UNIVERSITY OF CALGARY
HASKAYNE SCHOOL OF BUSINESS

Corporate Finance

Capital Budgeting – Project Risks and Real Options

René Wells

May 14, 2020

Agenda

Project analysis for multiple decisions points and uncertainty

Decision trees

Project risk assessment

Real options

Project monitoring

Amazon

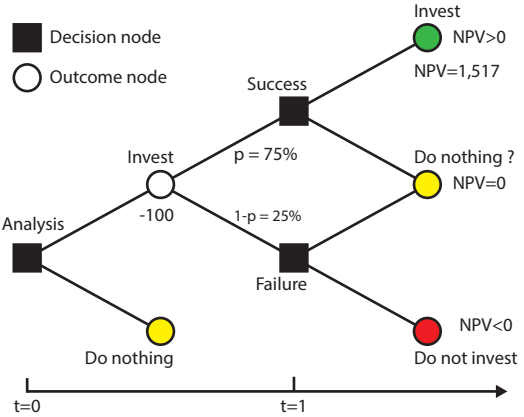
Chapter 9 of the textbook

Project analysis for multiple decision points and uncertainty

Until now we have implicitly assumed a single decision point and have calculated NPV assuming cash flows having 100% certainty. However, reality is often more complex and need to be managed as such.

- A project is often a sequence of decisions (e.g. pharma sequential decisions about a new drug);
  - Decisions trees can be used to calculate NPV as a risk-neutral certainty equivalent.
- Future cash flows are often inherently uncertain (and such uncertainty will only be resolved throughout the life of the project). So, NPV are point estimates with error (since each input is itself an estimate with error). The reliability of the NPV needs to be assessed and quantified.
  - Using sensitivity, scenarios, break-even analyses and Monte Carlo simulations.
- A decision can be altered after the fact (e.g. responding to new information becoming available). Management has the ability, opportunity, and arguably the duty to manage the project once approved with the aim of maximizing the value the firm gets out of the project.
  - Such opportunities for adjustments are called embedded real options, the value of which the basic NPV approach does not take into consideration.
- Some projects give rise to future business opportunities (i.e. deliver a real option).

Decision trees: managing a sequence of decisions



$$Payoff = p \times NPV_{1S} + (1-p) \times NPV_{1F} = 0.75 \times 1{,}517 + 0.25 \times 0 = 1{,}138$$

$$NPV_0 = -Investment + \frac{Payoff}{1+r} = -100 + \frac{1{,}138}{1+0.15} = 890$$

Analysis of NPV and project risk assessment

Sensitivity analysis

- Change each input one at a time by +/- % → recalculate NPV
- The more sensitive the NPV is to changes in inputs the higher the risk
- Further investigate the input(s) that lead to negative NPV

Scenario analysis (e.g. baseline/expected, pessimistic, optimistic)

- Consider different economic environments or major events
- For each scenario, forecast a new set of inputs → recalculate NPV
- Find out which circumstances can lead to negative NPV

Break-even analysis

- For each input calculate at which threshold level the NPV equals 0
- e.g. fixed costs can increase by % before NPV turns negative

Monte Carlo simulations

- Assign a distribution to each input
  - e.g. normal with a mean of X and a standard deviation of Y
- Assign relationships between inputs (e.g. correlations)
- Draw from each input distribution; calculate NPV; repeat a lot
- Get a distribution of the NPV (e.g. mean, median, and standard deviation)

Project risk analysis

The four methods just described assess/measure the total risk of the project.

- At the firm level, the appropriate measure is not the total risk of the project but its marginal contribution to the risk of the firm (the 'within-firm risk').
- From the shareholder perspective, the appropriate risk measure would be the marginal contribution of the project to the overall risk they bear.
  - If shareholders are well diversified, then the project's systematic risk (e.g. measured by CAPM beta) is the most appropriate measure of project's risk.
- Assuming that the three risk measures are highly correlated and total risk is the easiest to estimate, then the latter is the most pragmatic approach.

Methodologies to adjust project evaluation to reflect its risk level

- Adjust the required rate of return accordingly to reflect risk differences.
- Adjust an uncertain cash flow to its certainty-equivalent (i.e. the higher the uncertainty of a cash flow, the smaller its certainty-equivalent).
- Both can be done for a single cash flow (e.g. cash flow out of the salvage value of equipment is very uncertain), but within reason (i.e. do not overdo it).

