Chapter 10 Handling Project Uncertainty

10.1)

(a)

$$\text{AEC}(10\%) = (25,000 - 5,000)(A/P, 10\%, 6) + 0.1(5,000) + 3,000$$
$$= \$8,092$$

(b)

$$\text{AEC}(10\%) = (25,000 - 5,000)(A/P, 10\%, 5) + 0.1(5,000) + 3,000$$
$$= \$8,776$$

(c)

$$\text{AEC}(10\%) = (25,000 - 5,000)(A/P, 10\%, 6) + 0.1(5,000) + 3,300$$
$$= \$8,392$$

10.2)

(a) Project cash flows based on most-likely estimates:

	Tax Rate(%)=	40		PW(i) =	$11,342	>0
	MARR(%)=	15%		IRR(%) =	20%	
	0	1	2	3	4	5
Income Statement						
Revenues (savings)		$35,000	$35,000	$35,000	$35,000	$35,000
Expenses:						
Depreciation		18,000	28,800	17,280	10,368	5,184
Taxable Income		$17,000	$6,200	$17,720	$24,632	$29,816
Income Taxes		6,800	2,480	7,088	9,853	11,926
Net Income		$10,200	$3,720	$10,632	$14,779	$17,890
Cash Flow Statement						
Operating Activities:						
Net Income		$ 10,200	$ 3,720	$ 10,632	$ 14,779	$ 17,890
Depreciation		$ 18,000	$ 28,800	$ 17,280	$ 10,368	$ 5,184
Investment Activities:						
Investment	$ (90,000)					
Salvage						20,000
Gains Tax						-3,853
Net Cash Flow	($90,000)	$28,200	$32,520	$27,912	$25,147	$ 39,221

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(b) Required annual savings (X): $34,930

Input			Output		
Tax Rate(%)=	40		PW(i) =	$0	
MARR(%)=	20%		IRR(%) =	20%	

	0	1	2	3	4	5
Income Statement						
Revenues (savings)		**$34,930**	$34,930	$34,930	$34,930	$34,930
Expenses:						
Depreciation		18,000	28,800	17,280	10,368	5,184
Taxable Income		$16,930	$6,130	$17,650	$24,562	$29,746
Income Taxes		6,772	2,452	7,060	9,825	11,898
Net Income		$10,158	$3,678	$10,590	$14,737	$17,848
Cash Flow Statement						
Operating Activities:						
Net Income		$ 10,158	$ 3,678	$ 10,590	$ 14,737	$ 17,848
Depreciation		$ 18,000	$ 28,800	$ 17,280	$ 10,368	$ 5,184
Investment Activities:						
Investment	$ (90,000)					
Salvage						20,000
Gains Tax						-3,853
Net Cash Flow	($90,000)	$28,158	$32,478	$27,870	$25,105	$ 39,179

(c)

Input			Output		Not acceptable
Tax Rate(%)=	40		PW(i) =	($8,771)	<0
MARR(%)=	15%		IRR(%) =	11%	

	0	1	2	3	4	5
Income Statement						
Revenues (savings)		$25,000	$25,000	$25,000	$25,000	$25,000
Expenses:						
Depreciation		18,000	28,800	17,280	10,368	5,184
Taxable Income		$7,000	($3,800)	$7,720	$14,632	$19,816
Income Taxes		2,800	(1,520)	3,088	5,853	7,926
Net Income		$4,200	($2,280)	$4,632	$8,779	$11,890
Cash Flow Statement						
Operating Activities:						
Net Income		$ 4,200	$ (2,280)	$ 4,632	$ 8,779	$ 11,890
Depreciation		$ 18,000	$ 28,800	$ 17,280	$ 10,368	$ 5,184
Investment Activities:						
Investment	$ (90,000)					
Salvage						20,000
Gains Tax						(3,853)
Net Cash Flow	($90,000)	$22,200	$26,520	$21,912	$19,147	$ 33,221

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10.3)

(a) Project's IRR if the investment is made now:

$$\text{PW}(i) = -\$600,000 + \$250,000(P/A, i, 5) = 0$$
$$i = 30.77\%$$

(b) Let X denote the revised annual cash flow:

$$\text{PW}(30.77\%) = -\$600,000 + X(P/A, 30.77\%, 4)(P/F, 30.77\%, 1) = 0$$
$$X = \boxed{\$366,885.54}$$

10.4) (a) Economic building height

- $5\% < i < 20\%$: The optimal building height is 5 Floors.

Net Cash Flows				
n	2 Floors	3 Floors	4 Floors	5 Floors
0	($500,000)	($750,000)	($1,250,000)	($2,000,000)
1	$199,100	$169,200	$149,200	$378,150
2	$199,100	$169,200	$149,200	$378,150
3	$199,100	$169,200	$149,200	$378,150
4	$199,100	$169,200	$149,200	$378,150
5	$799,100	$1,069,200	$2,149,200	$3,378,150

Sensitivity Analysis					
PW(*i*) as a Function of Interest Rate					Best Floor Plan
i (%)	2 Floors	3 Floors	4 Floors	5 Floors	
5	$832,115	$687,721	$963,010	$1,987,770	5
6	$787,037	$635,264	$873,001	$1,834,680	5
7	$744,141	$585,441	$787,722	$1,689,448	5
8	$703,298	$538,091	$706,879	$1,551,593	5
9	$664,388	$493,067	$630,199	$1,420,666	5
10	$627,298	$450,230	$557,428	$1,296,250	5
11	$591,924	$409,452	$488,330	$1,177,957	5

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12	$558,167	$370,612	$422,686	$1,065,427	5
13	$525,937	$333,599	$360,291	$958,321	5
14	$495,148	$298,309	$300,953	$856,326	5
15	$465,720	$264,644	$244,495	$759,148	5
16	$437,580	$232,512	$190,751	$666,513	5
17	$410,657	$201,829	$139,565	$578,166	5
18	$384,885	$172,516	$90,792	$493,867	5
19	$360,205	$144,496	$44,298	$413,393	5
20	$336,557	$117,701	($46)	$336,533	2

(b) Effects of overestimation on resale value:

Net Cash Flows

n	2 Floors	3 Floors	4 Floors	5 Floors
0	($500,000)	($750,000)	($1,250,000)	($2,000,000)
1	$199,100	$169,200	$149,200	$378,150
2	$199,100	$169,200	$149,200	$378,150
3	$199,100	$169,200	$149,200	$378,150
4	$199,100	$169,200	$149,200	$378,150
5	$739,100	$979,200	$1,949,200	$3,078,150

PW(i) as a Function of Interest Rate

i (%)					Best Floor Plan
15	$435,890	$219,898	$145,060	$609,995	5

Resale value	Present Worth as a Function of Number of Floors			
	2	3	4	5
Base	$465,720	$264,644	$244,495	$759,148
10% error	$435,890	$219,898	$145,060	$609,995
Difference	$29,831	$44,746	$99,435	$149,153

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10.5) (a) With infinite planning horizon: We assume that both machines will be available with the same cost in the future.

Model A

Financial Data								
	n	0	1	2	3	4	5-7	8
Depreciation			$9,289	$15,919	$11,369	$8,119	$5,805	$2,899
Book value		$65,000	$55,712	$39,793	$28,425	$20,306	$14,502	$0
Market value								$5,000
Gain/Loss								$5,000
Operation Cost			$7,500	$7,500	$7,500	$7,500	$7,500	$7,500
Cash Flow Statement								
Investment		($65,000)						
+(.30)*(Depreciation)			$2,787	$4,776	$3,411	$2,436	$1,741	$870
-(1-0.30)*(Operation cost)			($5,250)	($5,250)	($5,250)	($5,250)	($5,250)	($5,250)
Net proceeds from sale								$3,500
Net Cash Flow		($65,000)	($2,463)	($474)	($1,839)	($2,814)	($3,509)	($880)

PW (10%) = ($77,306) AE (10%) = ($14,491)

Model B

Financial Data										
	n	0	1	2	3	4	5-7	8	9	10
Depreciation			$11,932	$20,449	$14,604	$10,429	$7,457	$3,724		
Book value		$83,500	$71,568	$51,119	$36,515	$26,085	$18,629	$0	$0	$0
Market value										$8,000
Gain/Loss										$8,000
Operation Cost			$5,800	$5,800	$5,800	$5,800	$5,800	$5,800	$5,800	$5,800
Cash Flow Statement										
Investment		($83,500)								
+(.30)*(Depreciation)			$3,580	$6,135	$4,381	$3,129	$2,237	$1,117	$0	$0
-(1-0.30)*(Operation cost)			($4,060)	($4,060)	($4,060)	($4,060)	($4,060)	($4,060)	($4,060)	($4,060)
Net proceeds from sale										$5,600
Net Cash Flow		($83,500)	($480)	$2,075	$321	($931)	($1,823)	($2,943)	($4,060)	$1,540

PW (10%) = ($88,214) AE (10%) = ($14,356)

Model B is preferred over Model A.

