



# Capital budgeting

**Financial appraisal of  
investment projects**

**Don Dayananda · Richard Irons · Steve Harrison  
John Herbohn · Patrick Rowland**

**CAMBRIDGE**

# Capital Budgeting

---

## Financial Appraisal of Investment Projects

---

Don Dayananda,

Richard Irons, Steve Harrison,

John Herbohn and Patrick Rowland



**CAMBRIDGE**  
UNIVERSITY PRESS

PUBLISHED BY THE PRESS SYNDICATE OF THE UNIVERSITY OF CAMBRIDGE  
The Pitt Building, Trumpington Street, Cambridge, United Kingdom

CAMBRIDGE UNIVERSITY PRESS  
The Edinburgh Building, Cambridge CB2 2RU, UK  
40 West 20th Street, New York, NY 10011-4211, USA  
477 Williamstown Road, Port Melbourne, VIC 3207, Australia  
Ruiz de Alarcón 13, 28014 Madrid, Spain  
Dock House, The Waterfront, Cape Town 8001, South Africa  
<http://www.cambridge.org>

© Don Dayananda, Richard Irons, Steve Harrison, John Herbohn and Patrick Rowland 2002

This book is in copyright. Subject to statutory exception  
and to the provisions of relevant collective licensing agreements,  
no reproduction of any part may take place without  
the written permission of Cambridge University Press.

First published 2002

Printed in the United Kingdom at the University Press, Cambridge

*Typeface* Times Roman 10/13 pt    *System* L<sup>A</sup>T<sub>E</sub>X 2<sub>ε</sub> [T<sub>B</sub>]

*A catalogue record for this book is available from the British Library*

*Library of Congress Cataloguing in Publication data*

Capital budgeting: financial appraisal of investment projects / Don Dayananda ... [et al].  
p.      cm.

Includes bibliographical references and index.

ISBN 0 521 81782 X (hb) – ISBN 0 521 52098 3 (pb)

1. Capital budget.    2. Capital investments.    I. Dayananda, Don.

HG4028.C4    C346    2002

658.15'242 – dc21    2002019249

ISBN 0 521 81782 X hardback

ISBN 0 521 52098 3 paperback

# Preface

---

Capital budgeting is primarily concerned with how a firm makes decisions on *sizable* investments in *long-lived* projects to achieve the firm's overall goal. This is the decision area of financial management that establishes criteria for investing resources in *long-term* real assets.

Investment decisions (on *sizable long-term* projects) today will determine the firm's strategic position many years hence, and fix the future course of the firm. These investments will have a considerable impact on the firm's future cash flows and the risk associated with those cash flows. Capital budgeting decisions have a long-range impact on the firm's performance and they are critical to the firm's success or failure.

One of the most crucial and complex stages in the capital budgeting decision process is the financial or economic evaluation of the investment proposals. This 'project analysis' is the focus of this book. Project analysis usually involves the identification of relevant cash flows, their forecasting, risk analysis, and the application of project evaluation concepts, techniques and criteria to assess whether the proposed projects are likely to add value to the firm. When the project choice is subject to resource constraints, mathematical programming techniques such as linear programming are employed to select the feasible optimal combination of projects.

## ***Motivation for the book***

The writing of this book was motivated by the lack of a suitable capital budgeting textbook with the following desirable features and coverage:

- Analysis and applications based on sound conceptual and theoretical foundations with pedagogical tools appropriate for capital budgeting
- Cash flow forecasting
- Project choice under resource constraints
- Comprehensive illustrations of concepts, methods and approaches for project analysis under uncertainty (or risk), with applications to different industries
- Preparing the reader for actual project analysis in the real world which involves voluminous, tedious, complex and repetitive computations and relies heavily on computer packages.

The book bridges this gap in the market by including these features and areas of coverage.

### ***Distinctive features and areas of coverage***

Distinctive features include:

- Practical approach with applications based on sound and appropriate concepts and theory
- Concepts, techniques and applications are illustrated by worked examples, tables and charts
- Worked examples are extensively supported with live Excel workbooks easily accessible on the Web
- Use of pedagogical tools – such as Excel spreadsheet calculations accessible on the World Wide Web – to help the users of the book grasp important and difficult concepts and calculations, and make them clear, useful, attractive and sometimes fun by the use of technology (computer packages)
- Complex and difficult topics are explained intuitively with tableaux rather than in terms of algebra.