Practitioners' perspective

Survey evidence shows that most firms are assessing project risk using sensitivity/scenario analysis, while adjusting the discount rate is the most common methodology used to adjust for project risk.

Survey	Country	% of firms using each method		
		Sensitivity	Scenario	Simulation
Graham & Harvey (2001)	U.S.	52		14
Baker, Dutra, & Saadi (2011)	Canada	74	32	13
Arnold & Hatzopoulos (2000)	U.K.	85		31

Survey	Country	% of firms using each method		
		Discount rate	Cash flows	Shorter PB
Payne & Al. (1999)	U.S.	47	33	14
Baker, Dutra, & Saadi (2011)	Canada	28	1	9
Arnold & Hatzopoulos (2000)	U.K.	52	-	20

Real options are valuable

The ability of management to exercise project-embedded real options (e.g. by scaling-up, scaling down or even abandoning a project during its lifetime to improve cash-flows according to circumstances) will improve financial returns and therefore create value. It makes such real options valuable.

For some industries, like resources-based and pharma-related, investments are large and outcomes uncertain, making management of real options quite critical to the success of a firm (or its failure).

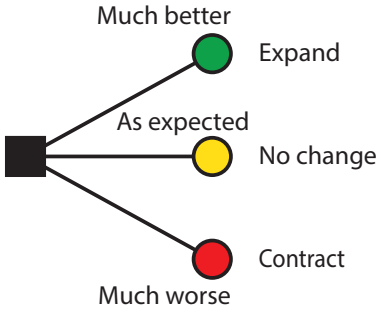
If a project has an option embedded in it (or even several), NPV will miss the option premium and understate the value of the project. So, logically, the value of the real options embedded in a project should be taken into consideration when evaluating a project.

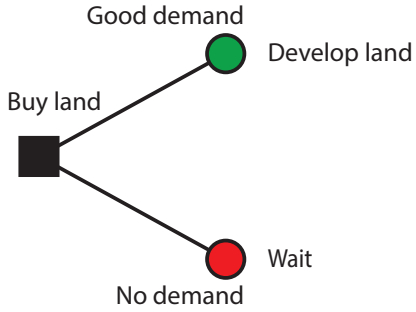
Valuing real options embedded in a project can be quantitatively challenging, but, at the minimum, the presence and significance of real options in a given project shall be qualitatively identified and analyzed.

Project-embedded real options

Dynamic capital budgeting is when size and timing of cash flows can be altered by management according to circumstances as they occur throughout the life of the project.

- Option to expand (scale-up)
- Option to abandon (scale-down)
- Option to delay





Option to expand

An option to expand is embedded if proceeding with the project provides the firm with one or several opportunities to scale-up the project, proceed with other projects or enter new markets in the future that would not be available to the firm otherwise.

A real option is created as the first investment is expected to provide the firm with the opportunity but not the obligation to make a second investment at a later date (but the opportunity would not exist or be significantly more challenging without having made the first investment).

The first project might be undertaken with a negative NPV as long as the present value of the expansion option is large enough.

The value of the expansion option is affected by many factors, especially by its timing and the extent to which the future business opportunity might be impacted by competitive or technology uncertainties.

Option to delay

An option to delay could be embedded if the value of a project is likely to evolve through time as a consequence of changes in expected cash flows and discount rates (or even as a by-product of changes in competition, technology or regulations).

Assuming the project has initially a negative NPV and is 'exclusive' to the firm, a real option is created as the firm waits until as a consequence of changing circumstances the NPV of the project become positive.

Of note, a project might have a positive NPV today but if its NPV could improve markedly as a consequences of changing circumstances it might make sense to delay it. For such case, an option is embedded in the project.

Option to abandon

An option to abandon could be embedded if management has the the flexibility to terminate or sell the project during its lifetime on an economic basis.

To some extent such option is to exist if sufficient flexibility has been planned for and built in project through, for example, investing in stages, having short term contracts or contract with exit clauses, outsourcing or leasing rather than buying production facilities.

Also an option to abandon exists if the assets used or expertise developed could be sold or redeployed easily into another project.

Practitioners' perspective

Survey evidence shows that real options are mostly used by larger firms in some industries where sophisticated analysis is common (tech, energy, utilities, health, and manufacturing).

Survey	Country	% of firms using real options
Graham & Harvey (2002)	U.S.	27
Baker, Dutra, & Saadi (2011)	Canada	10
Brounen & Al. (2004)	U.K.	29

Respondents who indicated not using real options reported such analysis requires too much sophistication and/or the firm is lacking in the required expertise/knowledge.