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(b) Break-even annual O&M costs for machine A: Let *X* denote a before-tax annual operating cost for model.

Model A

Financial Data										
	n	0	1	2	3	4	5	6	7	8
Depreciation			$9,289	$15,919	$11,369	$8,119	$5,805	$5,805	$5,805	$2,899
Book value		$65,000	$55,712	$39,793	$28,425	$20,306	$14,502	$8,697	$2,893	$0
Market value										$5,000
Gain/Loss										$5,000
Operation Cost			**$7,309**	**$7,309**	**$7,309**	**$7,309**	**$7,309**	**$7,309**	**$7,309**	**$7,309**
Cash Flow Statement										
Investment		($65,000)								
+(.30)*(Depreciation)			$2,787	$4,776	$3,411	$2,436	$1,741	$1,741	$1,741	$870
-(1-0.30)*(Operation cost)			($5,116)	($5,116)	($5,116)	($5,116)	($5,116)	($5,116)	($5,116)	($5,116)
Net proceeds from sale										$3,500
Net Cash Flow		($65,000)	($2,330)	($341)	($1,706)	($2,681)	($3,375)	($3,375)	($3,375)	($747)

PW (10%) = ($76,593) AEC(10%) = $14,357

Since we are comparing two mutually exclusive alternatives with unequal service lives, we could use AEC instead of PW. With the annual O&M cost of $7,309, the AEC of the both model would be the same. If we use the PW as a base to compare, we need to assume a least common multiple of 40 years.

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(c) With a shorter service life, Model A is preferred over Model B.

Financial Data							
	n	0	1	2	3	4	5
Depreciation			$9,289	$15,919	$11,369	$8,119	$2,902
Book value		$65,000	$55,712	$39,793	$28,425	$20,306	$17,404
Market value							$13,000
Gain/Loss							($4,404)
Operation Cost			$7,500	$7,500	$7,500	$7,500	$7,500
Cash Flow Statement							
Investment		($65,000)					
+(.30)*(Depreciation)			$2,787	$4,776	$3,411	$2,436	$871
-(1-0.30)*(Operation cost)			($5,250)	($5,250)	($5,250)	($5,250)	($5,250)
Net proceeds from sale							$14,321
Net Cash Flow		($65,000)	($2,463)	($474)	($1,839)	($2,814)	$9,942

PW (10%) = ($64,763) AEC(10%) = $17,084

Model B

Financial Data							
	n	0	1	2	3	4	5
Depreciation			$11,932	$20,449	$14,604	$10,429	$3,728
Book value		$83,500	$71,568	$51,119	$36,515	$26,085	$22,357
Market value							$18,500
Gain/Loss							($3,857)
Operation Cost			$5,800	$5,800	$5,800	$5,800	$5,800
Cash Flow Statement							
Investment		($83,500)					
+(.30)*(Depreciation)			$3,580	$6,135	$4,381	$3,129	$1,118
-(1-0.30)*(Operation cost)			($4,060)	($4,060)	($4,060)	($4,060)	($4,060)
Net proceeds from sale							$19,657
Net Cash Flow		($83,500)	($480)	$2,075	$321	($931)	$16,716

PW (10%) = ($72,238) AEC(10%) = $19,056

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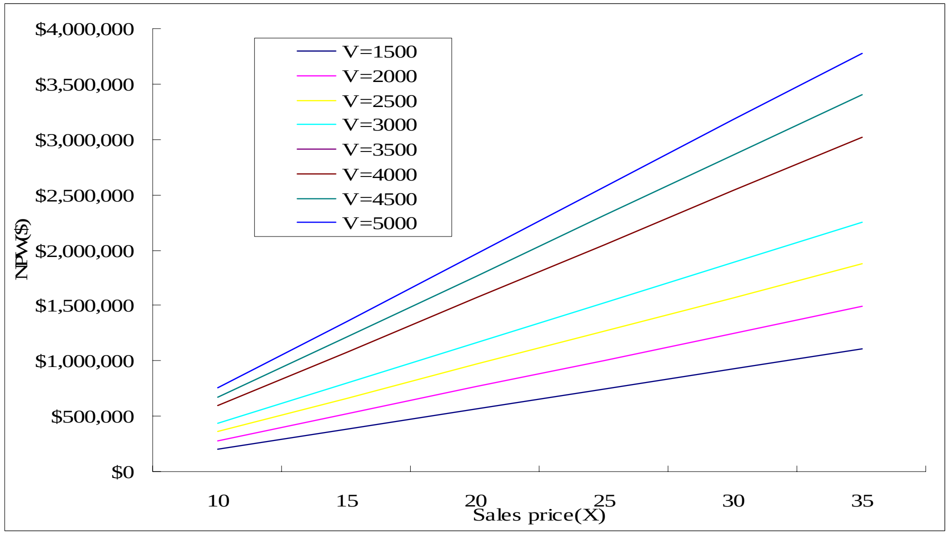
10.6) Sensitivity graph as a function of number of units produced and sales price per unit.

	V						
x	1500	2000	2500	3000	4000	4500	5000
10	$202,880	$281,700	$360,520	$439,340	$596,980	$675,800	$754,620
15	$384,448	$523,790	$663,133	$802,475	$1,081,160	$1,220,503	$1,359,845
20	$566,015	$765,880	$965,745	$1,165,610	$1,565,340	$1,765,205	$1,965,070
25	$747,583	$1,007,970	$1,268,358	$1,528,745	$2,049,520	$2,309,908	$2,570,295
30	$929,150	$1,250,060	$1,570,970	$1,891,880	$2,533,700	$2,854,610	$3,175,520
35	$1,110,718	$1,492,150	$1,873,583	$2,255,015	$3,017,880	$3,399,313	$3,780,745



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10.7)

(a) Project cash flows based on most-likely estimates:

	0	1	2	3	4	5	6	7	8
Income Statement									
Revenue:									
Bill savings		$3,000,000	$3,000,000	$3,000,000	$3,000,000	$3,000,000	$3,000,000	$3,000,000	$3,000,000
Mile Savings		1,250,000	$1,250,000	$1,250,000	$1,250,000	$1,250,000	$1,250,000	$1,250,000	$1,250,000
Expenses:									
Depreciation		2,000,000	3,200,000	1,920,000	1,152,000	1,152,000	576,000		
Taxable Income		2,250,000	1,050,000	2,330,000	3,098,000	3,098,000	3,674,000	4,250,000	4,250,000
Income Tax (38%)		855,000	399,000	885,400	1,177,240	1,177,240	1,396,120	1,615,000	1,615,000
Net Income		$1,395,000	$651,000	$1,444,600	$1,920,760	$1,920,760	$2,277,880	$2,635,000	$2,635,000
Cash Flow Statement									
Cash From Operation:									
Net Income		1,395,000	651,000	1,444,600	1,920,760	1,920,760	2,277,880	2,635,000	2,635,000
Depreciation		2,000,000	3,200,000	1,920,000	1,152,000	1,152,000	576,000	0	0
Investment&Salvage	-10,000,000								
Net Cash Flow	-10,000,000	3,395,000	3,851,000	3,364,600	3,072,760	3,072,760	2,853,880	2,635,000	2,635,000