Areas of coverage include:

- Quantitative and qualitative techniques for cash flow forecasting
- Application of mathematical programming techniques such as linear programming for decision support when the project choice is subject to resource constraints
- Sensitivity and break-even analysis and simulation – with applications to various industries such as the computer, airline, forestry and property industries, each of which has its unique characteristics
- As well as the standard industrial investment examples, the exotic and environmentally sensitive area of forestry investment and the increasingly demanding area of property investment are analysed with examples and case studies. The intricacies of investment across international borders are also discussed.

All of this material is reinforced with some challenging end-of-chapter review questions. Solutions to all the calculation questions are fully worked on Excel spreadsheets and are available on the Web.

### ***Organization of the book***

This book follows a natural progression from the development of basic concepts, principles and techniques to the application of them in increasingly complex and real-world situations. Identification and estimation of cash flows are important initial steps in project analysis and are dealt with in Chapters 2 to 4. Once the cash flows have been estimated, investment proposals are subjected to project evaluation techniques. The application of these techniques involves financial mathematics (Chapter 5). Chapter 6 uses the cash flow concepts and

the formulae (from Chapters 2 and 5) to evaluate case study projects using several project evaluation criteria such as net present value (NPV), internal rate of return (IRR) and payback period, and demonstrates the versatility of the NPV criterion. This basic model is then expanded to deal with risk (or uncertainty of cash flows) through the use of the risk-adjusted discount rate and certainty equivalent methods (Chapter 7), sensitivity and break-even analyses (Chapter 8) and risk simulation methods (Chapter 9). These concepts and methods are then applied in a case study involving the evaluation of a forestry investment in Chapter 10. Resource constraints on the capital budgeting decision are considered in Chapters 11 and 12 by introducing the basics of linear programming (LP), applying the LP technique for selection of the optimal project portfolios and presenting extensions to the LP technique which make the approach more versatile. A number of special topics in capital budgeting are covered towards the end of the book. They include forestry investment analysis (Chapter 13), property investment analysis (Chapters 14 and 15) and evaluation of international investments (Chapter 16).

### ***Joint authorship***

The positive side of joint authorship has been the rich interplay of ideas and lively debate on both conceptual and applied matters. The book has certainly benefited from this spirited interplay of ideas. Keeping five academics working, and working towards a common goal, an integrated exposition, has been a challenging management task. We have all benefited from the discipline of a common goal and pressing deadlines.

### ***Intended audience***

We have endeavoured in this text to make the capital budgeting concepts, theory, techniques and applications accessible to the interested reader, and trust that the reader will garner a better understanding of this important topic from our treatment. This book should suit both advanced undergraduate and postgraduate students, investment practitioners, financial modellers and practising managers. Although the book relies on material that is covered in corporate finance, economics, accounting and statistics courses, it is self-contained in that prior knowledge of those areas, while useful, is not essential.

### ***Teaching and learning aids***

*Excel workbooks* referred to in the text are accessible on the Web (at <http://publishing.cambridge.org/resources/052181782x/>). They provide details relating to calculations and the student can use the examples provided to practise various computations. Estimating regression equations, performing sensitivity and break-even analyses, conducting simulation experiments and solving linear programming problems are all done using Excel and they are all provided on the Web for the readers of this book to experiment with.

An *Instructor's Manual* includes answers to end-of-chapter review questions.

*Acknowledgements*

We have benefited from the encouragement and support of colleagues, family and friends. We particularly acknowledge the support given by Kathy Ramm, Head of the School of Commerce, Central Queensland University. We are also grateful to the talented staff at Cambridge University Press, especially Ashwin Rattan (Commissioning Editor, Economics and Finance), Chris Harrison (Publishing Director, Humanities and Social Sciences), Robert Whitelock (Senior Copy-Editorial Controller, Humanities and Social Sciences), Chris Doubleday (commissioned copy-editor for this book), Karl Howe (Production Controller) and Deirdre Gyenes (Design Controller).

*A final word*

We have significant combined research, teaching and industry experience behind us, and trust that this understanding of the learning process shines through in the text. Corporate financial management is not a process to be lightly embarked upon, but we hope your journey can be made more rewarding by the way in which this book has been presented.

