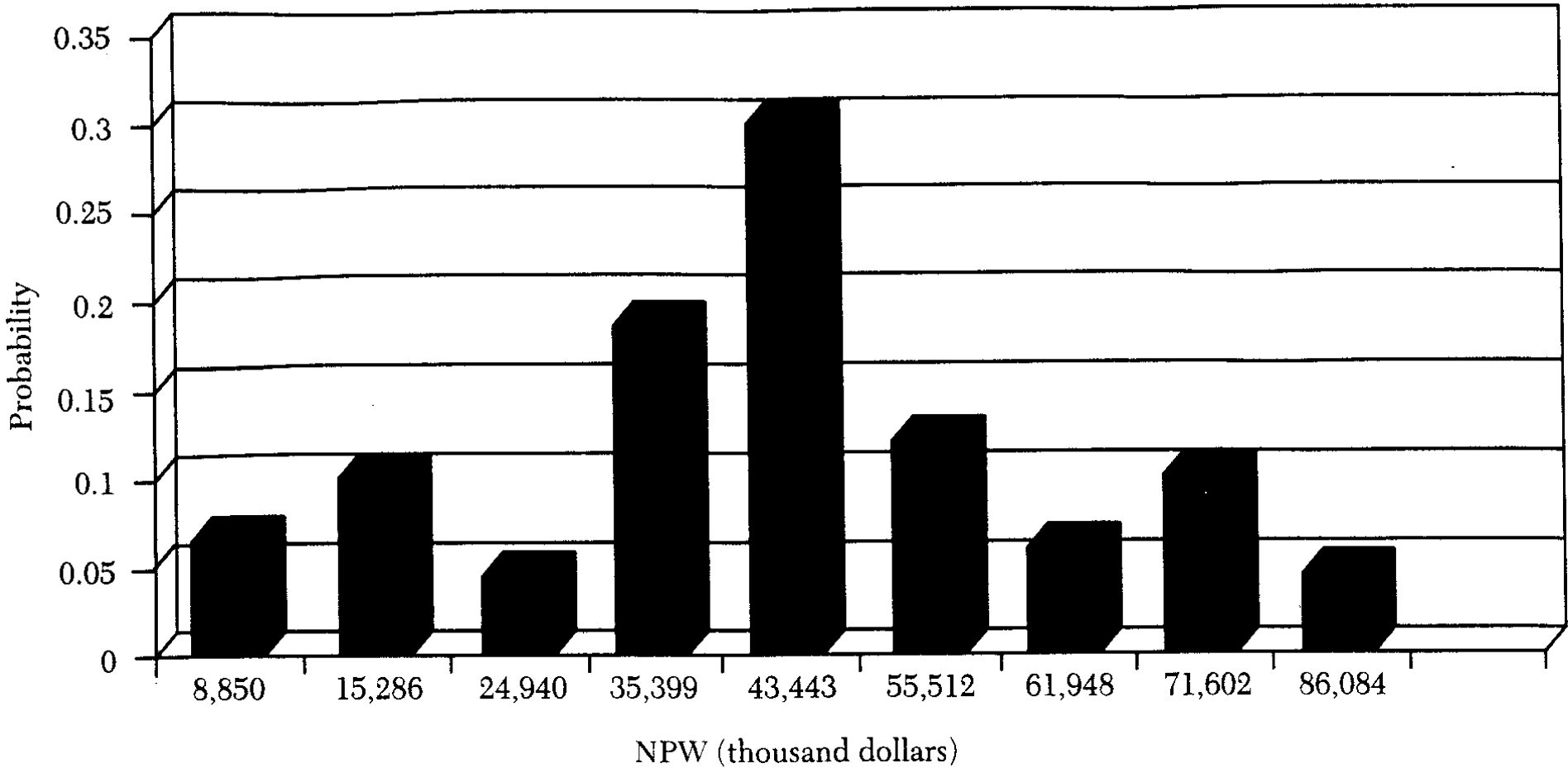
$$
\begin{aligned}
P(x,y) &= P(x = 1600, y = \$48) \\
&= P(x = 1600 \mid y = \$48)P(y = \$48) \\
&= 0.10 \times 0.30 \\
&= 0.03.
\end{aligned}
$$

Joint Event (X,Y)	$P(X,Y)$
(1600, \$48)	0.030
(2000, \$48)	0.192
(2400, \$48)	0.078
(1600, \$50)	0.085
(2000, \$50)	0.330
(2400, \$50)	0.085
(1600, \$53)	0.100
(2000, \$53)	0.080
(2400, \$53)	0.020
	Sum = 1.000