PW (18%) = $3,204,044

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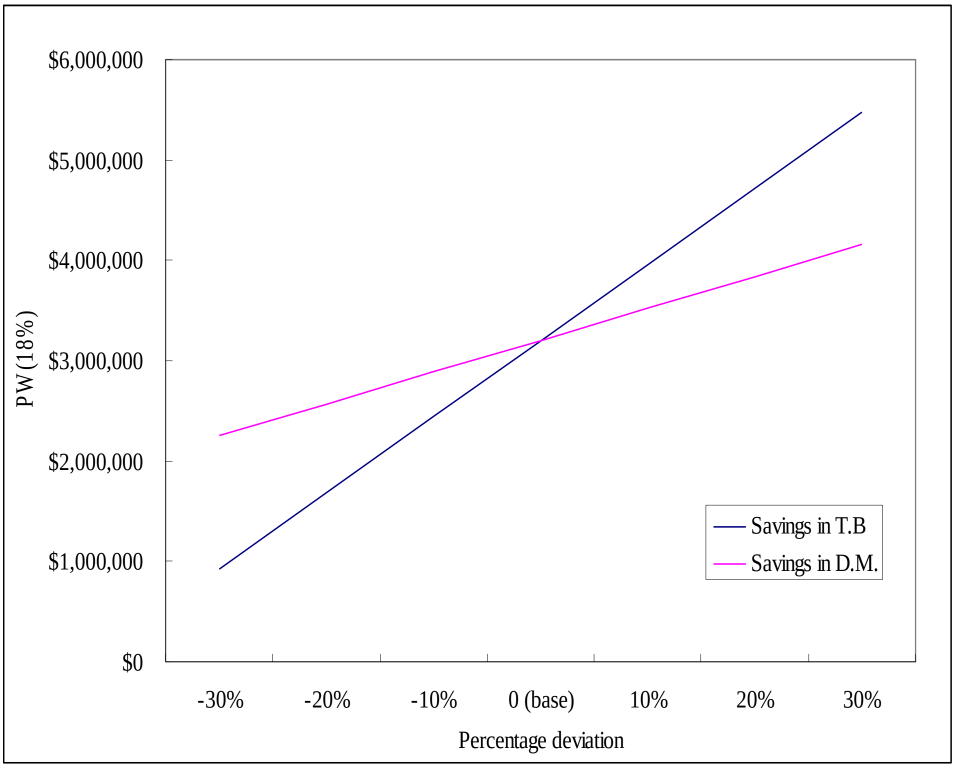
(b) Sensitivity analysis:

Percentage deviation	Savings In T.B	PW(18%)	Savings In D.M	PW(18%)
-30%	$2,100,000	$928,762	$875,000	$2,256,010
-20%	2,400,000	1,687,189	1,000,000	2,572,021
-10%	2,700,000	2,445,616	1,125,000	2,888,032
0 (base)	3,000,000	3,204,044	1,250,000	3,204,044
+10%	3,300,000	3,962,471	1,375,000	3,520,055
+20%	3,600,000	4,720,898	1,500,000	3,836,066
+30%	3,900,000	5,479,325	1,625,000	4,152,078

(c) Sensitivity diagrams



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10.8)

- PW of net investment:

$$P_0 = -\$3,500,000 - \$500,000 - \$700,000 = -\$4,700,000$$

- PW of after-tax revenue:

$$P_1 = \$6,000(365)X(1-0.30)(P/A,10\%,25) \\ = \$13,915,041X$$

- PW of after-tax operating costs:

$$P_2 = -(\$430,000 + \$220,000X)(1-0.30)(P/A,10\%,25) \\ = -\$2,732,177 - 1,397,858X$$

- PW of tax credit (shield) on depreciation:

	Depreciation		Combined
n	Building	Furniture	Tax savings
1	$86,006	$100,030	$55,811
2	$89,744	$171,430	$78,352
3	$89,744	$122,430	$63,652
4	$89,744	$87,430	$53,152
5	$89,744	$62,510	$45,676
6	$89,744	$62,440	$45,655
7	$89,744	$62,510	$45,676
8	$89,744	$31,220	$36,289
9--24	$89,744	0	$26,923
25	$86,006	0	$25,802

$$P_3 = \$55,811(P/F,10\%,1) + \$78,352(P/F,10\%,2) \\ + \cdots + \$25,802(P/F,10\%,25) \\ = \$394,763$$

- PW of net proceeds from sale:

Property	Cost basis	Salvage value	Book value	Gains (losses)	Gains Taxes
Furniture	$700,000	$0	$0	$0	$0
Building	$3,500,000	$0	$1,263,889	($1,263,889)	($379,167)
Land	$500,000	$1,693,177	$500,000	$1,193,177	$357,953

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$$\text{Net proceeds from sale} = \$1{,}693{,}177 + \$379{,}167 - \$357{,}953$$
$$= \$1{,}714{,}391$$
$$P_4 = \$1{,}714{,}391(P/F, 10\%, 25)$$
$$= \$158{,}231$$

$$\text{PW}(10\%) = P_0 + P_1 + P_2 + P_3 + P_4$$
$$= -\$6{,}879{,}183 + 12{,}517{,}183X$$
$$= 0$$
$$X = \boxed{54.96\%}$$

10.9)

(a) With an assumption of the unit price of \$100, the PW(12%) for options A and B would be the same when unit cost is set at \$9.35. Here we also assumed that the old machine is sold off and the current net after-tax salvage value in the amount of \$15,000 is credited for Option B. If the firm retains the old machines for other use, then the unit cost would be \$8.93.

Option A	100			
	0	1	2	3
Income Statement				
Revenue:				
		\$2,500,000	\$2,500,000	\$2,500,000
Expenses:				
Operating cost		225,000	225,000	225,000
Depreciation		0	0	0
Taxable Income		2,275,000	2,275,000	2,275,000
Income Tax (40%)		910,000	910,000	910,000
Net Income		\$1,365,000	\$1,365,000	\$1,365,000
Cash Flow Statement				
Cash From Operation:				
Net Income		1,365,000	1,365,000	1,365,000
Depreciation		0	0	0
Investment&Salvage				6,000
Gain taxes				-2,400
Net Cash Flow	0	1,365,000	1,365,000	1,368,600

PW (12%) = \$3,281,062

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Option B	100		unit cost=	9.345227724
	0	1	2	3
Income Statement				
Revenue:				
		$2,500,000	$2,500,000	$2,500,000
Expenses:				
Operating cost		233,631	233,631	233,631
Depreciation		0	0	0
Taxable Income		2,266,369	2,266,369	2,266,369
Income Tax (40%)		906,548	906,548	906,548
Net Income		$1,359,822	$1,359,822	$1,359,822
Cash Flow Statement				
Cash From Operation:				
Net Income		1,359,822	1,359,822	1,359,822
Depreciation		0	0	0
Investment&Salvage	25,000			
Gain taxes	(10,000)			0
Net Cash Flow	15,000	1,359,822	1,359,822	1,359,822

PW (12%) = $3,281,062

(b) If we assume the unit price of $100, the PW(12%) for options A and C would be $3,342,656, when unit cost is set at $7.22.

Option C				
	0	1	2	3
Income Statement				
Revenue:				
		$2,500,000	$2,500,000	$2,500,000
Expenses:				
Operating cost		168,750	168,750	168,750
Depreciation		7,860	13,470	4,810
Taxable Income		2,323,391	2,317,781	2,326,440
Income Tax (40%)		929,356	927,112	930,576
Net Income		$1,394,034	$1,390,668	$1,395,864
Cash Flow Statement				
Cash From Operation:				
Net Income		1,394,034	1,390,668	1,395,864
Depreciation		7,860	13,470	4,810
Investment&Salvage	(55,000)			15,000
Gain taxes				5,545
Net Sale of old machine	15,000			
Net Cash Flow	(40,000)	1,401,894	1,404,138	1,421,218

PW (12%) = $3,342,656

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Option B		100		unit cost=	7.219238803
	0		1	2	3
Income Statement					
Revenue:					
			$2,500,000	$2,500,000	$2,500,000
Expenses:					
Operating cost			180,481	180,481	180,481
Depreciation			0	0	0
Taxable Income			2,319,519	2,319,519	2,319,519
Income Tax (40%)			927,808	927,808	927,808
Net Income			$1,391,711	$1,391,711	$1,391,711
Cash Flow Statement					
Cash From Operation:					
Net Income			1,391,711	1,391,711	1,391,711
Depreciation			0	0	0
Investment&Salvage					
Gain taxes					0
Net Cash Flow		0	1,391,711	1,391,711	1,391,711

PW (12%) = $3,342,656

Need to add the net proceeds from sale.

(c). Option C is the most economical.

.

10.10) Useful life of the old bulb:

$$14,600/(19\times 365) = 2.1 \text{ years}$$

For computational simplicity, let's assume the useful life of 2 years for the old bulb. Then, the new bulb will last 4 years. Let X denote the price for the new light bulb. With an analysis period of 4 years, we can compute the equivalent present worth cost for each option as follows:

$$\begin{aligned} \text{PW}(15\%)_{\text{old}} &= (1-0.40)[\$61.90+\$61.90(P/F,15\%,2)] \\ &= \$65.23 \\ \text{PW}(15\%)_{\text{new}} &= (1-0.40)(X+\$16) \end{aligned}$$

The break-even price for the new bulb will be

$$\begin{aligned} 0.6X + 9.6 &= \$65.23 \\ X &= \boxed{\$92.72} \end{aligned}$$

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Since the new light bulb costs only $60, it is a good bargain.

