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Financial and Economic Research Methods

ACIAR Training Manual

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Course Overview

The workshop is designed as an intensive five-day activity, to cover a number of financial and economic research techniques and their applications to natural resource management. The workshop is supported by the notes on various research techniques provided in this workshop manual. The material is divided into modules or topics.

Most of the topics covered are relatively basic and widely used, including sample survey methods and methods of financial appraisal of investment projects. However, an introduction is provided to some more advanced areas, including risk analysis, linear programming, and the application of cost-benefit analysis to research projects.

Some of the sessions take the form of lectures, but with opportunity for group interaction. Powerpoint slides will be used extensively in these sessions. To ensure a high level of participation, there will also be collective tasks, where questions will be put to the whole workshop group, and split group tasks, where the workshop participants are split into two or three groups, assigned specific tasks, and asked to make a report to the whole

group at the end of the session. Also, there will be several takeaway tasks which participants are invited to attempt outside workshop session.

A number of computer sessions will be held in which the financial functions of the Excel spreadsheet package will be demonstrated and used. These sessions will typically be held in the time block immediately after lunch, and are designed to provide experience in carrying out some of the various forms of analysis explained in the workshop presentation sessions. The workshop materials include a collection of screen shots to assist in understanding how to use the Excel capabilities.

The workshop program is provided on the next page. This sets out the times for the various activities, and relates the topics in this manual to the specific workshop sessions.

A critical starting point for the workshop is to read up on Topics 3 and 4 in the manual, to gain familiarisation with discounted cash flow analysis concepts, particularly for participants who have had little exposure to these techniques.

1. An Introduction to Financial and Economic Research Methods

Natural resource managers require a wide range of information about the biological and bio-economic systems with which they are dealing. Some information will be available from routine reporting and monitoring, but often specific research has to be carried out to collect data and process these data into information which is of assistance for decision-support.

Natural resource management is a particularly diverse field. It may be viewed for example by:

- resource type – renewables (forestry, water resources, fisheries, biodiversity), partially renewables (land, recreation resources) and non-renewables (particularly minerals and fossil fuels).
- decision type – physical management, conservation and use (e.g. extractive, touristic).
- problem or policy areas, e.g. property rights and access to resources, promoting sustainable resource use and preventing depletion and degradation, promoting investment to improve livelihoods.

A wide variety of values have been identified for natural (and environmental) resources, sometimes divided into use, option and existence values. While use values are widely understood, there is less appreciation of

option and existence values, interest in which has been generated by concerns over quality of the environment and sustainable development.

ACIAR projects concentrate in particular on use values of renewable (and particularly biological) resources. Particular socio-economic research areas in relation to ACIAR activities include collecting and analysing information about resource use and the characteristics and attitudes of the users, gaining a better understanding of current farming systems and devising improvements to the management of these systems (often with the use of formal or informal systems models), and generating policy recommendations.

This workshop has been designed to present some of the financial and socio-economic research techniques relevant for researchers concerned with natural resource management projects, with a focus on survey and case study data collection, and on financial and economic analysis of investment and research projects. Because participants are involved in ACIAR projects, the workshop has a focus on applications of financial and economic research methods to ACIAR projects. A number of examples will relate to forestry projects, although the methods will have application to other natural resource types.

Some examples of financial and economic research methods are listed in the following table.

Table 1. Socioeconomic research methods in small-scale forestry

Data collection	Stakeholder analysis Elicitation of expert opinion (including consultations with experts, SWOT analysis, the Delphi method, focus groups) Case studies Participatory rural appraisal Sample surveys using probability sampling
Data analysis	Analysis of survey data - descriptive statistics Multivariate analysis (including cluster analysis and factor analysis) Price forecasting (time series models) Scenario analysis
Non-market valuation	Valuing non-wood forest products and services Evaluation of forest recreation benefits using the travel cost method Estimation of total economic value - the contingent valuation method Choice modelling or choice experiments The hedonic price method Benefit transfer
Reporting	Reporting systems for forest enterprises and agencies
Physical and financial modelling	Stand yield modelling (including under sparse data) The optimal economic rotation (the Faustmann formula) Discounted cash flow analysis and sensitivity analysis Development of financial models of forestry investments and overall enterprises Modelling carbon sequestration Cost-benefit analysis (CBA) and cost-effectiveness analysis (CEA) Risk or venture analysis
Watershed and regional modelling	Geographical information systems (farm, watershed and regional level) Interindustry input-output analysis Transshipment modelling (locational efficiency and logistics analysis) Multicriteria analysis (and the analytic hierarchy process) Resource allocation models - linear programming Resource allocation models - goal programming Regional development models
Policy analysis	Synthesis of policy directions (transferring research to policy)

Source: Harrison, S., Herbohn, J., Mangaoang, E. and Vanclay, J. eds. (2002), Socio-economic Research Methods in Forestry: A Training Manual, Cooperative Research Centre for Tropical Rainforest Ecology and Management, Cairns, p. 10.

2. Collecting Socio-economic Data through Survey methods

Surveys are one of the most common techniques to collect socio-economic data from individuals. The process of developing and conducting a survey is relatively straightforward. Saying this, surveys are also often very poorly conducted and much of the information collected can be of little or no use if they are not well designed and implemented. Part of the problem arises from the fact that questionnaires on the surface appear to be easy things to develop and people mistakenly think that useful information can be collected with little effort and cost. This is seldom the case.

This module outlines the process of collecting socio-economic data using various types of survey. The first section outlines and discusses the various basic steps to developing and conducting a survey.

Overview of the Steps in Conducting a Survey

The survey process may be thought of as both the development and administration of a questionnaire or survey instrument, and the analysis of the survey data. That is, a survey is a process with a series of steps linked with one another. The major steps involved in the survey process are set out in Figure 2.1. The decisions made in the early stages will affect the choices at the later stages – thus the forward links in Figure 2.1. For instance the information needs specified at the start will affect the choice of sampling design, the way in which the questionnaire is structured and the selection of data analysis techniques.