Respondents indicated using real options as a management tool to help form a strategic vision, to incorporate managerial flexibility into the analysis, and as a way to think about uncertainty and its effect on valuation.

Project monitoring

Projects are usually monitored to keep track of progress and to compare actual results against forecasts. Periodic review (e.g. annual) can be used as a decision point for management as below noted.

$$\sum_{t=now}^{T} \frac{C_i}{(1+r)^t} < 0 \rightarrow \text{liquidate the project}$$

$$\sum_{t=now}^{T} \frac{C_i}{(1+r)^t} < \textit{Salvage value} \rightarrow \text{terminate (get salvage value)}$$

$$\sum_{t=now}^{T} \frac{C_i}{(1+r)^t} < \textit{Divestiture value} \rightarrow \text{divest (sell the project)}$$

$$\sum_{t=now}^{T} \frac{C_i}{(1+r)^t} > \textit{Divestiture value} \rightarrow \text{continue the project}$$

Of note, projects are not liquidated, terminated or sold on the basis of the actual results not being as good as initially forecasted, but according to the remaining life NPV per above thresholds.

Real option: Amazon (commerce versus web services)

Amazon is the well-know eretailer which started in 1994 selling books. It is now one of the largest company in the world with 750,000 employees. Jeff Bezos, an engineer graduate of Princeton, founded Amazon after an 8-year career in finance. He initially operated from his garage.

Since its beginnings the company has been very focused in term of strategy, notably "Get Big Fast", i.e. purposefully get a large market share and reap economies of scale (notably low cost).

Most of the enterprise value of Amazon resides in Amazon Web Services (AWS), a B2B cloud computing service officially launched in 2006. It is the case since AWS is significantly more profitable than the eretail side of the business. AWS is an example of a real option, with the added benefit of operational synergies, as all the IT of the eretailer has been moved within AWS which is able to provide formidable economies of scale to its parent.

Of note, 'Amazon doesn't allow PowerPoint slides during meetings. "Instead, we write narratively structured six-page memos," then silently read them before meetings begin, Mr. Bezos wrote.' (here).

Real option: Amazon (commerce versus web services)

	Year Ended December 31,		
	2014	2015	2016
North America			
Net sales	$ 50,834	$ 63,708	$ 79,785
Operating expenses	49,542	60,957	75,686
Operating income before stock-based compensation and other	1,292	2,751	4,099
Stock-based compensation and other	932	1,326	1,738
Operating income	$ 360	$ 1,425	$ 2,361
International			
Net sales	$ 33,510	$ 35,418	$ 43,983
Operating expenses	33,654	35,509	44,460
Operating income (loss) before stock-based compensation and other	(144)	(91)	(477)
Stock-based compensation and other	496	608	806
Operating income (loss)	$ (640)	$ (699)	$ (1,283)
AWS			
Net sales	$ 4,644	$ 7,880	$ 12,219
Operating expenses	3,984	6,017	8,513
Operating income before stock-based compensation and other	660	1,863	3,706
Stock-based compensation and other	202	356	598
Operating income	$ 458	$ 1,507	$ 3,108
Consolidated			
Net sales	$ 88,988	$ 107,006	$ 135,987
Operating expenses	87,180	102,483	128,659
Operating income before stock-based compensation and other	1,808	4,523	7,328
Stock-based compensation and other	1,630	2,290	3,142
Operating income	178	2,233	4,186
Total non-operating income (expense)	(289)	(665)	(294)
Provision for income taxes	(167)	(950)	(1,425)
Equity-method investment activity, net of tax	37	(22)	(96)
Net income (loss)	$ (241)	$ 596	$ 2,371

Real option: Amazon (commerce versus web services)