10.11)

- PW of net investment:

$$P_0 = -\$350,000$$

- PW of after-tax rental revenue:

$$P_1 = X(1-0.30)(P/A,10\%,20)$$
$$= \$5.95952X$$

- PW of after-tax operating costs:

$$P_2 = -(1-0.30)\$18,000(P/A,10\%,20)$$
$$= -\$107,271$$

- PW of tax credit (shield) on depreciation: (In this problem, we assume that the purchasing cost of $350,000 does not include any land value. Therefore, the entire purchasing cost will be the cost basis for depreciation purpose.)

Depreciation		Combined
n	Building	Tax savings
1	$8,601	$8,601 (0.30) =$2580
2-19	$8,974	$8,974 (0.30) =$2692
20	$8,601	$8,601 (0.30) = $2580

$$P_3 = \$2,580(P/F,10\%,1) + \$2,692(P/A,10\%,18)(P/F,10\%,1)$$
$$+\$2,580(P/F,10\%,20)$$
$$= \$22,800$$

- PW of net proceeds from sale:

$$\text{Total depreciation} = \$178,734$$
$$\text{Book value} = \$350,000 - \$178,734$$
$$= \$171,266$$

$$\text{Salvage value} = \$350,000(1.05)^{20} = \$928,654$$

$$\text{Taxable gain} = \$928,654 - \$171,266$$
$$= \$757,388$$
$$\text{Gains tax} = \$757,388(0.30) = \$227,216$$

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$$
\begin{aligned}
\text{Net proceeds from sale} &= \$928,654 - \$227,216 \\
&= \$701,438 \\
P_4 &= \$701,438(P/F, 10\%, 20) \\
&= \$104,264
\end{aligned}
$$

The break-even rental

$$
\begin{aligned}
PW(10\%) &= P_0 + P_1 + P_2 + P_3 + P_4 \\
&= -\$330,207 + \$5.95952X \\
&= 0 \\
X &= \boxed{\$55,408}
\end{aligned}
$$

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10.12) Let *X* denote the additional annual revenue (above $16,000) for model A that is required to break even.

- After-tax cash flows for Model A:

Cash flows elements	End of Year					
	0	1	2	3	4-5	6
Investment	-$80,000					
(0.40) D_n		6,400	10,240	6,144	3,686	1,843
-(0.60)O& M_n		-13,200	-13,200	-13,200	-13,200	-13,200
+(0.60) R_n		9,600	9,600	9,600	9,600	9,600
		+0.6X	+0.6X	+0.6X	+0.6X	+0.6X
Net proceeds						12,000
Net cash flow	-$80,000	$2,800 +0.6X	$6,640 +0.6X	$2,544 +0.6X	$86 +0.6X	$10,234 +0.6X

$$\begin{aligned}\text{PW}(20\%)_A &= -\$80,000 + 0.6X(P/A, 20\%, 6) \\ &\quad + \$2,800(P/F, 20\%, 1) + \cdots + \$10,234(P/F, 20\%, 6) \\ &= -\$68,077 + \$1.9953X\end{aligned}$$

- After-tax cash flows for Model B:

Cash flows elements	End of Year					
	0	1	2	3	4-5	6
Investment	-$52,000					
(0.40) D_n		4,160	6,656	3,994	2,397	1,198
-(0.60)O& M_n		-10,200	-10,200	-10,200	-10,200	-10,200
+(0.60) R_n		0	0	0	0	0
Net proceeds						9,000
Net cash flow	-$52,000	-$6,040	-$3,544	-$6,206	-$7,803	-$2

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$$\begin{aligned}\text{PW}(20\%)_B &= -\$52,000 - \$6,040(P/F,20\%,1)\\ &\quad + \cdots - \$2(P/F,20\%,6)\\ &= -\$69,985\end{aligned}$$

Now let $\text{PW}(20\%)_A = \text{PW}(20\%)_B$ and solve for X.

$$\begin{aligned}-\$68,077 + 1.9953X &= -\$69,985\\ X &= \boxed{-\$957}\end{aligned}$$

The required break-even annual revenue for model A is then

$$\$16,000 + X = \$15,043$$

10.13) Let X denote the annual number of copies to break-even. If the selling price is set at \$0.50 per copy,

$$\begin{aligned}\text{A/T annual revenue} &= (0.6)[\$0.1 + (\$0.50 - \$0.15)]X\\ &= 0.27X\\ \text{A/T O\&M cost} &= -(0.60)[\$300,000(12) + \$0.20X]\\ &= -\$2,160,000 - 0.12X\\ \text{Depreciation tax credit} &= (0.40)[\$85,714(P/F,12\%,1) + \cdots\\ &\quad + \$26,775(P/F,12\%,8)](A/P,12\%,10)\\ &= (0.40)(408,576)(A/P,12\%,10)\\ &= \$28,923\\ \text{CR}(12\%) &= -\$600,000(A/P,12\%,10)\\ &\quad + \$100,000(A/F,12\%,10)\\ &= -\$100,500\end{aligned}$$

Gains tax $= \$40,000$ (or AE(12%) = \$40,000(A/F,12%,10) = \$2,279)

$$\begin{aligned}\text{AE}(12\%) &= 0.27X - \$2,160,000 - 0.12X + \$28,923 - \$100,500 - \$2,279\\ &= 0.15X - \$2,233,856\\ &= 0\\ X &= \boxed{14,892,373} \text{ copies per year}\end{aligned}$$

or 40,801 copies per day

Note: This is assuming 365 days per year and making no use of “25 printing days per month” information in the problem.

10.14)

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$$E[return] = (0.15 \times 5\%) + (0.25 \times 15\%) + (0.35 \times 22\%)$$
$$+ (0.15 \times 30\%) + (0.1 \times 40\%)$$
$$= 20.7\%$$

$$\sigma^2 = (0.15 \times (5 - 20.7)^2) + (0.25 \times (15 - 20.7)^2) + (0.35 \times (22 - 20.7)^2)$$
$$+ (0.15 \times (30 - 20.7)^2) + (0.1 \times (40 - 20.7)^2)$$
$$= 95.91$$
$$\sigma = 9.79\%$$

10.15) We can calculate the mean and variance for each periods with the three- point estimate.

Period (n)	Pessimistic	Most Likely	Optimistic	E[A_n]	Var[A_n]
0	($10,000)	($8,000)	($7,000)	($8,167)	250,000
1	$5,000	$12,000	$15,000	$11,333	2,777,778
2	$4,000	$10,000	$13,000	$9,500	2,250,000

$$E[\text{PW}(10\%)] = -\$8,167 + \frac{\$11,333}{1.1} + \frac{\$9,500}{1.1^2}$$
$$= \$9,986.97$$
$$V[\text{PW}(10\%)] = 250,000 + \frac{2,777,778}{1.1^2} + \frac{2,250,000}{1.1^4}$$
$$= 4,082,464.57$$
$$z = \frac{0 - 9,986.97}{\sqrt{4,082,464}} = -4.9428$$

NORMDIST(-4.9428,0,1,1)= 0.0000385%

10.16)

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$$\begin{aligned} PW(12\%)_{light} &= -\$8,000,000 + \$1,300,000(P/A,12\%,3) \\ &= -\$4,877,619 \\ PW(12\%)_{moderate} &= -\$8,000,000 + \$2,500,000(P/A,12\%,4) \\ &= -\$406,627 \\ PW(12\%)_{high} &= -\$8,000,000 + \$4,000,000(P/A,12\%,4) \\ &= \$4,149,397 \\ E[PW(12\%)] &= -\$4,877,619(0.20) - \$406,627(0.40) \\ &\quad +\$4,149,397(0.40) \\ &= \boxed{\$521,584} \end{aligned}$$

10.17) (a)

$$\begin{aligned} E[\text{PW}(10\%)] &= -\$1,000 + \frac{\$500}{1.1} + \frac{\$1,500}{1.1^2} + \frac{\$800}{1.1^3} \\ &= \$1,295.27 \\ V[\text{PW}(10\%)] &= \frac{200^2}{1.1^2} + \frac{300^2}{1.1^4} + \frac{100^2}{1.1^6} \\ &= 100,173.8 \end{aligned}$$

(b)

$$z = \frac{\$1,295.27 - \$1,295.27}{\sqrt{100,173.8}} = 0$$

NORMDIST(0,0,1,1) = 50%

(c)

$$\begin{aligned} \text{PW}(25\%)_{\text{certainty equivalent}} &= -\$1,000 + \frac{\$500}{1.25} + \frac{\$1,500}{1.25^2} + \frac{\$800}{1.25^3} \\ &= \$769.6 > 0 \end{aligned}$$

Yes, it would be justified.