If there were only forward links in the process then the conducting of a survey could be done one step at a time, completing each step before considering the next. Implicit in this 'single direction' approach is the assumption that there are no limiting factors in later steps. This is seldom, if ever, the case. For instance there are often limitations on data collection or data processing resources, i.e. a budget. These limitations restrict the alternatives available at earlier steps; these backward linkages are indicated in Figure 2.1 by dashed lines running upwards.

Backward linkages run from the collect data and analyse data boxes back to the develop questionnaire and sample design phases. Data collection is often one of the most expensive and time consuming part of the survey process. It would make little sense to choose the sampling design without first selecting the method that you will use to collect the data, because different data collection methods with require different sampling designs and different types of questionnaires.

This illustrates that major decisions concerning data collection and analysis should always be

considered before selecting a sample and designing a questionnaire. The following sections discuss the key components of each the steps in conducting a survey in more detail.

Identifying Information Needs and Whether a Survey is Worthwhile

The amount of information that can be collected about an issue or project is almost unlimited. Because time and resources are however limiting, it is necessary to prioritise the information needs. Information needs can be categorised into three levels of importance: (a) absolutely essential, constituting the reason for the survey (in the case of project appraisal, these data are required for the appraisal to be undertaken), (b) highly valuable for making important decisions, (c) supporting data which clarifies the picture but is not essential.

There are no hard and fast rules that can be applied to determine whether it is worthwhile to conduct a survey. In very general terms, you would undertake a survey only if the value of the information you collected from it outweighed the costs of collecting that information. Some authors such as Alreck and Settle suggest that the potential value of the information should be at least two or three times the entire cost of the survey. On the surface this seems to be a neat and easily applied rule; however, there are problems in actually applying it because of problems with measuring the costs and benefits of the information.

While the cost of undertaking a survey can be relatively easily estimated (e.g. costs of staff time in developing and printing questionnaires, travel and accommodation or postage costs, data processing costs), there are often overruns due to unexpected problems encountered in the implementation of the survey, e.g. delays due to bad weather preventing interviewers accessing remote communities and vehicle breakdowns. The benefits can difficult to quantify in dollar terms. What dollar value do you place on the utility of the information you collect? Also, it is almost impossible to estimate ex ante (i.e. before the survey is undertaken) what the precise benefits of the information will be.

Alreck and Settle provide a highly useful framework for assessing the overall value of a survey relative to the level of expenditure (Table 2-1). They suggest that the cost of errors, the amount of existing uncertainty and the reduction in uncertainty are three factors that should be considered.

Factors Indicating High Value

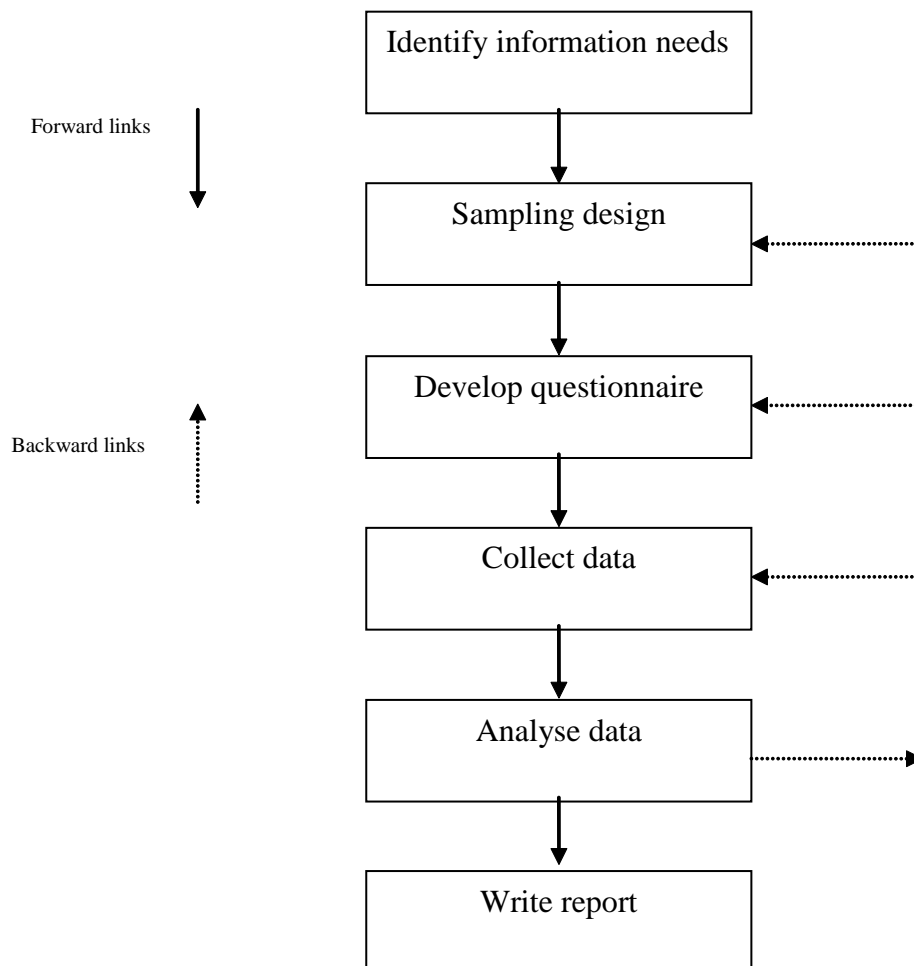
1. The cost of selecting a 'bad' alternative or failing to select the best alternative would be relatively high
2. There is a very high degree of uncertainty about which alternative to choose, based on existing information
3. Survey research information is likely to reduce a large proportion of the existing uncertainty

Factors Indicating Low Value

1. The cost of selecting a "bad" alternative or rejecting a good alternative is low
2. There is little uncertainty about the decision, based on existing information or information from other sources
3. Survey research information will remove only a small portion of the uncertainty surrounding the decision or action.