NPW Probability Distribution with Independent Random Variables

Event No.	Outcome x	Outcome y	Marginal Probability X $p(x)$	Marginal Probability Y $p(y)$	Joint Probability $P(x, y)$	Cumulative Joint Probability	NPW
1	1600	$ 48	0.200	0.300	0.060	0.060	$ 8,850
2	1600	50	0.200	0.500	0.100	0.160	15,286
3	1600	53	0.200	0.200	0.040	0.200	24,940
4	2000	48	0.600	0.300	0.180	0.380	35,399
5	2000	50	0.600	0.500	0.300	0.680	43,443*
6	2000	53	0.600	0.200	0.120	0.800	55,512
7	2400	48	0.200	0.300	0.060	0.860	61,948
8	2400	50	0.200	0.500	0.100	0.960	71,602
9	2400	53	0.200	0.200	0.040	1.000	86,084

NPW probability distributions: When X and Y are independent



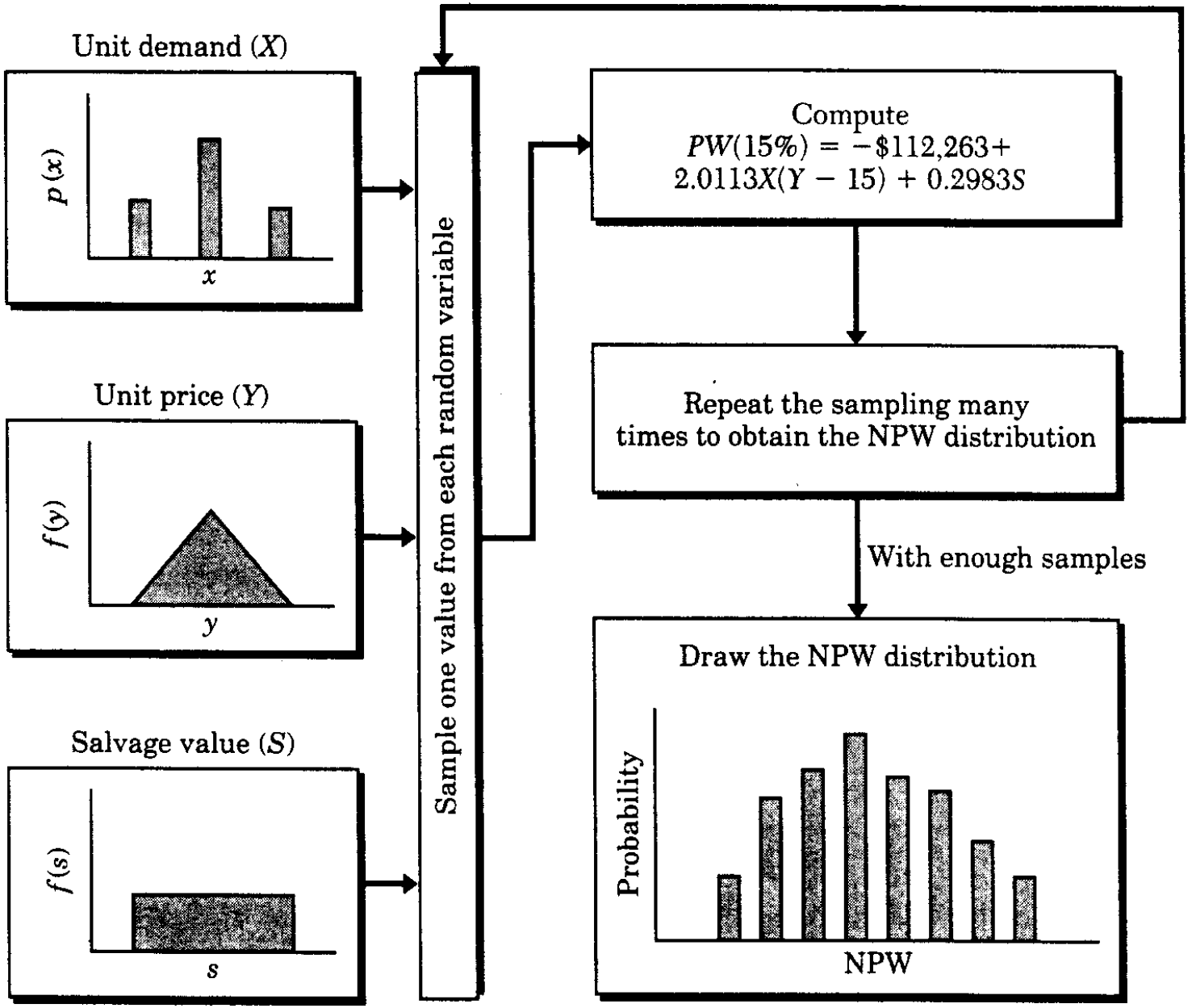
Calculation of the Mean of NPW Distribution