10.18)

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(a)

$$E[\text{PW}(10\%)] = -\$300 + \frac{\$120}{1.1} + \frac{\$150}{1.1^2} + \frac{\$150}{1.1^3} + \frac{\$110}{1.1^4} + \frac{\$100}{1.1^5}$$
$$= \$182.98$$

$$V[\text{PW}(10\%)] = 20^2 + \frac{10^2}{1.1^2} + \frac{15^2}{1.1^4} + \frac{20^2}{1.1^6} + \frac{25^2}{1.1^8} + \frac{30^2}{1.1^{10}}$$
$$= 1{,}501$$

(b) Certainty equivalent value:

$$\text{PW}(18\%)_{\text{certainty equivalent}} = -\$300 + \frac{\$120}{1.18} + \frac{\$150}{1.18^2} + \frac{\$150}{1.18^3} + \frac{\$110}{1.18^4} + \frac{\$100}{1.18^5}$$
$$= \$101 > 0$$

Yes, it would be justified.

10.19)

(a)

$$E[\text{PW}(12\%)] = -\$18 + \frac{\$5}{1.12} + \frac{\$8}{1.12^2} + \frac{\$12}{1.12^3} + \frac{\$10}{1.12^4} + \frac{\$5}{1.12^5}$$
$$= \$10.58M$$

$$V[\text{PW}(12\%)] = 0^2 + \frac{8^2}{1.12^2} + \frac{9^2}{1.12^4} + \frac{10^2}{1.12^6} + \frac{5^2}{1.12^8} + \frac{3^2}{1.12^{10}}$$
$$= 166.155$$

(b)

$$z = \frac{0 - 10.58}{\sqrt{166.155}} = -0.8208$$

NORMDIST(-0.8208,0,1,1) = 20.59%

(c) Using Excel's Goal Seek function to get *i*.

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$$E[\text{PW}(i)] = -\$18 + \frac{\$5}{(1+i)} + \frac{\$8}{(1+i)^2} + \frac{\$12}{(1+i)^3} + \frac{\$10}{(1+i)^4} + \frac{\$5}{(1+i)^5}$$
$$= 0$$

$$i = 32.38\%$$

10.20)

(a)

$$E[\text{PW}(10\%)] = -\$2,500 + \frac{\$2,200}{1.1} + \frac{\$1,800}{1.1^2}$$
$$= \$987.6 \ > 0, \text{ acceptable.}$$

(b)

$$V[\text{PW}(10\%)] = 100^2 + \frac{200^2}{1.1^2} + \frac{300^2}{1.1^4}$$
$$= 104,529$$

$$\sigma = \sqrt{104,529} = \$323.31$$

(c)

$$V[\text{PW}(10\%)] = 100^2 + \frac{200^2}{1.1^2} + \frac{300^2}{1.1^4}$$
$$= 104,529$$
$$\sigma = \sqrt{104,529} = \$323.31$$
$$\mu - 2\sigma = \$987.6 - 2(\$323.31)$$
$$= \$340.98$$

Using Excel

NORMDIST(-2,0,1,1) = 2.275%

10.21)

(a) The mean return for projects

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$$E[return]_A = (0.1\times -20\%) + (0.2\times 0\%) + (0.25\times 10\%)$$
$$+ (0.3\times 15\%) + (0.1\times 20\%) + (0.05\times 40\%)$$
$$= 9\%$$
$$E[return]_B = (0.1\times -35\%) + (0.2\times -10\%) + (0.25\times 15\%)$$
$$+ (0.3\times 25\%) + (0.1\times 40\%) + (0.05\times 50\%)$$
$$= 12.25\%$$

(b) The variance of return for projects

$$\sigma^2{}_A = (0.1\times(-20-9)^2) + (0.2\times(0-9)^2)$$
$$+ (0.25\times(10-9)^2) + (0.3\times(15-9)^2)$$
$$+ (0.1\times(20-9)^2) + (0.05\times(40-9)^2)$$
$$= 171.50$$
$$\sigma^2{}_B = (0.1\times(-35-12.25)^2) + (0.2\times(-10-12.25)^2)$$
$$+ (0.25\times(15-12.25)^2) + (0.3\times(25-12.25)^2)$$
$$+ (0.1\times(40-12.25)^2) + (0.05\times(50-12.25)^2)$$
$$= 521.19$$

(c) It is not a clear case, because $E[return]_B > E[return]_A$ but also $Var_B > Var_A$.

If you make decision solely based on the principle of maximization of expected return, you may prefer project B.

10.22)

(a)

$$E[\text{PW}(12\%)]_A = (0.3)\left[-\$150,000 + \$35,000(P/A,12\%,5)\right]$$
$$+ (0.5)\left[-\$150,000 + \$40,000(P/A,12\%,5)\right]$$
$$+ (0.2)\left[-\$150,000 + \$50,000(P/A,12\%,5)\right]$$
$$= -\$4,006.6$$
$$E[\text{PW}(12\%)]_B = (0.3)\left[-\$180,000 + \$45,000(P/A,12\%,5)\right]$$
$$+ (0.5)\left[-\$180,000 + \$55,000(P/A,12\%,5)\right]$$
$$+ (0.2)\left[-\$180,000 + \$67,000(P/A,12\%,5)\right]$$
$$= \$16,100$$

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$$\sigma^2_A = (0.3\times(-23{,}832+4{,}006.6)^2)+(0.5\times(-5{,}808+4{,}006.6)^2)$$
$$+(0.2\times(30{,}240+4{,}006.6)^2)$$
$$=354{,}097{,}713$$
$$\sigma^2_B = (0.3\times(-17{,}785-16{,}100)^2)+(0.5\times(18{,}263-16{,}100)^2)$$
$$+(0.2\times(61{,}520-16{,}100)^2)$$
$$=759{,}392{,}532$$

(b).Project A has a higher probability to lose money.

$$z_A = \frac{0+4{,}006.6}{\sqrt{354{,}097{,}713}} = 0.2129$$

NORMDIST(0.2129,0,1,1)=58.43%

$$z_B = \frac{0-16{,}100}{\sqrt{759{,}392{,}532}} = -0.58428$$

NORMDIST(-0.58428,0,1,1)= 27.95%

10.23)

(a) The PW distribution for project 1:

Event (*x*,*y*)	Joint probability	PW(10%)
($20,$10)	0.18	$400
($20,$20)	0.12	0
($40,$10)	0.42	2,400
($40,$20)	0.28	1,600

(b) The mean and variance of the PW for Project 1:

$$E[\text{PW}(10\%)]_1 = \$400(0.18)+\$0(0.12)+\$2{,}400(0.42)$$
$$+\$1{,}600(0.28)$$
$$=\$1{,}528$$
$$Var[\text{PW}(10\%)]_1 = (400-1{,}528)^2(0.18)+(0-1{,}528)^2(0.12)$$
$$+(2{,}400-1{,}528)^2(0.42)$$
$$+(1{,}600-1{,}528)^2(0.28)$$
$$=830{,}016$$

(c) The mean and variance of the PW for Project 2:

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$$E[\mathrm{PW}(10\%)]_2 = \$0(0.24) + \$400(0.20) + \$1,600(0.36)$$
$$+\$2,400(0.20)$$
$$= \$1,136$$
$$Var[\mathrm{PW}(10\%)]_2 = (0 - 1,136)^2(0.24) + (400 - 1,136)^2(0.20)$$
$$+(1,600 - 1,136)^2(0.36)$$
$$+(2,400 - 1,136)^2(0.20)$$
$$= 815,104$$

(d)

It is not a clear case, because $E_1 > E_2$ but also $Var_1 > Var_2$.

If Juan makes the decision solely based on the principle of maximization of expected value, she may prefer contract A.

10.24)

Expected value criterion: Assume that the opportunity cost rate is 7.5%.

- Option 1:

$$E[R]_1 = \$2,450(0.25) + \$2,000(0.45) + \$1,675(0.30)$$
$$-\$150(F/P, 7.5\%, 1)$$
$$= \$1,854$$

- Option 2:

$$E[R]_2 = \$25,000(0.075) = \$1,875$$

Option 2 is the better choice based on the principle of expected value maximization.