Source: Based on Alreck and Settle (p. 29).

Figure 2-1: major steps in the survey and data analysis process



Choosing the Sampling Design

A crucial part of any survey is deciding what group of people or objects is to be surveyed; this group is commonly referred to as the reference population. When seeking estimates for input into project appraisals it is critical to ask the people who have the experience, knowledge and skills to be able to provide reliable and relevant information. There is no point asking people in an inland community about the management of a fishery if they have no involvement in the utilisation of that resource. Similarly, it is pointless seeking information about forest management practices of people living in cities with no connection to the forest areas. In both cases, it is best to target the survey to those people who are involved with the fishery or forest area.

In the case of gathering judgemental estimates used in project appraisal, the population is likely to comprise a small number of experts or semi-experts. In such cases, it may be feasible to distribute questionnaires to all members of the population, i.e. to carry out a census. However in most cases the population is of a size that does not permit every member to be contacted, within the budget and timeframe of the study. In such cases, a choice needs to be made regarding the basic sampling design. Here the typical choices are between probability (random) or non-probability (or convenience) sampling. If random sampling is chosen then further choices need to be made between sampling designs, the typical contenders being simple random sampling, stratified sampling and multistage sampling.

Random sampling is where each member of the population has an equal chance of being included in the sample. If you have a random sample then you can make statistical inferences about the population based on your survey results – this is a very important reason to attempt to obtain a random sample. In some cases it may not be feasible to select respondents randomly and you may have to resort to a convenience sample – that

is selecting respondents that are convenient to reach.

Just say that you are interested in the way people use the forests surrounding a village. The population would be all the people who use the forest – these would include the people who live in the forest, the people who live in the village and those coming from outside of the community (i.e. those not living in either the village or the forest) such as people travelling from other villages to collect medicinal herbs. In this example, the total population might be 2500 – which makes it impossible to interview each person. Rather, a sample has to be selected, from which inferences are drawn for the entire population.

In order to undertake a random sample, each member of the population would have to have an equal probability of being selected in the sample. Stratified random sampling is when the population is divided into a number of groups (or strata) and individuals are sampled randomly from within each of these groups. In the forest use example, you might decide to stratify (break up) the population into three groups – people living in the forest, people living in the village who use the forest and people from other areas who use the forest.

Convenience sampling is where respondents are selected that are convenient to reach. In the forest example, you might have limited resources and the forest area is difficult to access. As a result you might undertake a convenience sample in which people are intercepted at a market and asked questions about their use of products from a nearby forest area. In this case, you are not sampling randomly from the total population in which you are interested. Why? As a result, some types of respondents may have a greater chance of being selected than others. In this case then, the 'sample' will not be representative of the population and you will not be able to make statistically valid inferences about the population based on your survey.

Split Group Task

Developing a Sampling Strategy of a Fishing Sustainability Study

Split into groups to consider the following example. Recent research into fish populations on the reefs surrounding Batu Island suggests that the fish populations are being exploited at a rate higher than what is sustainable. You have been asked, as a policy adviser, to suggest policy initiatives that will reduce the pressure on the fish resource. In order to do this, you need to understand how the resource is currently being harvested and what the key pressures are on why the resource is being exploited unsustainably.

What are some of the key pieces of information you need?

What is the reference or target population?

What is the best sampling strategy to collect information from the reference population?

Instruction Notes: Some aspects to investigate might include which fishermen operate on the reef (local versus from other islands); where they sell the fish (markets where fish mongers get their fish and their markups, and whether they are fishermen or middlemen); the preferences and attitudes of people who buy fish; whether villages will still buy particular species of fish even if catching these species is made illegal.

As a rule of thumb, the less expert or focussed the population with respect to the parameters being estimated (often corresponding to a large population), the shorter should be the questionnaire. Distributing long questionnaires to groups with little or no interest in the outcomes of the survey will result in a low response rate. Long questionnaires are also more expensive to produce and analyse and are thus the survey becomes highly costly when large numbers are distributed. This is an example of forward and backward links between different steps.

Developing the Questionnaire

Collection of demographic data

Almost all socio-economic questionnaires will ask for some demographic data, i.e. general information about the economic and social background of the respondent. This data can be used for a number of purposes. For instance, there is often strong correlations between socio-economic characteristics of respondents (e.g. off-farm income, food self sufficiency and education level) and attitudes towards the management of natural resources. Demographic data are often a key component of multivariate predictive or explanatory models, and are also often used in cluster analysis. In addition, background demographic data collected on respondents, when combined with statistical data collected by governments, can help in discussing the broader implications of the survey or to check for response bias.

Split Group Task

Split into three groups, and identify the key demographic information you might collect in the survey for the fishing sustainability study introduced above. Be prepared to justify why you chose each item, i.e. what might be the relevance of the item in helping to explain the meaning and significance of the data collected in other parts of the questionnaire?

Question format: structured verses unstructured

Survey questions come in two main formats – structured and unstructured. Structured questionnaires are composed of a series of questions or statements to which the respondent must choose from a predefined list of answers or ratings. For instance, you may ask farmers whether they use inorganic fertiliser on their rice crop, and provide the following alternatives as a Likert Scale for them to choose from: Always, Often, Sometimes, Rarely or Never. Unstructured questions, also referred to as open-ended questions, provide the respondent with only the question (and not a list of answers). For instance, you might ask the question farmers 'How often do you fertilise your rice crop'.

Structured questions are much easier to analyse. The main reasons are:

1. The dimension of the answer are the same for all

respondents in structured questions, e.g. all will give one of the five answers using the same dimension (i.e. all use the same scale. For an unstructured questionnaire one farmer might say 'seldom', another might say 'every month', another farmer might say 'after it rains, three times during the season'. These three answers involve three different dimensions that cannot be easily compared.