# Contents

---

<i>List of figures</i>	page xiii
<i>List of tables</i>	xiv
<i>Preface</i>	xvii
<b>1 Capital budgeting: an overview</b>	<b>1</b>
Study objectives	2
Shareholder wealth maximization and net present value	3
Classification of investment projects	4
The capital budgeting process	5
Organization of the book	9
Concluding comments	10
Review questions	11
<b>2 Project cash flows</b>	<b>12</b>
Study objectives	14
Essentials in cash flow identification	14
Example 2.1	15
Example 2.2	16
Asset expansion project cash flows	23
Example 2.3. The Delta Project	27
Asset replacement project cash flows	31
Example 2.4. The Repco Replacement Investment Project	32
Concluding comments	34
Review questions	35
<b>3 Forecasting cash flows: quantitative techniques and routes</b>	<b>37</b>
Study objectives	39
Quantitative techniques: forecasting with regression analysis; forecasting with time-trend projections; forecasting using smoothing models	39



More complex time series forecasting methods	49
Forecasting routes	51
Concluding comments	52
Review questions	53
<b>4 Forecasting cash flows: qualitative or judgemental techniques</b>	<b>55</b>
Study objectives	56
Obtaining information from individuals	56
Using groups to make forecasts	60
The Delphi technique applied to appraising forestry projects	64
Example 4.1. Appraising forestry projects involving new species	65
Example 4.2. Collecting data for forestry projects involving new planting systems	66
Scenario projection	69
Example 4.3. Using scenario projection to forecast demand	70
Concluding comments: which technique is best?	71
Review questions	73
<b>5 Essential formulae in project appraisal</b>	<b>74</b>
Study objectives	75
Symbols used	75
Rate of return	76
Example 5.1	76
Note on timing and timing symbols	76
Future value of a <i>single</i> sum	77
Example 5.2	77
Example 5.3	78
Present value of a <i>single</i> sum	78
Example 5.4	78
Example 5.5	79
Future value of a <i>series</i> of cash flows	79
Example 5.6	79
Present value of a <i>series</i> of cash flows	80
Example 5.7	80
Example 5.8	80
Present value when the discount rate varies	81
Example 5.9	81
Present value of an ordinary annuity	81
Example 5.10	82
Present value of a deferred annuity	83
Example 5.11	83
Example 5.12	83

Perpetuity	84
Net present value	85
Example 5.13	85
Net present value of an infinite chain	85
Internal rate of return	86
Example 5.14	86
Loan calculations	87
Example 5.15	87
Loan amortization schedule	89
Concluding comments	89
Review questions	90
<b>6 Project analysis under certainty</b>	<b>91</b>
Study objectives	92
Certainty Assumption	92
Net present value model	93
The net present value model applied	95
Other project appraisal methods	96
Suitability of different project evaluation techniques	97
Mutual exclusivity and project ranking	102
Asset replacement investment decisions	108
Project retirement	109
Concluding comments	111
Review questions	111
<b>7 Project analysis under risk</b>	<b>114</b>
Study objectives	115
The concepts of risk and uncertainty	115
Main elements of the RADR and CE techniques	116
The risk-adjusted discount rate method	118
Estimating the RADR	118
Estimating the RADR using the firm's cost of capital	119
Example 7.1. Computation of the WACC for Costor Company	120
Estimating the RADR using the CAPM	120
The certainty equivalent method	126
Example 7.2. Computing NPV using CE: Cecorp	127
The relationship between CE and RADR	128
Example 7.3. Ceradr Company investment project	128
Comparison of RADR and CE	129
Concluding comments	130
Review questions	130

<b>8</b>	<b>Sensitivity and break-even analysis</b>	133
	Study objectives	133
	Sensitivity analysis	134
	Procedures in sensitivity analysis	135
	Sensitivity analysis example: Delta Project	135
	Developing pessimistic and optimistic forecasts	138
	Pessimistic and optimistic forecasts of variable values for the Delta Project example	141
	Applying the sensitivity tests	144
	Sensitivity test results	145
	Break-even analysis	149
	Break-even analysis and decision-making	150
	Concluding comments	150
	Review questions	151
<b>9</b>	<b>Simulation concepts and methods</b>	153
	Study objectives	154
	What is simulation?	154
	Elements of simulation models for capital budgeting	156
	Steps in simulation modelling and experimentation	158
	Risk analysis or Monte Carlo simulation	162
	Example 9.1. Computer project	163
	Design and development of a more complex simulation model	171
	Example 9.2. FlyByNight project	171
	Deterministic simulation of financial performance	175
	Example 9.3. FlyByNight deterministic model	175
	Stochastic simulation of financial performance	177
	Example 9.4. FlyByNight stochastic simulation	177
	Choice of experimental design	179
	Advantages and disadvantages of simulation compared with other techniques in capital budgeting	179
	Concluding comments	180
	Review questions	180
	Appendix: Generation of random variates	181
<b>10</b>	<b>Case study in financial modelling and simulation of a forestry investment</b>	185
	Study objectives	185
	Key parameters for forestry models	186
	Sources of variability in forestry investment performance	187
	Methods of allowing for risk in the evaluation of forestry investments	189
	Problems faced in developing forestry financial models	190
	Developing a financial model: a step-by-step approach	191