10.25)

(a)

$$E[\mathrm{PW}]_1 = (\$2,000)(0.20) + (\$3,000)(0.60)$$
$$+(\$3,500)(0.20) - \$1,000$$
$$= \$1,900$$
$$E[\mathrm{PW}]_2 = (\$1,000)(0.30) + (\$2,500)(0.40) + (\$4,500)(0.30)$$
$$-\$800$$
$$= \$1,850$$

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Project 1 is preferred over Project 2.

(b)

$$Var[\text{PW}]_1 = (2,000-1,900)^2(0.20)+(3,000-1,900)^2(0.60)$$
$$+(3,500-1,900)^2(0.20)$$
$$=1,240,000$$
$$Var[\text{PW}]_2 = (1,000-1,850)^2(0.30)+(2,500-1,850)^2(0.40)$$
$$+(4,500-1,850)^2(0.30)$$
$$=2,492,500$$

Project 1 is still preferred, because $Var[\text{PW}]_1 < Var[\text{PW}]_2$

but $E[\text{PW}]_1 > E[\text{PW}]_2$.

10.26)

(a) Mean and variance calculations:

$$E[\text{PW}]_A = (\$100,000)(0.20)+(\$50,000)(0.40)$$
$$+(0)(0.40)$$
$$=\$40,000$$
$$E[\text{PW}]_B = (\$40,000)(0.30)+(\$10,000)(0.40)$$
$$+(-\$10,000)(0.30)$$
$$=\$13,000$$
$$Var[\text{PW}]_A = (100,000-40,000)^2(0.20)$$
$$+(50,000-40,000)^2(0.40)$$
$$+(0-40,000)^2(0.40)$$
$$=1,400,000,000$$
$$Var[\text{PW}]_B = (40,000-13,000)^2(0.30)$$
$$+(10,000-13,000)^2(0.40)$$
$$+(-10,000-13,000)^2(0.30)$$
$$=381,000,000$$

Contract A has no chance of losing money, so the executive should certainly choose A rather than no contract at all. Between A and B, the choice is less clear-cut, because $E_A > E_B$ but also $Var_A > Var_B$. If he makes the decision solely based on the principle of maximization of expected value, he may prefer contract A.

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(b) Assuming that the contracts are statistically independent from each other,

Joint event ($PW_A > PW_B$)	Joint Probability
($100,000,$40,000)	(0.20)(0.30) = 0.06
($100,000,$10,000)	(0.20)(0.40) = 0.08
($100,000,-$10,000)	(0.20)(0.30) = 0.06
($50,000,$40,000)	(0.40)(0.30) = 0.12
($50,000,$10,000)	(0.40)(0.40) = 0.16
($50,000,-$10,000)	(0.40)(0.30) = 0.12
($0,-$10,000)	(0.40)(0.30) = 0.12
	$\Sigma = 0.72$

10.27)

(a)

- Machine A:

$$\begin{aligned} \text{CR}(10\%)_A &= (\$60,000 - \$22,000)(A/P,10\%,6) \\ &\quad +(0.10)(\$22,000) \\ &= \$10,924 \\ E[\text{AE}(10\%)]_A &= (\$5,000)(0.20) + (\$8,000)(0.30) \\ &\quad +(\$10,000)(0.30) + (\$12,000)(0.20) \\ &\quad +\$10,924 \\ &= \$19,725 \\ Var[\text{AE}(10\%)]_A &= (15,924 - 19,725)^2(0.20) \\ &\quad +(18,924 - 19,725)^2(0.30) \\ &\quad +(20,924 - 19,725)^2(0.30) \\ &\quad +(22,924 - 19,725)^2(0.20) \\ &= 5,560,000 \end{aligned}$$

- Machine B:

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$$\begin{aligned}\text{CR}(10\%)_B &= \$35,000(A/P,10\%,4)\\ &= \$11,042\\ E[\text{AE}(10\%)]_B &= (\$8,000)(0.10)+(\$10,000)(0.30)\\ &\quad +(\$12,000)(0.40)+(\$14,000)(0.20)\\ &\quad +\$11,042\\ &= \$22,442\\ Var[\text{AE}(10\%)]_B &= (19,042-22,442)^2(0.10)\\ &\quad +(21,042-22,442)^2(0.30)\\ &\quad +(23,042-22,442)^2(0.40)\\ &\quad +(25,042-22,442)^2(0.20)\\ &= 3,240,000\end{aligned}$$

(b) $\text{Prob}[\text{AE}(10\%)_A > \text{AE}(10\%)_B]$:

Joint event $(\text{O\&M}_A, \text{O\&M}_B)$	$(\text{AE}_A, \text{AE}_B)$	Joint Probability
($10,000, $8,000)	($20,924, $19,042)	(0.30)(0.10) = 0.03
($12,000, $8,000)	($22,924, $19,042)	(0.20)(0.10) = 0.02
($12,000, $10,000)	($22,924, $21,042)	(0.20)(0.30) = 0.06
		$\Sigma = 0.11$

10.28)

(a) Mean and variance calculation (Note: For a random variable *Y*, which can be expressed as a linear function of another random variable *X* (say, $Y = aX$, where a is a constant) the variance of *Y* can be calculated as a function of variance of *X*, $Var[Y] = a^2 Var[X]$.

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$$
\begin{aligned}
E[\text{PW}]_A &= -\$5,000 + \$4,000(P/A, 15\%, 2) \\
&= \$1,502.84 \\
E[\text{PW}]_B &= -\$10,000 + \$6,000(P/F, 15\%, 1) \\
&\quad + \$8,000(P/F, 15\%, 2) \\
&= \$1,266.54 \\
V[\text{PW}]_A &= 1,000^2 + (P/F, 15\%, 1)^2 1,000^2 \\
&\quad + (P/F, 15\%, 2)^2 1,500^2 \\
&= 3,042,588 \\
V[\text{PW}]_B &= 2,000^2 + (P/F, 15\%, 1)^2 1,500^2 \\
&\quad + (P/F, 15\%, 2)^2 2,000^2 \\
&= 7,988,336
\end{aligned}
$$

(b) Comparing risky projects

	Project A	Project B
$E[PW]$	\$1,503	\$1,267
$V[PW]$	3,042,588	7,988,336

Project A is preferred over project B, because $V[PW]_A < V[PW]_B$

and $E[PW]_A > E[PW]_B$.

10.29) Select (b).

10.30)

- Cash flow for this investment
  Assumption: MARR is 15%.

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	0	1	2	3	4	5
Income Statement						
Revenue:						
Unit price		$50	$50	$50	$50	$50
Demand(units)		2,000	2,000	2,000	2,000	2,000
Sales Revenue		$100,000	$100,000	$100,000	$100,000	$100,000
Expenses:						
Unit variable cost		$15	$15	$15	$15	$15
Variable cost		$30,000	$30,000	$30,000	$30,000	$30,000
Fixed cost		$10,000	$10,000	$10,000	$10,000	$10,000
Depreciation		$17,863	$30,613	$21,863	$15,613	$5,581
Taxable Income		$42,138	$29,388	$38,138	$44,388	$54,419
Income Tax (40%)		$16,855	$11,755	$15,255	$17,755	$21,768
Net Income		$25,283	$17,633	$22,883	$26,633	$32,651
Cash Flow Statement						
Cash From Operation:						
Net Income		$25,283	$17,633	$22,883	$26,633	$32,651
Depreciation		$17,863	$30,613	$21,863	$15,613	$5,581
Investment	($125,000)					
Salvage						$40,000
Gains tax						($2,613)
Net Cash Flow	($125,000)	$43,145	$48,245	$44,745	$42,245	$75,620
	NPV(15%)=	$40,168				

- Sensitivity analysis for five key input variables

Deviation	-20%	-15%	-10%	-5%	0%	5%	10%	15%	20%
Unit price	($57)	$9,999	$20,055	$30,111	$40,168	$50,225	$60,281	$70,337	$80,393
Demand(units)	$12,010	$19,049	$26,088	$33,130	$40,168	$47,208	$54,247	$61,286	$68,325
Variable cost	$52,236	$49,219	$46,202	$43,186	$40,168	$37,152	$34,135	$31,118	$28,101
Fixed cost	$44,191	$43,185	$42,179	$41,175	$40,168	$39,163	$38,157	$37,151	$36,145
Salvage value	$37,782	$38,378	$38,974	$39,573	$40,168	$40,765	$41,361	$41,957	$42,553