2. Structured responses are much easier to compare between respondents and groups than unstructured responses. Before unstructured responses can be compared they must be grouped into categories, which is time consuming. Further, subjective judgment must be exercised about the meaning of the responses and how they fit into the categories that are defined. In our example, this would involve the four open-ended responses having to be placed into one of the five categories used in the closed questions. How would you classify each of the four responses in point (1) above?

3. Ticking one predefined option is both quicker and more accurate than asking for an open-ended answer. As such, structured questions have the benefit of being more accurate and faster to gather. Accuracy is important for obvious reasons. Ease of completing the survey is also critical as it respondents are more likely to be positively disposed to the survey if it is easy and quick to answer.

Composing open-ended and categorical structured questions

It is critical that questions are stated clearly and that there is no ambiguity about what the question is asking. In the case of structured questions which provide a list of categories from which the respondent is to choose, it is also important that the answers provided are mutually exclusive and include all possible options. It is also important to make sure that there is more variation between the categories than within them.

It is always difficult to know exactly how many categories should be included. As a rule of thumb, 6 to 8 categories are generally the maximum number. Any more than this and the respondent can be overwhelmed with detail. Most importantly, too many categories can pose problems for data analysis. Cross tabulations are a common means of analysing categorical data. If there are many narrow categories, then there is likely to be only a few responses for several of the categories; this will mean that there will be inadequate cell sizes for the cross tabs analysis. In such cases, it will be necessary to combine some of the cells. There are also some dangers in selecting too few categories initially. Once aggregated data have been collected (e.g. using 5 categories) it cannot then be disaggregated into further categories (e.g. into 6 categories). The reverse however is possible – you can always aggregate two categories and thus go from 6 to 5 categories.

Group Discussion Point

The following is an example of a structured question with a list of categories from which to choose. Is the list all-inclusive? Is the list mutually exclusive? Is the number of categories appropriate?

How did you first learn about the principles of 'landcare'?

- From a friend or neighbour who uses 'landcare'
- From a relative or family member
- From a newspaper or magazine
- From a friend or neighbour who uses 'landcare'
- From a news story
- From a sign on a demonstration farm
- By some other announcement

Composing scaled structured questions

Structured questions may also have a scale for an answer. There are many different types of scales that can be used. One very common scale is the Likert Scale. The Likert scale is commonly used to obtain respondents' views on a particular statement or issue. When a Likert scale is used, the respondent is asked how much they agree or disagree with the statement, and the scale is then given. A typical Likert scale is:

1. Strongly Agree
2. Agree
3. Neutral
4. Disagree
5. Strongly disagree

There are number of question formats that can be used. Box 1 shows two examples. There are many other

scales that can be used. We have already seen an example of another one – the verbal frequency scale used in one of the examples above (i.e. Always, Often, Sometimes, Rarely or Never). Another common scale is where respondents are asked to rank the importance of a factor, e.g. from 'extremely important' through to 'not important at all', in say three or five categories.

The Structure of the Questionnaire and Conducting a Pilot Survey

Care must be taken to group questions logically, and to identify the most important questions to be put to respondents, and to place these appropriately within the questionnaire, e.g. at a point where rapport has been established with the respondent. More intrusive or personal questions are often placed near the end of the questionnaire.

Box 1: Example formats of questions on a Likert scale

Question XX. Logging in the remaining native forests should be banned (please tick)

<input type="radio"/> Strongly agree	<input type="radio"/> Agree	<input type="radio"/> Neutral	<input type="radio"/> Disagree	<input type="radio"/> Strongly disagree
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Question XX. Please indicate how strongly you agree or disagree with the following statements.

	Statement	Strongly agree	Agree	Neutral	Disagree	Strongly disagree
1	Trees improve the environment	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
2	Trees help protect the local catchment	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
3	Trees are a good way to make money	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
4	Trees help protect my land from squatters	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
5	Trees do not lower the water table	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
6	Tree help attract wildlife and birds	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

Questionnaire development usually proceeds through a number of drafts. As part of this process, the instrument may be tested on a small sub-sample in a pilot survey; this usually leads to some revision of questions. It also assists in checking that the questionnaire will elicit all the information required and that no redundant information is being sought. Pilot testing also provides information about the duration of interviews and identifies the questions in which respondents have difficulty answering. Often only half a dozen respondents are needed for pilot testing and often the time and responses spent are repaid many times over by the identification of potential problems. In addition, some of the information collected in the pilot testing may be useful in the data analysis. This is best done by reference back to the previously identified information needs.

Collecting the Survey Data

Almost all texts on survey design and implementation are focussed on the conducting surveys in developed countries which have well developed communication infrastructure that allows direct access to most members of a reference population. Most texts on survey design and implementation will say that implementation of the survey may be through personal interview, telephone interview, drop-off-and-collect or by post. In developed countries personal interviews are generally prohibitively expensive and time consuming and are suited to the situation where the target or reference population is small and not widely dispersed. In many developing countries, personal interviews are often the only practical means of conducting a survey. In the case of surveys associated with natural resource management issues in developing countries, typically respondents (or at least a proportion of the population being sampled) are poorly educated and sometimes illiterate. In many developing countries the technique of Participatory Rapid Appraisal is used instead of a formal survey. There are some advantages of this technique, especially in terms of being able to collect large amounts of information cost effectively. However the technique does not offer the same rigour as a well designed survey and the results are less likely to be acceptable for publication in respected journals.

Non-response bias is generally not a problem with personal interviews because of high participation rates typically associated with this method. This is especially so if respondents are being interviewed as part of their employment duties, which is sometimes the case when information is being collected as input into project appraisal.

In surveys of communities it is often necessary to get adopt the appropriate protocols for making contact with respondents. For instance, in the Philippines, it might be appropriate to first contact the mayor of the Local Government Unit (LGU) to inform them about the purpose of the survey and the communities in which the survey will be undertaken. Contact may be first through

an official letter and subsequently followed up by a meeting. It is then appropriate to contact the barangay captains and then get them to introduce the survey team to the local community.

