CHAPTER 11
PROJECT ANALYSIS AND EVALUATION

Answers to Concepts Review and Critical Thinking Questions

1. Forecasting risk is the risk that a poor decision is made because of errors in projected cash flows. The danger is greatest with a new product because the cash flows are probably harder to predict.

2. With a sensitivity analysis, one variable is examined over a broad range of values. With a scenario analysis, all variables are examined for a limited range of values.

3. It is true that if average revenue is less than average cost, the firm is losing money. This much of the statement is therefore correct. At the margin, however, accepting a project with marginal revenue in excess of its marginal cost clearly acts to increase operating cash flow.

4. It makes wages and salaries a fixed cost, driving up operating leverage.

5. Fixed costs are relatively high because airlines are relatively capital intensive (and airplanes are expensive). Skilled employees such as pilots and mechanics mean relatively high wages which, because of union agreements, are relatively fixed. Maintenance expenses are significant and relatively fixed as well.

6. From the shareholder perspective, the financial break-even point is the most important. A project can exceed the accounting and cash break-even points but still be below the financial break-even point. This causes a reduction in shareholder (your) wealth.

7. The project will reach the cash break-even first, the accounting break-even next and finally the financial break-even. For a project with an initial investment and sales after, this ordering will always apply. The cash break-even is achieved first since it excludes depreciation. The accounting break-even is next since it includes depreciation. Finally, the financial break-even, which includes the time value of money, is achieved.

8. Soft capital rationing implies that the firm as a whole isn't short of capital, but the division or project does not have the necessary capital. The implication is that the firm is passing up positive NPV projects. With hard capital rationing the firm is unable to raise capital for a project under any circumstances. Probably the most common reason for hard capital rationing is financial distress, meaning bankruptcy is a possibility.

9. The implication is that they will face hard capital rationing.

Solutions to Questions and Problems

Basic

1. *a.* Total variable costs = $0.74 + 2.61 = $3.35

b. Total costs = variable costs + fixed costs = $3.35(300,000) + $610,000 = $1,615,000

c. Q_C = $610,000 / ($7.00 – 3.35) = 167,123 units

Q_A = ($610,000 + 150,000) / ($7.00 – 3.35) = 208,219 units

2. Total costs = ($10.94 + 32)(140,000) + $800,000 = $6,811,600
Marginal cost = cost of producing one more unit = $42.94
Average cost = total cost/total quantity = $6,811,600/140,000 = $48.65
Minimum acceptable total revenue = 10,000($42.94) = $429,400.
Additional units should be produced only if the cost of producing those units can be recovered.

3.

	Base Case	Lower Bound	Upper Bound
Unit sales	90,000	76,500	103,500
Price/unit	$1,850	$1,572.50	$2,127.50
Variable cost/unit	$160.00	$136.00	$184.00
Fixed costs	$7,000,000	$5,950,000	$8,050,000

Scenario	Unit Sales	Unit Price	Unit Variable Cost	Fixed Costs
Base	90,000	$1,850	$160.00	$7,000,000
Best	103,500	$2,127.50	$136.00	$5,950,000
Worst	76,500	$1,572.50	$184.00	$8,050,000

4. An estimate for the impact of changes in price on the profitability of the project can be found from the sensitivity of NPV with respect to price: $\Delta NPV/\Delta P$. This measure can be calculated by finding the NPV at any two different price levels and forming the ratio of the changes in these parameters. Whenever a sensitivity analysis is performed, all other variables are held constant at their base-case values.

5. *a.* D = $924,000/6 = $154,000 per year

Q_A = ($800,000 + 154,000)/($34 – 19) = 63,600 units

DOL = 1 + FC/OCF = 1 + FC/D = 1 + [$800,000/$154,000] = 6.195

b. OCF_{base} = [(P – v)Q – FC](1 – t) + tD

= [($34 – 19)(130,000) – 800,000](0.65) + 0.35($154,000) = $801,400

NPV_{base} = –$924,000 + $801,400($PVIFA_{15\%,6}$) = $2,108,884.43

Say Q = 135,000:

OCF_{new} = [($34 – 19)(135,000) – 800,000](0.65) + 0.35($154,000) = $850,150

NPV_{new} = –$924,000 + $850,150($PVIFA_{15\%,6}$) = $2,293,377.96

$\Delta NPV/\Delta S$ = ($2,293,377.96 – 2,108,884.43)/(135,000 – 130,000) = +$36.899