- Sensitivity graph for the BMC's transmission-housings project

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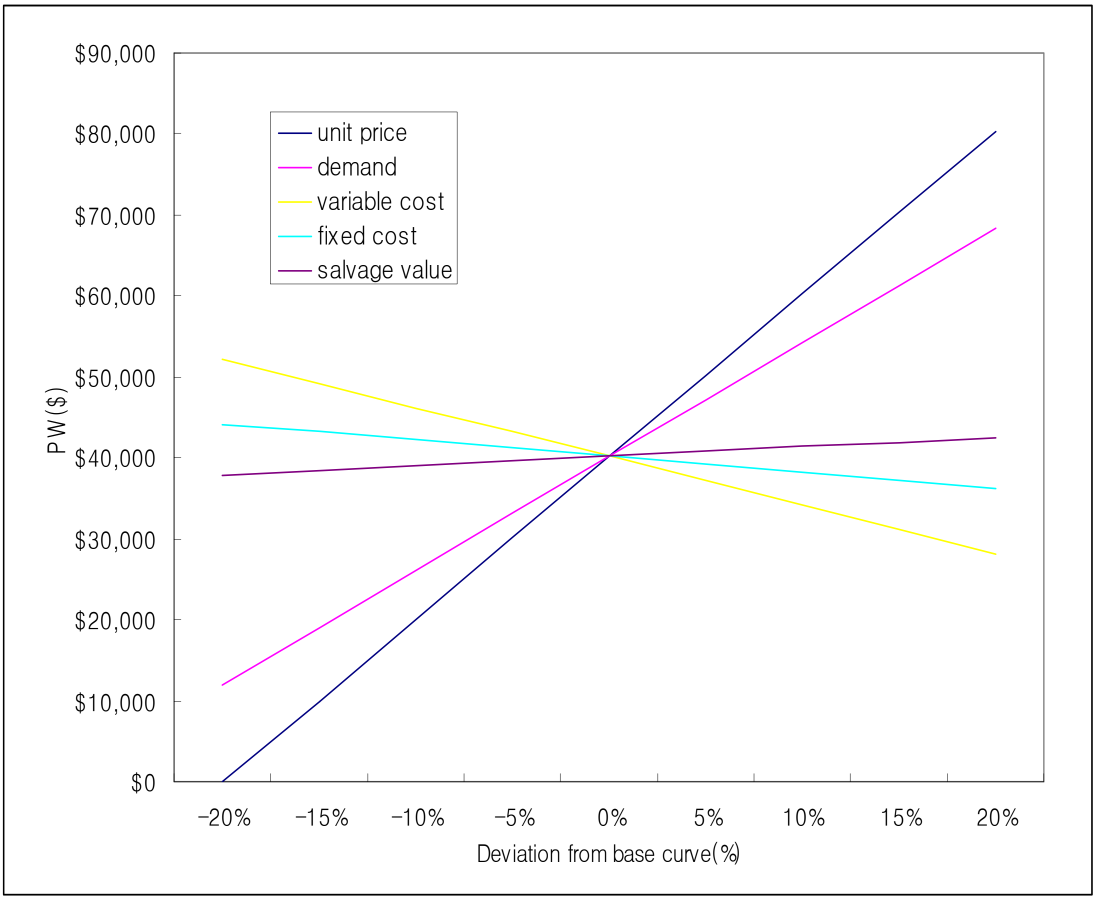

10.31)

(a)

$$\overline{f} = 0.25(3\%) + 0.5(5\%) + 0.25(7\%) = 5\%$$

$$i = i' + \overline{f} + i'\overline{f} = 0.1 + 0.05 + 0.1(0.05) = 0.155$$

Salvage_year 2=$6,000(1.05)^2=$6,615
Gain tax_year 2=$1,443 (tax credit)
Working capital_year 2=$3,308

$$\begin{aligned} PW(15.5\%) &= -\$26,000 + (0.6X + 0.4(\$7,666))(P/F,15.5\%,1)) \\ &+ (0.6X + 0.4(\$5,112) + \$6,615 + \$1,443 + \$3,308)(P/F,15.5\%,2)) \\ &= 0.96924X - \$13,294.1 \end{aligned}$$

(b) & (c)

- $X = \$15,000, \quad PW(15.5\%) = \$1,583$

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Income Statement	inflation	0	1	2
Revenue (Savings)	5%		$15,000	$15,750
Expenses:				
O&M				
Depreciation			$ 7,666	$ 5,112
Interest				
Taxable Income			$7,334	$10,638
Income Taxes (40%)			$2,934	$4,255
Net Income			$4,400	$6,383
Cash Flow Statement				
Cash from operation				
Net Income			$4,400	$6,383
Depreciation			$7,666	$5,112
Cash from investing activities:				
Investment / Salvage	5%	$ (23,000)		$ 6,615
Gains Tax				$ 1,443
Working capital	5%	$ (3,000)		$ 3,308
Cash from financing activities:				
Loan repayment				
Net Cash Flow (actual)		($26,000)	$12,066	$22,860
Net Cash Flow (constant)		-26,000	11,492	20,735
		PW (15.5%) =	$ 1,583	

- $X = \$25{,}000, \quad \text{PW}(15.5\%) = \$11{,}501$

Income Statement	inflation	0	1	2
Revenue (Savings)	5%		$25,000	$26,250
Expenses:				
O&M				
Depreciation			$ 7,666	$ 5,112
Interest				
Taxable Income			$17,334	$21,138
Income Taxes (40%)			$6,934	$8,455
Net Income			$10,400	$12,683
Cash Flow Statement				
Cash from operation				
Net Income			$10,400	$12,683
Depreciation			$7,666	$5,112
Cash from investing activities:				
Investment / Salvage	5%	$ (23,000)		$ 6,615
Gains Tax				$ 1,443
Working capital	5%	$ (3,000)		$ 3,308
Cash from financing activities:				
Loan repayment				
Net Cash Flow (actual)		($26,000)	$18,066	$29,160
Net Cash Flow (constant)		(26,000)	17,206	26,449
		PW (15.5%) =	$ 11,501	

- $X = \$35{,}000, \quad \text{PW}(15.5\%) = \$21{,}418$

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Income Statement	inflation	0	1	2
Revenue (Savings)	5%		$35,000	$36,750
Expenses:				
O&M				
Depreciation			$ 7,666	$ 5,112
Interest				
Taxable Income			$27,334	$31,638
Income Taxes (40%)			$10,934	$12,655
Net Income			$16,400	$18,983
Cash Flow Statement				
Cash from operation				
Net Income			$16,400	$18,983
Depreciation			$7,666	$5,112
Cash from investing activities:				
Investment / Salvage	5%	$ (23,000)		$ 6,615
Gains Tax				$ 1,443
Working capital	5%	$ (3,000)		$ 3,308
Cash from financing activities:				
Loan repayment				
Net Cash Flow (actual)		($26,000)	$24,066	$35,460
Net Cash Flow (constant)		(26,000)	22,920	32,163
		PW (15.5%) =	$ 21,418	

$$X = \$15{,}000, \quad \text{PW}(15.5\%) = \$1{,}583$$
$$X = \$25{,}000, \quad \text{PW}(15.5\%) = \$11{,}501$$
$$X = \$35{,}000, \quad \text{PW}(15.5\%) = \$21{,}418$$

$$\begin{aligned} E[\text{PW}(15.5\%)] &= \$1{,}583(0.2) + \$11{,}501(0.5) + \$21{,}418(0.3) \\ &= \$12{,}492.5 \\ Var[\text{PW}(15.5\%)] &= (1{,}583 - 12{,}492.5)^2(0.2) + (11{,}501 - 12{,}492.5)^2(0.5) \\ &\quad + (21{,}418 - 12{,}492.5)^2(0.3) \\ &= 48{,}194{,}339.25 \end{aligned}$$

10.32)

Since the amount of annual labor savings is the same for both alternatives, this labor savings factor is not considered in the following analysis.

(a) After-tax cash flows:

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	After-Tax Cash Flows	
n	Lectra System	Tex System
0	-$136,150	-$195,500
1	117,927	149,075
2	124,462	158,459
3	117,491	148,449
4	113,308	142,443
5	113,308	142,443
6	122,171	146,939
PW(12%)	$350,189	$415,383
AE(12%)	$85,175	$101,032

Based on the most-likely estimates, the Tex system is the better choice.