In developed countries, telephone interviewing can be effective, especially where the information required is straightforward, but is not suitable for the collection of information that is complex and requires detailed thought or calculations. Similarly, in developed countries, postal surveys are usually undertaken when large sample sizes are required, from a modest budget. Non-response bias is an issue that needs to be considered no matter what method is used; however, it is especially a concern with postal surveys. Telephone or postal surveys are unlikely to be appropriate in most situations in developing countries due to the lack of access to a large proportion of the population.

Analysis of Survey Data

Data analysis is the process through which the survey responses are summarised into descriptive statistics and graphs, and perhaps subjected to inferential statistical methods such as multivariate analysis and significance tests. In a highly structured questionnaire, highly specific information is sought. Respondents will be required to provide specific estimates, such as estimates of the roundlog volume by species purchased by a sawmiller in a year tree or the amount of fish that a household consumes per week. Alternatively, respondents may be required to choose one option from a discrete set of options or to rank a particular statement on a predetermined scale. In such cases, descriptive statistics such as means, medians and standard errors can be easily calculated and used in project appraisal. Open-ended questions within a questionnaire allow respondents the opportunity to answer the question in their own words, and relay their particular perceptions, which can provide insights into specific issues and problems, but also poses challenges when analysing the responses,

It is beyond the scope of this workshop to delve further into the analysis of survey data. However two concluding suggestions are made. First, a much overlooked stage in data analysis is the cleaning of the data set. This process is critical to ensure that the reported results contain few errors. In addition, time spent cleaning the data at the beginning of the analysis process will reap benefits in saved time later in the process where errors are detected and the whole analysis needs to be repeated with the corrected data set. Second – as a word of caution – the analysis of survey data is often very poorly done. Analysis is usually restricted to simple descriptive statistics and graphs, and analyses such as these are seldom sufficient to justify publication within respected national or international journals.

Report Generation

Report generation produces a permanent record of the data collection process and findings. When the information is being collected for internal use by the agency conducting the survey – often the case in project appraisal – the report, if prepared at all, may be rudimentary and involve simple summary tables and brief discussion of the data. Reports that are for wider circulation require much more work, and usually involve more complex data analysis, together with carefully thought out discussion and interpretation of the results. Journal articles may be the target form of publication for the results of a survey. In such cases, it is often useful to first prepare a detailed report and then distil the key results into the journal article. Due to word limitations imposed by journals, in a journal article you will not be able to report the detail that you can in a report and so the focus is on key and interesting results. Reports are seldom refereed so there is usually no problem basing a journal article on results contained in a report. In addition to reporting the results of your survey, a journal article will typically require you to place your work in a broader context. This is done by including a literature review of similar work at the start of the article and in the discussion comparing your results to those obtained by others.

Concluding Comments on Surveys

The preceding material represented a brief outline of some of the major elements of undertaking a survey. A number of texts are available which provide more detail on the survey process. An excellent survey research resource is *The Survey Research Handbook* by Alreck and Settle (1995).

Special Types of Surveys: The Delphi Method and other Group Surveys

The discussion above has focussed on the conducting surveys of individuals – that is each person separately and independently completes the questionnaire. Another option is to get people to complete a survey as a group. Surveys of groups have particular application to collection of information for project appraisal. Experts are surveyed in order to elicit information to be used in a project appraisal.

The Delphi method

The Delphi method was originally developed by the Rand Corporation in the 1950s to obtain consensus among experts. Since this time it has been refined further and applied to gain information in a wide range of fields. These fields are as diverse as regional economic development, health care policy, sociology, environmental risks, prediction of fruit prices, tourism and recreation, forestry and advanced manufacturing techniques. The Delphi technique may be particularly useful in situations where strictly objective data are scarce.

The Delphi method is designed to elicit estimates from experts within a group or panel without allowing interaction between individuals on the panel, thus avoiding problems with dominant members. Experts do however have the ability to revise their estimates on the basis of group views. Such an option is not available using the traditional survey method. This technique proceeds through a series of data collection rounds. In a classic Delphi survey, the first round is unstructured, allowing panellists to identify freely and elaborate on the issues that they consider important. These are then consolidated into a single set by the monitors, who then produce a structured questionnaire designed to elicit the views, opinions and judgements of the panellists in a quantitative form. The consolidated list of scenarios is presented to the panellists in round two, at which time they place estimates on key variable such as the time an event will occur. These responses are then summarised and the summary information is presented to the panellists, who are invited to reassess their original opinions in light of anonymous individual responses. In addition, if panellists assessments fall outside the upper or lower quartiles, they may be asked to provide justifications as to why they consider their estimates are more accurate than the median values. Further rounds of collection of estimates, compiling summary information and inviting revisions continues until there is no further convergence of expert opinion. Experience reveals this usually occurs after two rounds, or at the most four rounds.

There are a number of variants on the classical Delphi method. When the issues are well defined, a clearly defined scenario can be developed by the monitoring team. In such circumstances, it is common to replace the unstructured first round with a highly structured set of questions through which specific estimates of parameters are obtained. A statistical summary of all responses is then provided to the panel for the second round, rather than in the third. In such cases, it is common for the Delphi method to include only one or two iterations.

The classic Delphi method is conducted through a combination of a polling procedure and a conference. Communication between conference panellists is however restricted and undertaken through the monitoring team. Even though panellists are at the same physical location, there is no face-to-face contact. A variant is the 'paper' Delphi (sometimes also known as a 'paper and pencil Delphi poll') that is conducted entirely by mail. Another variant is the 'real time' Delphi whereby feedback is provided by computer and final results are usually available at the end of the session.