If sales were to drop by 500 units, then NPV would drop by $36.899(500) = $18,449.35

c. v = $18: OCF_{new} = [($34 – 18)(130,000) – 800,000](0.65) + 0.35($154,000) = $885,900

$\Delta OCF/\Delta v$ = ($801,400 – 885,900)/($19 – 18) = –$84,500

If variable costs fell by $1 then, OCF would rise by $84,500

6. OCF_{best} = {[($34)(1.1) – ($19)(0.9)](130K)(1.1) – 800K(0.9)}(0.65) + 0.35(154K) = $1,472,785
NPV_{best} = –$924,000 + $1,472,785($PVIFA_{15\%,6}$) = $4,649,729.34
OCF_{worst} = {[($34)(0.9) – ($19)(1.1)](130K)(0.9) – 800K(1.1)}(0.65) + 0.35(154K) = $219,585
NPV_{worst} = –$924,000 + $219,585($PVIFA_{15\%,6}$) = –$92,984.37

7. (1): Q_C = $16M/($2,000 – 1,675) = 49,231 — Q_A = ($16M + 7M)/($2,000 – 1,675) = 70,769
(2): Q_C = $60,000/($40 – 32) = 7,500 — Q_A = ($60,000 + 150,000)/($40 – 32) = 26,250
(3): Q_C = $500/($7 – 2) = 100 — Q_A = ($500 + 420)/($7 – 2) = 184

8. (1): Q_A = 125,400 = ($175,000 + D)/($34 – 26) — D = $828,200
(2): Q_A = 140,000 = ($3M + 1.25M)/(P – $50) — P = $80.36
(3): Q_A = 5,263 = ($145,000 + 90,000)/($100 – v) — v = $55.35

9. Q_A = [$4,000 + ($9,000/3)]/($65 – 33) = 219 — Q_C = $4,000/($65 – 33) = 125
NPV = 0 implies $9,000 = OCF($PVIFA_{16\%,3}$) — OCF = $4,007.32
Q_F = ($4,000 + $4,007.32)/($65 – 33) = 250 — DOL = 1 + ($4,000/$4,007.32) = 1.998

10. Q_C = FC/(P–v); 12,000 = $110,000/(P – $20); P = $29.17
Q_A = (FC+D)/(P–v); 18,000 = ($110,000 + D)/($29.17 – 20); D = $55,060
I = (D)(N); I = 5($55,060) = $275,300
OCF = $275,300/($PVIFA_{18\%,5}$) = $88,034.84
Q_f = ($110,000 + 88,034.84)/($29.17 – 20) = 21,596

11. DOL = %ΔOCF/%ΔQ; %ΔOCF = 3[(36,000 – 30,000)/30,000] = 60.00%
The new level of operating leverage is lower since FC/OCF is smaller.

12. DOL = 3 = 1 + $150,000/OCF; — OCF = $75,000
New OCF = $75,000(1.50) = $112,500 — New DOL = 1 + ($150,000/$112,500) = 2.333

13. DOL = 1 + ($30,000/$63,000) = 1.4762 — %ΔQ = (7,300 – 7,000)/7,000 = 4.29%
%ΔOCF = DOL(%ΔQ) = 1.4762(.0429) = 6.33% — New OCF = $63,000(1.0633) = $66,985.71
DOL at 7,300 units = 1 + ($30,000/$66,985.71) = 1.4478

14. DOL = 3.5 = 1 + FC/OCF; FC = (3.5 – 1)$9,000 = $22,500
%ΔQ = (11,000 – 10,000)/10,000 or (9,000 – 10,000)/10,000 = ±10.0%
%ΔOCF = 3.5(±10.0%) = 35%
OCF at 11,000 units = $9,000(1.35) = $12,150; OCF at 9,000 units = $9,000(0.65) = $5,850

15. DOL at 11,000 units = 1 + $22,500/$12,150 = 2.8519
DOL at 9,000 units = 1 + $22,500/$5,850 = 4.8462

Intermediate

16.

a.	IRR = 0%;	payback = N years;	NPV = I [(1/N)($PVIFA_{r\%,N}$) – 1]
b.	IRR = –100%;	payback = ∞;	NPV = – I
c.	IRR = r %;	payback < N years;	NPV = 0

17. OCF @ 110,000 units = [($26 – 18)(110,000) – 185,000](0.66) + 0.34($420,000/3) = $506,300
OCF @ 111,000 units = [($26 – 18)(111,000) – 185,000](0.66) + 0.34($420,000/3) = $511,580
Sensitivity =ΔOCF/ΔQ = ($511,580 – 506,300)/(111,000 – 110,000) = +$5.28
OCF will increase by $5.28 for every additional unit sold.