Example 10.1. Flores Venture Capital Ltd forestry project	192
Comparing forestry projects of different harvest rotations	199
Example 10.2. FVC Ltd: comparison of one-stage and two-stage harvest options	199
Risk analysis or Monte Carlo analysis	200
Example 10.3. Simulation analysis of FVC Ltd forestry project	200
Concluding comments	202
Review questions	203
<b>11 Resource constraints and linear programming</b>	<b>204</b>
Study objectives	206
LP with two decision variables and three constraints	206
Example 11.1. Roclap: product mix problem	206
Investment opportunities and by-product constraints	212
Example 11.2. Capital rationing problem	212
LP and project choice	214
Example 11.3. Project portfolio selection problem	215
Concluding comments	217
Review questions	217
<b>12 More advanced linear programming concepts and methods</b>	<b>219</b>
Study objectives	219
Basic LP assumptions and their implications for capital budgeting	220
Expanding the number of projects and constraints	221
Example 12.1. Power generator's decision problem	222
Indivisible investments and integer activity levels	224
Example 12.2. Resort development problem	225
Borrowing and capital transfers	226
Example 12.3. Borrowing and capital transfer problem	226
Contingent or dependent projects	228
Example 12.4. Infrastructure problem	228
Mutually exclusive projects	229
Example 12.5. Sports gear problem	230
Some other LP extensions for capital budgeting	231
Concluding comments	233
Review questions	234
<b>13 Financial modelling case study in forestry project evaluation</b>	<b>236</b>
Study objectives	237
Forestry evaluation models: uses and user groups	237
Financial models available to evaluate forestry investments	238
The Australian Cabinet Timbers Financial Model (ACTFM)	239
Review of model development and design options	246

Concluding comments	249
Review questions	250
<b>14 Property investment analysis</b>	<b>251</b>
Study objectives	252
Income-producing properties	252
Example 14.1. Property cash flows from the industrial property	256
Example 14.2. Equity cash flows before tax from the industrial property	258
Example 14.3. Equity cash flows after tax from the industrial property	261
Corporate real estate	263
Example 14.4. Acquiring the industrial property for operations	263
Example 14.5. Leasing or buying the industrial property for operations	266
Development feasibility	268
Example 14.6. Initial screening of an industrial building project	268
Example 14.7. Project cash flows from a property development	270
Example 14.8. Equity cash flows from the development project	271
Concluding comments	272
Review questions	272
<b>15 Forecasting and analysing risks in property investments</b>	<b>274</b>
Study objectives	275
Forecasting	275
Example 15.1. Forecasting operating cash flows for the industrial property	278
Example 15.2. Forecasting resale proceeds for the industrial property	283
Example 15.3. Forecasting development cash flows for a residential project	285
Risk analysis	288
Example 15.4. Net present value of the industrial property – sensitivity analysis	289
Example 15.5. Overbuilding for the industrial property – scenario analysis	290
Example 15.6. Development risks – Monte Carlo (risk) simulation	293
Concluding comments	293
Review questions	295
<b>16 Multinational corporations and international project appraisal</b>	<b>297</b>
Study objectives	298
Definition of selected terms used in the chapter	298
The parent’s perspective versus the subsidiary’s perspective	299
Example 16.1. Garment project	301
Exchange rate risk	303
Country risk	304

/A strategy to reduce a project's exchange rate and country risks	305
Other country risk reduction measures	309
Incorporating exchange rate and country risk in project analysis	310
Concluding comments	311
Review questions	311
<i>References</i>	313
<i>Index</i>	316

# *Figures*

---

1.1	Corporate goal, financial management and capital budgeting	<i>page 2</i>
1.2	The capital budgeting process	5
3.1	Forecasting techniques and routes	39
4.1	Major steps in the survey and data analysis process	57
4.2	A simple model for appraising investment in forestry projects	64
4.3	Modified extract of survey form used in stage 1 of Delphi survey in Example 4.1	66
6.1	Net present value profiles for projects A and B	100
7.1	Main features of RADR and CE techniques	117
8.1	Project NPV versus unit selling price	148
8.2	Project NPV versus required rate of return	148
8.3	Project NPV versus initial outlay	148
9.1	Cumulative relative frequency curve for NPV of computer project	169
10.1	NPV and LEV profiles of FVC Ltd forestry investment	197
10.2	Cumulative relative frequency distribution for forestry investment for FVC Ltd	202
11.1	Graphical solution to the product mix problem	207
11.2	Product mix problem: iso-contribution lines and optimal product mix	208
13.1	Schematic representation of the structure of the ACTFM	240
13.2	ACTFM: example of plantation output sheet	242
13.3	Prescriptive costs sheet	244
13.4	Costs during plantation sheet	244
13.5	Annual costs sheet	244
15.1	Trend in industrial rents per square metre	281
15.2	Distribution of possible net present values	294
16.1	A strategy for an MNC to reduce a host country project's exchange rate and country risks	306