The quality of forecasts provided by Delphi method (and other forecasting techniques) very much depends on how the technique is applied. The following is a list of suggestions of how to best apply the Delphi method:

1. The criteria for the selection of panellists (education, experience) should be carefully determined and clearly communicated.
2. A minimum of 10 panellists after dropout are recommended although it is sometimes suggested that five is sufficient
3. Commitment to serve on the panel should be secured before the first round of forecasts is requested. This will improve motivation and ensure a balanced sample if dropout is likely. Time should be taken to explain the Delphi technique and the information provided.
4. A range of forecast problems may be presented, although these should be less than 25 in number. Where appropriate, the main forecast should be broken down into sub-problems. Alternatively, different outcomes might be presented and their likelihood requested. Either way, the forecast will be useless unless the right problems are presented, hence the effort needs to be put into framing the problem. Some pretesting may be appropriate, especially if the Delphi survey is being undertaken through the post.
5. Problem statements should not be longer than 20 words and should use quantitative data (e.g. 50% increase) rather than fuzzy linguistics (e.g. 'considerable increase').
6. The "rules" for good questionnaire design should be applied to the presentation of problems. These include avoiding compound sentences.
7. If the purpose of the Delphi process is to generate forecast problems then it is suggested that examples of attractive and undesirable scenarios be presented.
8. There is little difference in the manner in which the Delphi approach is designed in the sense that the same steps are involved in the process, regardless of whether it is administered by mail, a networked computer or face-to-face meeting. Factors such as cost, the need for timely information or the availability of experts to attend a face-to-face meeting may determine the appropriate method.
9. The principle of anonymity should be ensured. The organiser's opinions on the forecast should not be communicated to the panellists.
10. The amount and form of the feedback will need to be carefully managed. The number of rounds will depend on the panellists and the manner in which the Delphi survey is conducted (i.e. at what stage a highly structured questionnaire is distributed). The general advice is that more rather than fewer rounds, as well as descriptive feedback, are preferable. Medians should be provided.

11. Extreme responses should be screened for the panellist's expertise. If the expert has relatively low expertise, then the response might be discounted. If the Delphi survey is directed to research applications, a detailed report of the process should be published to allow replication by other researchers at a later time. The range of responses should be published to demonstrate consensus or panellists' reasoning.

The nominal group technique

The nominal group technique (NGT) uses the basic Delphi structure but in face-to-face meetings which allow discussion among participants. A meeting with NGT starts without any interaction, with individuals initially writing down ideas or estimates related to the problem or scenario. Each individual then presents their ideas or estimates, with no discussion until all participants have spoken. Then each idea or estimate is discussed. The process is then repeated. For this reason, NGT is sometimes known as the 'estimate-talk-estimate' procedure. In practical terms, like Delphi, the framing of the questions or the scenario is crucial for the success of the process. Also, ideally, the leader or moderator of the discussion should come from outside the group.

Other group techniques

A number of other group techniques are available. The Devil's Advocate and Dialectical Inquiry involve individuals or small groups taking a 'devil's advocate' role or using the dialectic approach (presenting multiple views) to explore alternative different options. Both methods are considered to be ways of overcoming the problem of 'group think' discussed earlier.

A further approach to group judgmental forecasting draws upon elements of the nominal group technique and Inquiry Systems. Inquiry systems according to Lock are simply philosophical systems that underlie different approaches to analyzing or investigating particular phenomena. This approach consists of seven phases:

1. Problem/task definition
2. Pre-collection of estimates of the variable of interest and the reasoning behind the estimate
3. Sharing of the estimates and clarification of the underlying reasoning behind them
4. Discussion of underlying reasoning
5. Encouragement of multiple advocacy (dialectic inquiry)
6. Individual revision of estimates
7. Synthesis of estimates

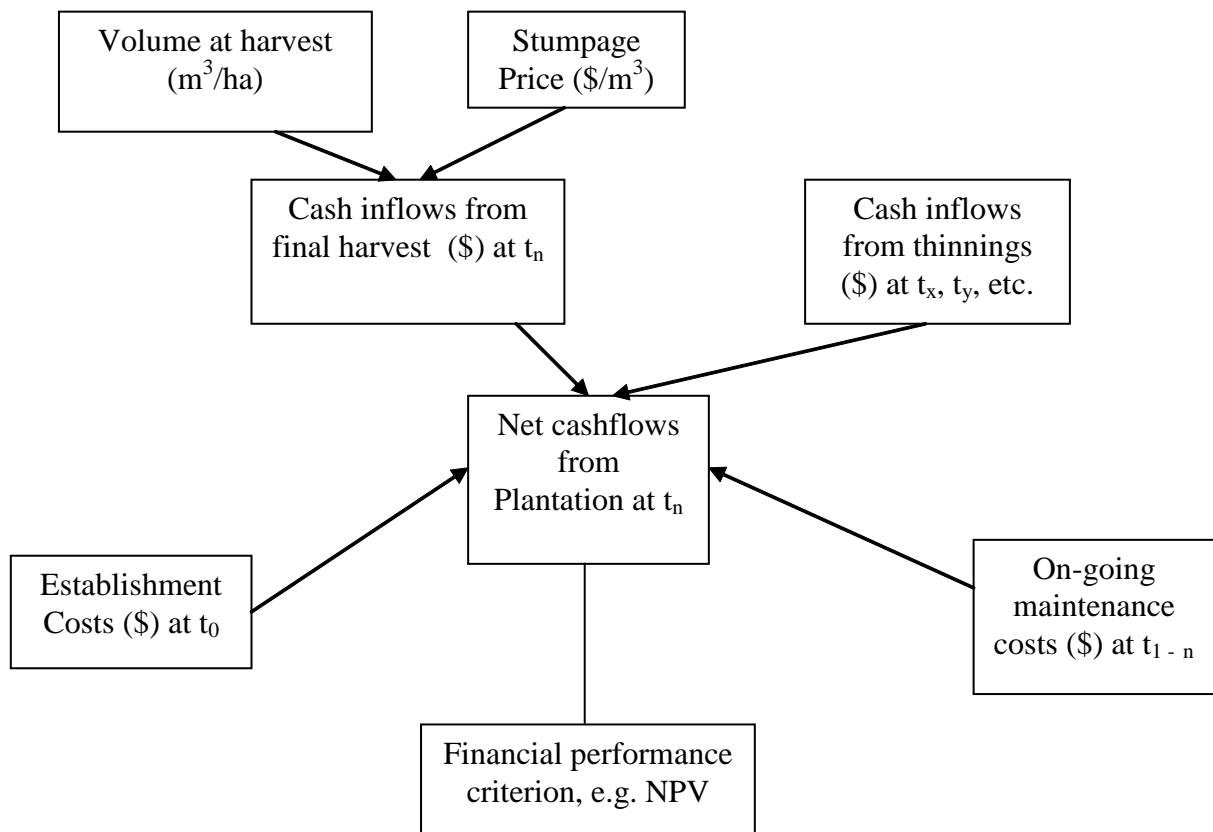
This approach recognises the benefits of communication between groups.