18. DOL @ 110,000 units = 1 + ($185,000/$506,300) = 1.3654
Q_a = [$185,000 + ($420,000/3)]/($26 – 18) = 40,625
DOL @ 40,625 units = 1 + ($185,000/$140,000) = 2.3214

19. *a*. Sales = 160(1±0.10) = 176, 144; variable costs = $14,000(1±0.10) = $15,400, $12,600
Fixed costs = $150,000(1±0.10) = $165,000, $135,000
OCF_{base} = [($19,000 – 14,000)(160) – $150,000](0.65) + 0.35($680,000/4) = $482,000
NPV_{base} = –$680,000 + $482,000($PVIFA_{15\%,4}$) = $696,099.57
OCF_{worst} = [($19,000 – 15,400)(144) – $165,000](0.65) + 0.35($680,000/4) = $289,210
NPV_{worst} = –$680,000 + $289,210($PVIFA_{15\%,4}$) = +$145,688.29
OCF_{best} = [($19,000 – 12,600)(176) – $135,000](0.65) + 0.35($680,000/4) = $703,910
NPV_{best} = –$680,000 + $703,910($PVIFA_{15\%,4}$) = $1,329,647.82

b. Say FC are $160,000:
OCF = [($19,000 – 14,000)(160) – $160,000](0.65) + 0.35($680,000/4) = $475,500
NPV = –$680,000 + $475,500($PVIFA_{15\%,4}$) = $677,542.21
ΔNPV/ΔFC = ($677,542.21 – 696,099.57)/($160,000 – 150,000) = –1.856
For every dollar FC increase, NPV falls by $1.86.

c. Q_c = $150,000/($19,000 – 14,000) = 30

d. Q_a = [$150,000 + ($680,000/4)]/($19,000 – 14,000) = 64
At this level of output, DOL = 1 + ($150,000/$170,000) = 1.8824
For each 1% increase in unit sales, OCF will increase by 1.8824%.

20. The marketing study and the research and development are both sunk costs and should be ignored.

Sales		
New clubs	$600 × 50,000 =	$30,000,000
Exp. clubs	$1,000 × (– 12,000) =	–12,000,000
Cheap clubs	$300 × 10,000 =	3,000,000
		$21,000,000

Var. costs		
New clubs	$240 × 50,000 =	$12,000,000
Exp. clubs	$550 × (–12,000) =	–6,600,000
Cheap clubs	$100 × 10,000 =	1,000,000
		$6,400,000

Sales	$21,000,000
Variable costs	6,400,000
Costs	7,000,000
Depreciation	2,200,000
EBIT	5,400,000
Taxes	2,160,000

Net income	$ 3,240,000

OCF = EBIT + D – Taxes = \$5,400,000 + 2,200,000 – 2,160,000 = \$5,440,000
Payback period = 2 + \$5.42M/\$5.44M = 2.996 years
NPV = –\$15.4M – \$0.9M + \$5.44M(PVIFA$_{14\%,7}$) + \$0.9/1.14^7 = \$7,388,051.92
IRR = –\$15.4M – \$0.9M + \$5.44M(PVIFA$_{IRR\%,7}$) + \$0.9/IRR^7 = 27.59%

21.

	Base Case	Lower Bound	Upper Bound
Unit sales (new)	50,000	45,000	55,000
Price (new)	\$600	\$540	\$660
VC (new)	\$240	\$216	\$264
Fixed costs	\$7,000,000	\$6,300,000	\$7,700,000
Sales lost (expensive)	12,000	10,800	13,200
Sales gained (cheap)	10,000	9,000	11,000
Variable cost/unit	\$13,000	\$11,700	\$14,300
Fixed costs	\$125,000	\$112,500	\$137,500

Best case

Sales

New clubs	\$660 × 55,000 =	\$36,300,000
Exp. clubs	\$1,000 × (–10,800) =	– 10,800,000
Cheap clubs	\$300 × 11,000 =	3,300,000
		\$28,800,000

Var. costs

New clubs	\$216 × 55,000 =	\$11,880,000
Exp. clubs	\$550 × (–10,800) =	– 5,940,000
Cheap clubs	\$100 × 11,000 =	1,100,000
		\$7,040,000

Sales	\$28,800,000
Variable costs	7,040,000
Costs	6,300,000
Depreciation	2,200,000
EBIT	13,260,000
Taxes	5,304,000
Net income	\$ 7,956,000