## Tables

---

2.1	Delta Corporation's historical sales	page 27
2.2	Delta Project: cash flow analysis	28
2.3	RepcO Replacement Investment Project: initial investment	33
2.4	RepcO Replacement Investment Project: incremental operating cash flows	33
2.5	RepcO Replacement Investment Project: terminal cash flow	34
2.6	RepcO Replacement Investment Project: overall cash flow	34
3.1	Desk sales and number of households	40
3.2	Desk sales, number of households and average household income	43
3.3	Household and income projections, 2002–2006	44
3.4	Desk sales forecasts using two-variable and multiple regressions	44
3.5	Desk sales forecasts using time-trend regression	46
3.6	Hypothetical sales data and calculation of simple moving average	47
3.7	Forecasts using exponential smoothing model	49
3.8	Ticket sales, households and household income	54
4.1	Planting and harvesting scenario for a maple and messmate mixture	67
4.2	Estimates of model parameters for a maple and messmate mixed plantation	68
5.1	First three months of a loan amortization schedule	89
6.1	Delta Project: annual net cash flow	95
6.2	Cash flows, NPV and IRR for projects Big and Small	103
6.3	Cash flows, NPV and IRR for projects Near and Far	104
6.4	Cash flows, NPV and IRR for projects Short and Long	104
6.5	Replication chain cash flows as an annuity due	105
6.6	Cash flows within timed replication chains	107
6.7	Calculated individual NPVs for various replication cycle lengths within a chain	108
6.8	Calculated total NPVs for perpetual replacement over various replication cycle lengths within a chain	109
6.9	RepcO Replacement Investment Project: incremental cash flows	109
6.10	Cash flow forecasts for various retirement lives	110
6.11	Operational cash flows	112
7.1	Stock-market index Value and Delta Company share price	122



7.2	Stock-market index and share price returns	123
7.3	Cecorp: CE coefficients and cash flows	127
7.4	CapmBeta Company stock returns and stock-market index returns	131
7.5	CapmBeta Company: forecasted project cash flows	131
8.1	Pessimistic, most likely and optimistic forecasts	144
8.2	Results of sensitivity tests	145
9.1	Computer project: pessimistic, modal and optimistic values for selected cash flow variables	164
9.2	Computer project: random numbers and generated values under triangular distributions for the four stochastic variables	167
9.3	Computer project: Annual net cash flows and NPVs for first five replicates	168
9.4	Computer project: ordered NPVs and cumulative relative frequencies	168
9.5	FlyByNight: parameters of the basic model	173
9.6	FlyByNight: output from the basic model simulation run	174
9.7	FlyByNight: NPV levels from the deterministic simulation	176
9.8	FlyByNight: NPV estimates for individual replicates and mean of replicates	178
9A.1	Probability distribution of number of tickets sold	182
9A.2	Cumulative probability distribution of number of tickets sold, and ranges of random numbers	183
10.1	Sources of risk in farm forestry	188
10.2	FVC Ltd forestry project: Main cash categories and predicted timing	193
10.3	FVC Ltd forestry project: Cash outflows and timing associated with a two-species plantation	194
10.4	Estimated cash inflows for 1,000 ha plantation	195
10.5	NPV calculations for FVC Ltd forestry project	196
10.6	FVC Ltd forestry project: parameters selected for sensitivity analysis	198
10.7	NPVs for FVC Ltd forestry investment	198
10.8	Impact of harvesting all trees at year 34 compared with the two-stage harvest in Example 10.1	200
10.9	Calculation of random values used in NPV calculations	201
11.1	Initial tableau for the product mix problem	209
11.2	Revised LP tableau after solution for the product mix problem	211
11.3	Sensitivity report for the product mix problem	211
11.4	LP tableau after solution for the capital rationing problem	214
11.5	Sensitivity report for the capital rationing problem	214
11.6	NPVs, cash outflows and available capital in the project portfolio selection problem	215
11.7	LP model for the project portfolio selection problem	216
12.1	Power generator's decision problem: alternative technologies	222
12.2	LP tableau for power generator problem after solution	223
12.3	LP tableau and optimal plan for property developer decision problem	226
12.4	Property developer decision problem: alternative solution methods	226