(b) Let *X* and *Y* denote the annual material savings for the Lectra system and Tex system, respectively.

	After-Tax Cash Flows	
n	Lectra System	Tex System
0	-$136,150	-$195,500
1	0.6*X*-20,073	0.6*Y*-15,325
2	0.6*X*-13,538	0.6*Y*-5,941
3	0.6*X*-20,508	0.6*Y*-15,951
4	0.6*X*-24,691	0.6*Y*-21,956
5	0.6*X*-24,691	0.6*Y*-21,956
6	0.6*X*-15,828	0.6*Y*-17,461

- Lectra System:

$$\begin{aligned}
\text{AE}(12\%)_{\text{Lectra}} &= -\$52,824 + 0.6X \\
E[X] &= \$224,000 \\
Var[X] &= 2,124,000,000 \\
E[\text{AE}(12\%)]_{\text{Lectra}} &= -\$52,824 + 0.6E[X] \\
&= \$81,576 \\
Var[\text{AE}(12\%)]_{\text{Lectra}} &= (0.6)^2 Var[X] \\
&= 764,640,000
\end{aligned}$$

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- Tex System:

$$
\begin{aligned}
\text{AE}(12\%)_{\text{Tex}} &= -\$63,368 + 0.6Y \\
E[Y] &= \$259,400 \\
Var[Y] &= 1,718,440,000 \\
E[\text{AE}(12\%)]_{\text{Tex}} &= -\$63,368 + 0.6E[Y] \\
&= \$92,272 \\
Var[\text{AE}(12\%)]_{\text{Tex}} &= (0.6)^2 Var[Y] \\
&= 618,638,400
\end{aligned}
$$

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10.33)

(a) Incremental project cash flows (FMS - CMT):

No. of part types		3,000	3,000	3,000	3,000	3,000	3,000	3,000	3,000	3,000	3,000
No. of pieces per year		544,000	544,000	544,000	544,000	544,000	544,000	544,000	544,000	544,000	544,000
Year	0	1	2	3	4	5	5	7	8	9	10
Income Statement											
Revenue (Savings):											
Labor		$462,400	$462,400	$462,400	$462,400	$462,400	$462,400	$462,400	$462,400	$462,400	$462,400
Material		233,920	233,920	233,920	233,920	233,920	233,920	233,920	233,920	233,920	233,920
Overhead		1,200,000	1,200,000	1,200,000	1,200,000	1,200,000	1,200,000	1,200,000	1,200,000	1,200,000	1,200,000
Tooling		170,000	170,000	170,000	170,000	170,000	170,000	170,000	170,000	170,000	170,000
Inventory		109,500	109,500	109,500	109,500	109,500	109,500	109,500	109,500	109,500	109,500
Expenses:											
Depreciation		928,850	1,591,850	1,136,850	811,850	580,450	579,800	580,450	289,900		
Taxable Income		1,246,970	583,970	1,038,970	1,363,970	1,595,370	1,596,020	1,595,370	1,885,920	2,175,820	2,175,820
Income Tax (40%)		498,788	233,588	415,588	545,588	638,148	638,408	638,148	754,368	870,328	870,328
Net Income		$748,182	$350,382	$623,382	$818,382	$957,222	$957,612	$957,222	$1,131,552	$1,305,492	$1,305,492
Cash Flow Statement											
Cash From Operation:											
Net Income		748,182	350,382	623,382	818,382	957,222	957,612	957,222	1,131,552	1,305,492	1,305,492
Depreciation		928,850	1,591,850	1,136,850	811,850	580,450	579,800	580,450	289,900		
Investment&Salvage	(6,500,000)										500,000
Gains Tax (40%)											(200,000)
Net Cash Flow	$ (6,500,000)	$ 1,677,032	$ 1,942,232	$ 1,760,232	$ 1,630,232	$ 1,537,672	$ 1,537,412	$ 1,537,672	$ 1,421,452	$ 1,305,492	$ 1,605,492

PW (15%) = $1,756,225

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(b) &(c) Sensitivity analysis:

AOC = annual overhead cost

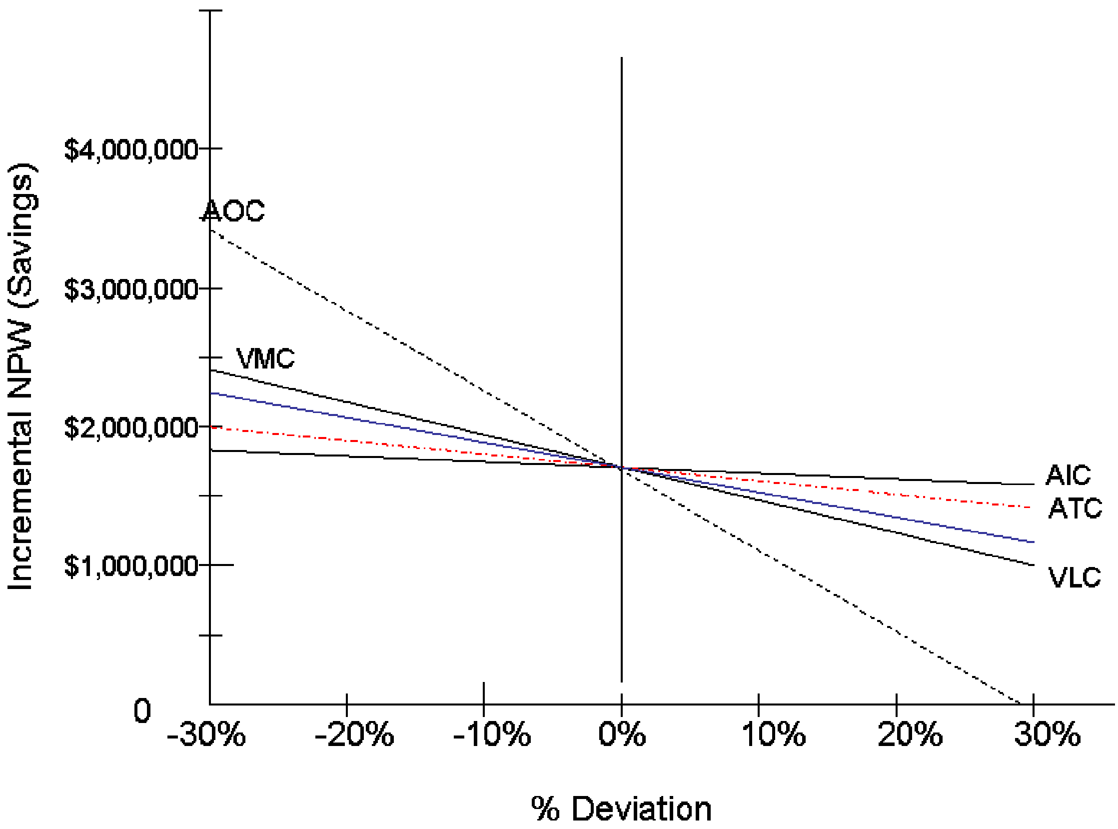
VLC = variable labor cost / part

AIC = annual inventory cost

ATC = annual tooling cost

VMC = variable material cost / part

Deviation	-30%	-20%	-10%	0%	10%	20%	30%
AOC	$3,517,813	$2,930,617	$2,343,421	$1,756,225	$1,169,030	$581,834	-$5,362
VLC	$2,395,095	$2,182,138	$1,969,182	$1,756,225	$1,543,268	$1,330,313	$1,117,356
AIC	$1,784,682	$1,775,196	$1,765,711	$1,756,225	$1,746,740	$1,737,225	$1,727,769
ATC	$2,027,239	$1,936,901	$1,846,563	$1,756,225	$1,665,888	$1,575,550	$1,485,212
VMC	$2,296,807	$2,116,613	$1,936,419	$1,756,225	$1,576,032	$1,395,838	$1,215,644



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(d) Best and worst scenarios:

- Best case: Material cost = \$1.00 per part, annual inventory cost = \$25,000

$$PW(15\%)_{FMS-CMT} = \$1,939,611$$

- Worst case: Material cost = \$1.40 per part, annual inventory cost = \$100,000

$$PW(15\%)_{FMS-CMT} = \$1,058,516$$

(e) Mean and variance:

- $E[PW(15\%)_{FMS-CMT}]$: \$1,595,123

- $Var[PW(15\%)_{FMS-CMT}]$: 46,073,274,329

(f) In no situation, the FMS would be a more expensive investment option than the CMT.

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