	Year Ended December 31,		
	2014	2015	2016
North America			
Net sales	$ 50,834	$ 63,708	$ 79,785
Operating expenses	49,542	60,957	75,686
Operating income before stock-based compensation and other	1,292	2,751	4,099
Stock-based compensation and other	932	1,326	1,738
Operating income	$ 360	$ 1,425	$ 2,361
International			
Net sales	$ 33,510	$ 35,418	$ 43,983
Operating expenses	33,654	35,509	44,460
Operating income (loss) before stock-based compensation and other	(144)	(91)	(477)
Stock-based compensation and other	496	608	806
Operating income (loss)	$ (640)	$ (699)	$ (1,283)
AWS			
Net sales	$ 4,644	$ 7,880	$ 12,219
Operating expenses	3,984	6,017	8,513
Operating income before stock-based compensation and other	660	1,863	3,706
Stock-based compensation and other	202	356	598
Operating income	$ 458	$ 1,507	$ 3,108
Consolidated			
Net sales	$ 88,988	$ 107,006	$ 135,987
Operating expenses	87,180	102,483	128,659
Operating income before stock-based compensation and other	1,808	4,523	7,328
Stock-based compensation and other	1,630	2,290	3,142
Operating income	178	2,233	4,186
Total non-operating income (expense)	(289)	(665)	(294)
Provision for income taxes	(167)	(950)	(1,425)
Equity-method investment activity, net of tax	37	(22)	(96)
Net income (loss)	$ (241)	$ 596	$ 2,371

Retail websites

Real option: Amazon (commerce versus web services)

	Year Ended December 31,		
	2014	2015	2016
North America			
Net sales	$ 50,834	$ 63,708	$ 79,785
Operating expenses	49,542	60,957	75,686
Operating income before stock-based compensation and other	1,292	2,751	4,099
Stock-based compensation and other	932	1,326	1,738
Operating income	$ 360	$ 1,425	$ 2,361
International			
Net sales	$ 33,510	$ 35,418	$ 43,983
Operating expenses	33,654	35,509	44,460
Operating income (loss) before stock-based compensation and other	(144)	(91)	(477)
Stock-based compensation and other	496	608	806
Operating income (loss)	$ (640)	$ (699)	$ (1,283)
AWS			
Net sales	$ 4,644	$ 7,880	$ 12,219
Operating expenses	3,984	6,017	8,513
Operating income before stock-based compensation and other	660	1,863	3,706
Stock-based compensation and other	202	356	598
Operating income	$ 458	$ 1,507	$ 3,108
Consolidated			
Net sales	$ 88,988	$ 107,006	$ 135,987
Operating expenses	87,180	102,483	128,659
Operating income before stock-based compensation and other	1,808	4,523	7,328
Stock-based compensation and other	1,630	2,290	3,142
Operating income	178	2,233	4,186
Total non-operating income (expense)	(289)	(665)	(294)
Provision for income taxes	(167)	(950)	(1,425)
Equity-method investment activity, net of tax	37	(22)	(96)
Net income (loss)	$ (241)	$ 596	$ 2,371

Retail websites

Cloud services

Real option: Amazon (commerce versus web services)

	Year Ended December 31,		
	2014	2015	2016
North America			
Net sales	$ 50,834	$ 63,708	$ 79,785
Operating expenses	49,542	60,957	75,686
Operating income before stock-based compensation and other	1,292	2,751	4,099
Stock-based compensation and other	932	1,326	1,738
Operating income	$ 360	$ 1,425	$ 2,361
International			
Net sales	$ 33,510	$ 35,418	$ 43,983
Operating expenses	33,654	35,509	44,460
Operating income (loss) before stock-based compensation and other	(144)	(91)	(477)
Stock-based compensation and other	496	608	806
Operating income (loss)	$ (640)	$ (699)	$ (1,283)
AWS			
Net sales	$ 4,644	$ 7,880	$ 12,219
Operating expenses	3,984	6,017	8,513
Operating income before stock-based compensation and other	660	1,863	3,706
Stock-based compensation and other	202	356	598
Operating income	$ 458	$ 1,507	$ 3,108
Consolidated			
Net sales	$ 88,988	$ 107,006	$ 135,987
Operating expenses	87,180	102,483	128,659
Operating income before stock-based compensation and other	1,808	4,523	7,328
Stock-based compensation and other	1,630	2,290	3,142
Operating income	178	2,233	4,186
Total non-operating income (expense)	(289)	(665)	(294)
Provision for income taxes	(167)	(950)	(1,425)
Equity-method investment activity, net of tax	37	(22)	(96)
Net income (loss)	$ (241)	$ 596	$ 2,371

Retail websites

Cloud services

Real option: Amazon (commerce versus web services)