The Delphi Technique Applied To Appraising Forestry Projects

The Delphi technique is now illustrated as a means of collecting information to undertake a financial analysis of forestry projects, based on two 'real-life' Delphi surveys undertaken in northern Australia.

A simple model of appraising forestry investment

A simple model for appraising investment in forestry projects is illustrated in Figure 2-2. This diagram illustrates the key parameters which need to be estimated for evaluation of forestry projects, viz. harvest volumes and stumpage prices for the various types of timber harvested, and input costs. It is also critical to have estimates of the timing of these items throughout the plantation life or 'rotation length'. The estimates made at the time of planting become forecasts for deriving cash flows for the various years throughout the plantation. This information can then be entered onto a spreadsheet in which annual net cash flows and financial performance criteria are derived. Performance estimates are typically made on a one-hectare basis, and then aggregated up for plantation size.



For a traditional exotic conifer plantation such as radiata or caribbean pine, it is relatively easy to obtain estimates of the various parameters of the model. For example, costs of establishment, ongoing maintenance and non-commercial thinning are easily obtained, for example from contractors. Yield estimates, along with final harvest price, are the two key parameters in determining final harvest revenue. For pine plantations there are well developed stand growth models for various site indices based on many years of past growth data that can provide accurate projections of likely yield. The following two examples, on the other hand, apply to situations where non-traditional species are grown, hence little stand growth data are available.

Example 2.1: Appraising forestry projects involving new planting systems

In recent years there has been a move away from traditional silviculture systems involving monocultures of a small number of mostly softwood species. In Australia for example, plantations of native hardwoods, including many rainforest species have been established. In the case of native timber species for which little is known about the silviculture, it is extremely difficult to obtain estimates of growth rates that can be accepted with a high degree of confidence. The Delphi technique is a convenient way of obtaining estimates of expected growth and harvest age of native species for which there exist no growth models based on past performance or physiological characteristics. This was in fact the case recently in tropical Australia, where it was necessary to obtain estimates of growth rates and harvest ages for 31 species (Herbohn et al. 1999). In this case, the Delphi method proved to be an effective method to collect plantation productivity data necessary for the financial appraisal.

This project used the Delphi method to provide estimates of (a) mean annual increment or MAI (m³/ha/yr) and (b) time to harvest (years) of 31 species. Harvest age and MAI are the key biological parameters needed to estimate yield and harvest scheduling for use in financial models. In this case the species for which information was sought, were either species that had been widely planted in the area or ones that had been included in a previous Delphi survey.

Opinions were sought from 13 individuals with extensive experience in growing of Australian tropical and sub-tropical rainforest species for either timber production or reforestation. Individuals generally had either extensive field experience or had undertaken research involving native rainforest and tropical eucalypt species.

Panellists were provided with a table listing the 31 selected species and asked to provide estimates of their 'best guess' of optimal rotation period (years) for each species along with estimates of 'shortest time to harvest' and 'longest time to harvest'. Estimates were also requested for the 'best guess' for expected yield (m³/ha/yr) based on the 'best guess' rotation period along with estimates of 'highest yield expected' and 'lowest expected yield'. In this section, participants were asked to assume that the trees would be planted on relatively fertile basaltic soils, that average annual rainfall would be between 1500-2000 mm, that initial planting density would be around 660 stems per hectare (sph) and suitable thinning regimes will be applied.

Questionnaires were distributed to participants followed by a visit by one of the research team. Responses for the estimates of growth rates and harvest ages of the 31 selected species were then collated and averages calculated. A summary table including the group averages was prepared and distributed to participants along with their original estimates. In this second round of the Delphi survey participants were given the opportunity to review their original estimates of growth rates and harvest ages in light of the group averages and to provide any appropriate revisions or comments. Few revisions were received in this second round and the Delphi process was then terminated. An extract of the survey form used in the first round of the Delphi survey is provided in Figure 2.3. In the second round, a similar table was compiled with the averages of estimates provided from all panellists, along with the estimates from that particular panellist.

Outcomes of the Delphi survey

The outcome of this Delphi survey was a table of harvest ages and yields, where for each variable the group mean and highest and lowest estimates were recorded.

Species	Common name	Optimal rotation period (years)			Yield based on 'best guess' rotation period (m3 / ha / yr)		
		Best Guess (years)	Shortest time to harvest (years)	Longest time to harvest (years)	Best Guess	Highest expected yield	Lowest expected yield
Acacia mangium							
Acacia melanoxylon	Blackwood						
Agathis robusta	Kauri Pine						
Araucaria cunninghamii	Hoop pine						
Beilschmieda bancroftii	Yellow walnut						
Blepharocarya involucrigera	Rose Butternut						
Cardwellia sublimis	Northern silky oak						
Castanospermum australe	Black Bean						
Cedrela odorata	West Indian cedar						
Ceratopetalum apetalum	Coachwood						

Example 2-2: Collecting data for forestry projects involving new planting systems

In north Queensland it has become a common practice to plant *Flindersia brayleana* with *Eucalyptus cloeziana* and many potential investors are interested in the possible financial returns from such as plantation. There is however a lack of growth models for this mixture. *Flindersia brayleana* exhibits marked crown shyness (i.e. stops growing when the leaves in its crown touch the leaves in a crown of another tree). There is also a neat relationship between crown diameter and the diameter of the stem. These two characteristics make it very easy to develop a well-structured plantation scenario involving the two species. A Delphi survey was carried out to obtain information that for development of a financial model for the two species mixture (see Herbohn and Harrison 2001).