Event No.	Outcome x	Outcome y	Marginal Probability X $p(x)$	Marginal Probability Y $p(y)$	Joint Probability $P(x, y)$	NPW	Weighted NPW
1	1600	$ 48	0.200	0.300	0.060	$ 8,850	$ 531
2	1600	50	0.200	0.500	0.100	15,286	1,529
3	1600	53	0.200	0.200	0.040	24,940	998
4	2000	48	0.600	0.300	0.180	35,399	6,372
5	2000	50	0.600	0.500	0.300	43,443	13,033
6	2000	53	0.600	0.200	0.120	55,512	6,661
7	2400	48	0.200	0	0.060	61,948	3,717
8	2400	50	0.200	00	0.100	71,602	7,160
9	2400	53	0.200	.200	0.040	86,084	3,443

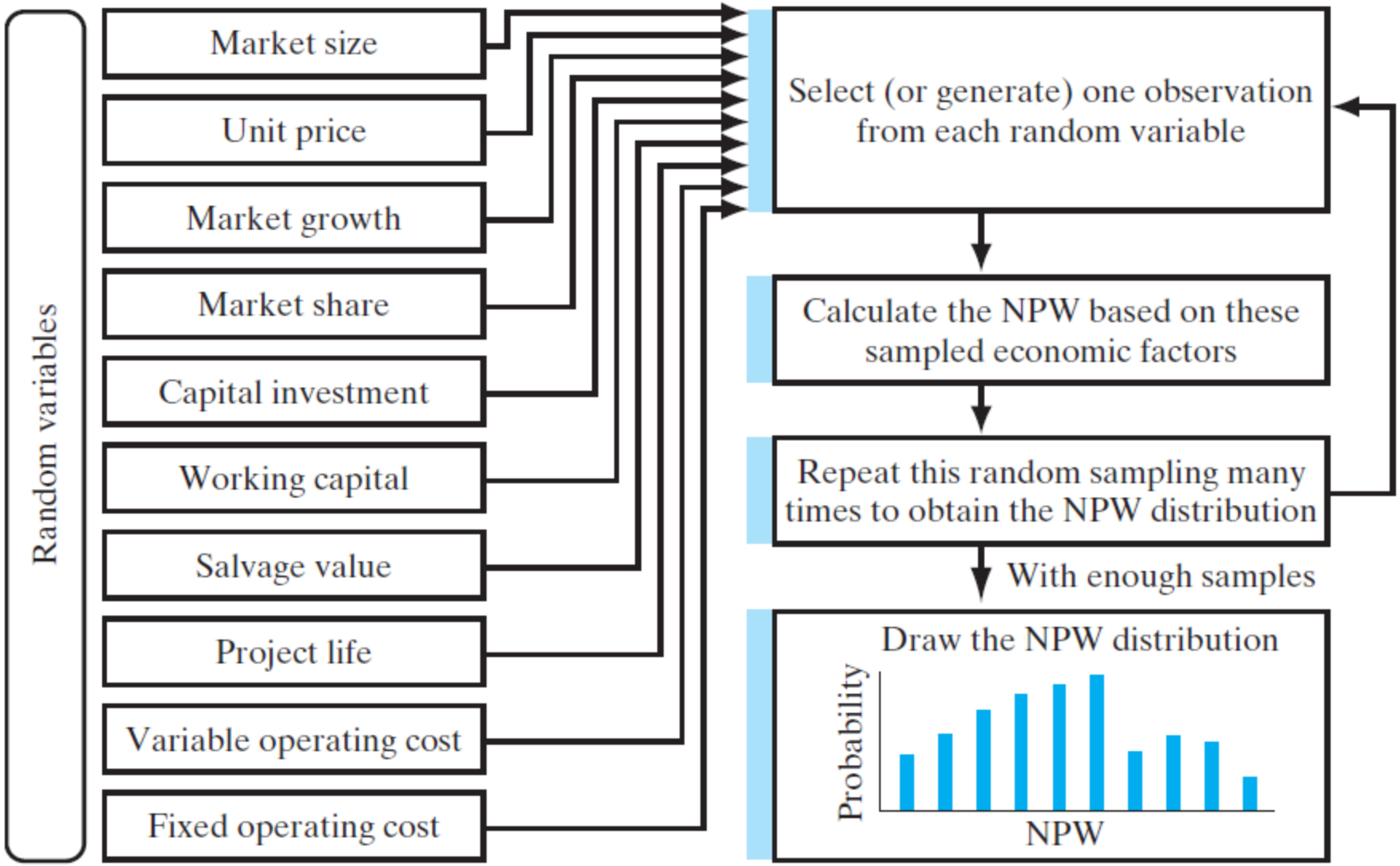
$E[PW(15\%)] = \$43,443$

P (NPW = 43,443) = 30%
P (NPW $\leq$ 43,443) = 68%
P (NPW $\geq$ 43,443) = 62%

A logical sequence of Monte Carlo simulation



Logical steps involved in simulating a risky investment



Practice

- 12.1, 12.2, 12.3, 12.4, 12.5, 12.6, 12.7, 12.8, 12.9, 12.10, 12.11, 12.12, 12.12, 12.14, 12.15

End