	Year Ended December 31,		
	2014	2015	2016
North America			
Net sales	$ 50,834	$ 63,708	$ 79,785
Operating expenses	49,542	60,957	75,686
Operating income before stock-based compensation and other	1,292	2,751	4,099
Stock-based compensation and other	932	1,326	1,738
Operating income	$ 360	$ 1,425	$ 2,361
International			
Net sales	$ 33,510	$ 35,418	$ 43,983
Operating expenses	33,654	35,509	44,460
Operating income (loss) before stock-based compensation and other	(144)	(91)	(477)
Stock-based compensation and other	496	608	806
Operating income (loss)	$ (640)	$ (699)	$ (1,283)
AWS			
Net sales	$ 4,644	$ 7,880	$ 12,219
Operating expenses	3,984	6,017	8,513
Operating income before stock-based compensation and other	660	1,863	3,706
Stock-based compensation and other	202	356	598
Operating income	$ 458	$ 1,507	$ 3,108
Consolidated			
Net sales	$ 88,988	$ 107,006	$ 135,987
Operating expenses	87,180	102,483	128,659
Operating income before stock-based compensation and other	1,808	4,523	7,328
Stock-based compensation and other	1,630	2,290	3,142
Operating income	178	2,233	4,186
Total non-operating income (expense)	(289)	(665)	(294)
Provision for income taxes	(167)	(950)	(1,425)
Equity-method investment activity, net of tax	37	(22)	(96)
Net income (loss)	$ (241)	$ 596	$ 2,371

Retail websites

Cloud services

Real option: Amazon (commerce versus web services)

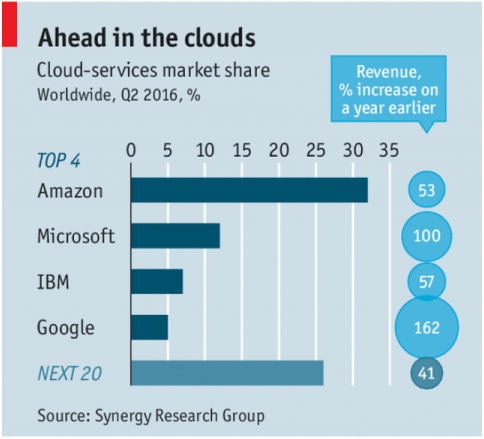
	Year Ended December 31,		
	2014	2015	2016
North America			
Net sales	$ 50,834	$ 63,708	$ 79,785
Operating expenses	49,542	60,957	75,686
Operating income before stock-based compensation and other	1,292	2,751	4,099
Stock-based compensation and other	932	1,326	1,738
Operating income	$ 360	$ 1,425	$ 2,361
International			
Net sales	$ 33,510	$ 35,418	$ 43,983
Operating expenses	33,654	35,509	44,460
Operating income (loss) before stock-based compensation and other	(144)	(91)	(477)
Stock-based compensation and other	496	608	806
Operating income (loss)	$ (640)	$ (699)	$ (1,283)
AWS			
Net sales	$ 4,644	$ 7,880	$ 12,219
Operating expenses	3,984	6,017	8,513
Operating income before stock-based compensation and other	660	1,863	3,706
Stock-based compensation and other	202	356	598
Operating income	$ 458	$ 1,507	$ 3,108
Consolidated			
Net sales	$ 88,988	$ 107,006	$ 135,987
Operating expenses	87,180	102,483	128,659
Operating income before stock-based compensation and other	1,808	4,523	7,328
Stock-based compensation and other	1,630	2,290	3,142
Operating income	178	2,233	4,186
Total non-operating income (expense)	(289)	(665)	(294)
Provision for income taxes	(167)	(950)	(1,425)
Equity-method investment activity, net of tax	37	(22)	(96)
Net income (loss)	$ (241)	$ 596	$ 2,371

Retail websites

Cloud services

Amazon cloud-services market share

Amazon dominates cloud-services (a fast-growing + profitable industry).



Chapter 9 of the textbook

Textbook sections covered

- 9.1 to 9.5

Worked examples

- Four worked examples are provided in chapter 9 of the textbook.

Exercises

- 24 exercises are provided in chapter 9 of the textbook.
- You should practice your Excel skills with a few of those.
- Suggest 9.6, 9.10, 9.11, 9.16, and 9.20
  - Hint: 9.20 On which basis the firm should go ahead?

9.6 Solution

Research	Probability of success	Cost	Payoff Success	Payoff Failure	Payoff Certainty eq.	Payoff net
None	50%	-	1,900,000	0	950,000	950,000
Focus group	65%	175,000	1,900,000	0	1,235,000	1,060,000
Market study	80%	390,000	1,900,000	0	1,520,000	1,130,000

$$\text{NPV} = (\text{payoff x probability of success}) \text{ - cost}$$

The firm should use the consulting firm since that option has the highest NPV.