OCF = EBIT + D – Taxes = \$13,260,000 + 2,200,000 – 5,304,000 = \$10,156,000
NPV = –\$15.4M – \$0.9M + \$10.156M(PVIFA$_{14\%,7}$) + \$0.9/1.14^7 = \$27,611,697.54

Worst case

Sales

New clubs	\$540 × 45,000 =	\$24,300,000
Exp. clubs	\$1,000 × (– 13,200) =	– 13,200,000
Cheap clubs	\$300 × 9,000 =	2,700,000

$13,800,000

Var. costs		
New clubs	$\$264 \times 45{,}000 =$	$11,880,000
Exp. clubs	$\$550 \times (-13{,}200) =$	– 7,260,000
Cheap clubs	$\$100 \times 9{,}000 =$	900,000
		$5,520,000

Sales	$13,800,000
Variable costs	5,520,000
Costs	7,700,000
Depreciation	2,200,000
EBIT	– 1,620,000
Taxes	648,000 *assumes a tax credit
Net income	– $ 972,000

OCF = EBIT + D – Taxes = –$1,620,000 + 2,200,000 + 648,000 = $1,228,000
NPV = –$15.4M – $0.9M + $1.228M(PVIFA$_{14\%,7}$) + $0.9/1.14^7 = –$10,674,288.07

22. Price = $700

Sales		
New clubs	$\$700 \times 50{,}000 =$	$35,000,000
Exp. clubs	$\$1{,}000 \times (-12{,}000) =$	–12,000,000
Cheap clubs	$\$300 \times 10{,}000 =$	3,000,000
		$26,000,000

Var. costs		
New clubs	$\$240 \times 50{,}000 =$	$12,000,000
Exp. clubs	$\$550 \times (-12{,}000) =$	–6,600,000
Cheap clubs	$\$100 \times 10{,}000 =$	1,000,000
		$6,400,000

Sales	$26,000,000
Variable costs	6,400,000
Costs	7,000,000
Depreciation	2,200,000
EBIT	10,400,000
Taxes	4,610,000
Net income	$ 6,240,000

OCF = EBIT + D – Taxes = $10,400,000 + 2,200,000 – 4,160,000 = $8,440,000
NPV = –$15.4M – $0.9M + $8.44M(PVIFA$_{14\%,7}$) + $0.9/1.14^7 = $20,252,966.43
ΔNPV/ΔP = ($20.252.966.43 – 7,388,051.92)/($700 – 600) = $128,649.15
For every dollar increase (decrease) in the price of the clubs, the NPV increases (decreases) by $128,649.15.

Quantity = 49,000

Sales		
New clubs	$\$600 \times 49{,}000 =$	$29,400,000
Exp. clubs	$\$1{,}000 \times (-2{,}000) =$	–12,000,000
Cheap clubs	$\$300 \times 10{,}000 =$	3,000,000
		$20,400,000

Var. costs		
New clubs	$\$240 \times 49{,}000 =$	$11,760,000
Exp. clubs	$\$550 \times (-12{,}000) =$	–6,600,000
Cheap clubs	$\$100 \times 10{,}000 =$	1,000,000
		$6,160,000

Sales	$20,400,000
Variable costs	6,160,000
Costs	7,000,000
Depreciation	2,200,000
EBIT	5,040,000
Taxes	2,016,000
Net income	$ 3,024,000

OCF = EBIT + D – Taxes = $5,040,000 + 2,200,000 – 2,016,000 = $5,224,000

NPV = –$15.4M – $0.9M + $5.224($PVIFA_{14\%,7}$) + $\$0.9/1.14^7$ = $6,461,778.07

$\Delta NPV/\Delta Q$ = ($6,461,778.07 – 7,388,051.92)/(49,000 – 50,000) = $926.27

For an increase (decrease) of one set of clubs sold per year, the NPV increases (decreases) by $926.27.

Challenge

23. *a.* From the tax-shield definition of OCF:

$OCF = [(P - v)Q - FC](1 - t) + tD$; $(OCF - tD)/(1 - t) = (P - v)Q - FC$

$\{FC + [(OCF - tD)/(1 - t)]\}/(P - v) = Q$

b. $Q_c = \{\$500{,}000 + [-0.38(\$700{,}000)/0.62]\}/(\$40{,}000 - 20{,}000) = 3.548 = 4$

$Q_a = \{\$500{,}000 + [\$700{,}000 - (\$700{,}000(0.38)/0.62)]\}/(\$40{,}000 - 20{,}000) = 60$

$OCF_f = \$3{,}500{,}000/PVIFA_{20\%,5} = \$1{,}170{,}328.96$; thus $Q_f = 97.93 = 98$

c. At the accounting break-even point, net income = 0, so OCF = NI + D = D

$Q_a = \{FC + [(D - tD)/(1 - t)]\}/(P - v) = (FC + D)/(P - v) = (FC + OCF)/(P - v)$

The tax rate has cancelled out in this case.