9.10 Solution

	Year 0	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7
Operations								
Units new		60,000	60,000	60,000	60,000	60,000	60,000	60,000
Units h-price		-12,000	-12,000	-12,000	-12,000	-12,000	-12,000	-12,000
Units l-price		15,000	15,000	15,000	15,000	15,000	15,000	15,000
Price/unit new		875	875	875	875	875	875	875
Price/unit h-price		1,100	1,100	1,100	1,100	1,100	1,100	1,100
Price/unit l-price		400	400	400	400	400	400	400
Revenue		45,300,000	45,300,000	45,300,000	45,300,000	45,300,000	45,300,000	45,300,000
Cost/unit new		-430	-430	-430	-430	-430	-430	-430
Cost/unit h-price		-620	-620	-620	-620	-620	-620	-620
Cost/unit l-price		-210	-210	-210	-210	-210	-210	-210
Var. costs		-21,510,000	-21,510,000	-21,510,000	-21,510,000	-21,510,000	-21,510,000	-21,510,000
Fixed costs		-9,300,000	-9,300,000	-9,300,000	-9,300,000	-9,300,000	-9,300,000	-9,300,000
Total costs		-30,810,000	-30,810,000	-30,810,000	-30,810,000	-30,810,000	-30,810,000	-30,810,000
CCA		2,940,000	5,292,000	4,233,600	3,386,880	2,709,504	2,167,603	1,734,083
EBIT		11,550,000	9,198,000	10,256,400	11,103,120	11,780,496	12,322,397	12,755,917
Taxes		4,620,000	3,679,200	4,102,560	4,441,248	4,712,198	4,928,959	5,102,367
EBIAT		6,930,000	5,518,800	6,153,840	6,661,872	7,068,298	7,393,438	7,653,550
Ops cash flow		9,870,000	10,810,800	10,387,440	10,048,752	9,777,802	9,561,041	9,387,633
Investments								
Working cap.	1,400,000	1,400,000	1,400,000	1,400,000	1,400,000	1,400,000	1,400,000	0
WC change	-1,400,000	0	0	0	0	0	0	1,400,000
Equipment	-29,400,000							0
Inv cash flow	-30,800,000	0	0	0	0	0	0	1,400,000
Cash flow	-30,800,000	9,870,000	10,810,800	10,387,440	10,048,752	9,777,802	9,561,041	10,787,633
Payback	2.97	NPV	14.0%	12,882,655	IRR	26.8%		

9.11 Solution

			Sensitivity
Price	875.000	883.750	1
NPV	12,882,655	14,233,471	154,379
Quantity	60,000	60,600	1
NPV	12,882,655	13,569,641	1,145

- For every dollar increase (decrease) in the price, the NPV will increase (decrease) by \$154,379.
- For an increase (decrease) of one set sold per year, the NPV increases (decreases) by \$1,145.

9.16 Solution

What is the probability that the movie will earn a profit?

- $p = (1 - 0.9) \times (1 - 0.7) = 0.1 \times 0.3 = 0.03$

How much Carl should expect to earn?

- $\$20{,}000{,}000 \times 0.01 \times 0.03 = \$6{,}000$
- Carl will earn either nothing with a probability of 97% or likely \$200,000 with a probability of only 3%.
- Carl would be better off with \$12,000 for each script.

9.20 Solution

	Pessimistic	Expected	Optimistic
Market size	130,000	150,000	165,000
Market share	21%	25%	28%
Selling price	140	145	150
Var. costs	102	98	94
Fixed costs	1,015,000	950,000	900,000
Investment	2,200,000	2,100,000	2,000,000
Revenue	3,822,000	5,437,500	6,930,000
Var. costs	2,784,600	3,675,000	4,342,800
Fixed costs	1,015,000	950,000	900,000
Depreciation	366,666.67	350,000.00	333,333.33
EBT	344,267	462,500	1,353,867
Tax	- 137,706.67	185,000.00	541,546.67
NI	206,560	277,500	812,320
OCF	160,107	627,500	1,145,653

	0	1	2	3	4	5	6	NPV
Pessimistic	- 2,200,000	160,107	160,107	160,107	160,107	160,107	160,107	- 1,559,966
Expected	- 2,100,000	627,500	627,500	627,500	627,500	627,500	627,500	408,462
Optimistic	- 2,000,000	1,145,653	1,145,653	1,145,653	1,145,653	1,145,653	1,145,653	2,579,806

The NPV under the pessimistic scenario is negative, but the firm should probably accept the project.