24. $DOL = \%\Delta OCF / \%\Delta Q = \{[(OCF_1 - OCF_0)/OCF_0] / [(Q_1 - Q_0)/Q_0]\}$

$OCF_1 = [(P - v)Q_1 - FC](1 - t) + tD$; $OCF_0 = [(P - v)Q_1 - FC](1 - t) + tD$;

$OCF_1 - OCF_0 = (P - v)(1 - t)(Q_1 - Q_0)$

$(OCF_1 - OCF_0)/OCF_0 = (P - v)(1 - t)(Q_1 - Q_0) / OCF_0$;

$[(OCF_1 - OCF_0)/OCF_0][(Q_1 - Q_0)/Q_0] = [(P - v)(1 - t)Q_0]/OCF_0 =$

$[OCF_0 - tD + FC(1 - t)]/OCF_0$;

$DOL = 1 + [FC(1 - t) - tD]/OCF_0$

25. *a*. OCF $= [(\$230 - 200)(35{,}000) - 300{,}000](0.62) + 0.38(\$1{,}500{,}000M/5) = \$579{,}000$
NPV $= -\$1.5M - 450K + 579K(PVIFA_{13\%,5}) + [\$450K + 500K(1 - .38)]/1.13^5$
$= \$498{,}974.45$

b. $OCF_{worst} = \{[(\$230)(0.9) - 200](35{,}000) - 300{,}000\}(0.62) + 0.38(\$1{,}725{,}000/5)$
$= \$97{,}000$
$NPV_{worst} = -\$1{,}725{,}000 - 450K(1.05) + \$97{,}000(PVIFA_{13\%,5}) +$
$[\$450K(1.05) + \$500K(0.85)(1 - .38)]/1.13^5 = -\$1{,}456{,}857.26$
$OCF_{best} = \{[\$230(1.1) - 200](35{,}000) - 300{,}000\}(0.62) + 0.38(\$1{,}275{,}000/5)$
$= \$1{,}061{,}000$
$NPV_{best} = -\$1{,}275{,}000 - 450K(0.95) + 1{,}061{,}000(PVIFA_{13\%,5}) +$
$[\$450K(0.95) + \$500K(1.15)(1 - .38)]/1.13^5 = \$2{,}454{,}806.16$

26. Q = 36,000: OCF $= [(\$230 - 200)(36{,}000) - 300{,}000](0.62) + 0.38(\$1{,}500{,}000M/5) = \$597{,}600$
$\Delta OCF/\Delta Q = (\$597{,}600 - 579{,}000)/(36{,}000 - 35{,}000) = +\$18.60$
$NPV = -\$1.5M - 450K + 597.6K(PVIFA_{13\%,5}) + [\$450K + \$500K(1 - .38)]/1.13^5 = \$564{,}394.95$
$\Delta NPV/\Delta Q = (\$564{,}394.95 - 498{,}974.45)/(36{,}000 - 35{,}000) = +\$65.42$
You wouldn't want Q to fall below the point where NPV = 0:
$\$498{,}974.45 = \$65.42(\Delta Q)$; $\Delta Q = 7{,}627$; $Q_{min} = 35{,}000 - 7{,}627 = 27{,}373$

27. At Q_c, OCF = 0: $0 = [(\$230 - 200)Q_c - 300{,}000](0.62) + 0.38(\$1{,}500{,}000/5)$; $Q_c = 3{,}871$
$Q_a = [\$300{,}000 + (\$1{,}500{,}000/5)]/(\$230 - 200)$; $Q_a = 20{,}000$
From #26, $Q_f = 27{,}373$

28. $DOL = 1 + [\$300{,}000(1 - 0.38) - 0.38(\$1{,}500{,}000/5)]/ \$579{,}000 = 1.12435$
Thus a 1% rise leads to a 1.12435% rise in OCF. If Q rises to 36,000, then
$\Delta Q = (36{,}000 - 35{,}000)/35{,}000 = 2.857\%$, so $\%\Delta OCF = 2.857\%(1.12435) = 3.212\%$
From #26, $\Delta OCF/OCF = (\$597{,}600 - 579{,}000)/\$579{,}000 = 0.03212$
In general, if Q rises by 1 unit, OCF rises by 3.212%.