A planting and harvesting scenario was developed for a 50:50 mixture of *Flindersia brayleyana* and *Eucalyptus cloeziana* (Table 2-2). Thinning and harvesting regimes are timed to occur just as *F. brayleyana* crowns touch, at which time lock-up of growth would be expected to occur.

Personal interviews were conducted with five North

Queensland forestry experts chosen for their familiarity with the species being modelled. At the commencement of interviews the plantation system was outlined and the requirements for information stated. Panellists were provided with a table, similar to Table 2-3 but with columns 2 and 3 blank, in which to record their estimates. After collation of estimates, outliers were identified and clarification was sought from participants. The final estimates of the parameters that were used as inputs to the financial analysis are provided in Table 2-3. In this instance, the Delphi method proved to be a timely and cost-effective means through which to collect the information and forecasts necessary to construct the financial model.

While it is difficult to judge the accuracy and quality of the forecast information obtained in Examples 2-1 and 2-2, the Delphi surveys provided information without which the construction of a financial model would have been impossible. The stimulus for under choosing to undertake a Delphi survey was the fact that forecasts of tree growth and harvest age from models based on quantitative growth data will not be available until recent plantings using this species mix reach harvest age, and efforts to develop quantitative models based on physiological and environmental parameters had failed to produce suitable models.

Table 2.2 - Planting and harvesting scenario for a *Flindersia brayleyana* and *Eucalyptus cloeziana* mixture

Stage and activity	Density after treatment (stems/ha)	Estimates requested from participants in Delphi survey of reforestation experts
1. Plant alternating rows of maple and eucalyptus at 3m x 5m spacing	660 (330 <i>F. brayleyana</i> , 330 <i>E. cloeziana</i>)	
2. Thin to waste every second tree, when <i>F. brayleyana</i> reaches 18 cm dbh.	340 (170 <i>F. brayleyana</i> , 170 <i>E. cloeziana</i>)	Age at which <i>F. brayleyana</i> expected to reach 18 cm dbh
3. Thin every second eucalypt to waste or for strainer posts. Thin when <i>F. brayleyana</i> reaches a dbh of 32 cm.	255 (170 <i>F. brayleyana</i> , 85 <i>E. cloeziana</i>)	Age when <i>F. brayleyana</i> expected to reach 32 cm dbh. Bole dbh, small-end diameter, bole length of <i>E. cloeziana</i> at this age
4. Remove every second <i>F. brayleyana</i> for strainer posts or small diam. Logs	170 (85 <i>F. brayleyana</i> , 85 <i>E. cloeziana</i>)	
5. Remove remaining eucalyptus for poles.	85 <i>F. brayleyana</i>	Ages when <i>E. cloeziana</i> expected to reach 5 specified pole dimensions
6. Harvest every second <i>F. brayleyana</i> when crowns touch (50cm dbh)	43 <i>F. brayleyana</i>	Age at which <i>F. brayleyana</i> expected to reach 50 cm dbh Small-end diameter and bole length at this time
7. Harvest remaining <i>F. brayleyana</i> (81cm dbh)	Nil	Age at which <i>F. brayleyana</i> expected to reach 81 cm dbh Small-end diameter and bole length at this time

Stage	Parameter	Parameter estimate from Delphi survey	
		Average	Range
2	Age when <i>F. brayleyana</i> expected to reach 18 cm dbh	8.6 years	7 - 10 years
3	Age when <i>F. brayleyana</i> expected to reach 32 cm dbh	17.6 years	15 - 20 years
4	At this age, the following are expected for <i>E. cloeziana</i>		
	- bole dbh	41.4 cm	35 - 50 cm
	- small end diameter	26.2 cm	15 - 35 cm
	- bole length	16.4 m	12 - 20 m
5	Age when <i>E. cloeziana</i> expected to reach specified dimensions for		
	- Pole 1	17.4	10 - 25 years
	- Pole 2	17.6	11 - 25 years
	- Pole 3	21.0	12 - 30 years
	- Pole 4	24.2	14 - 35 years
	- Pole 5	25.6	15 - 35 years
6	Age when <i>F. brayleyana</i> expected to reach 50 cm dbh	34 years	25 - 40 years
	Expected small-end dia. at this age	33 cm	30 - 40 cm
	Expected bole length at this age	14.8 m	6 - 20 m
7	Age when <i>F. brayleyana</i> expected to reach 81 cm dbh	60 years	50 - 65 years
	Expected small-end dia. at this age	57 cm	45 - 60 cm
	Expected bole length at this age	16.6 m	10 - 20 m

Split Group Task

You are involved in a project looking at sustainable development options for a forest reserve. One of the options that has been identified is ecotourism activities. You have been given the task of undertaking an economic analysis of the impact of establishing a resort within the reserve. You decide to use the Delphi method to collect the some information.

- Outline what information would be needed to undertake the analysis
- For the information needed, what could be collected using the Delphi method?
- Suggest how the information to the panel and questions could be framed.
- How many rounds of data collection would you expect to undertake? Discuss how these would proceed.

3. Introduction to Financial Investment Appraisal

This module introduces the concept of an investment project, and discusses types of projects and relationships between projects. Financial evaluation of projects is then placed in perspective as one of the ways in which projects are assessed. Finally, the concept of annual incremental net cash flows of projects is introduced.

What is Investment?

An investment means essentially spending now to make money or achieve other goals in the future. In a sense, investment is an alternative use of funds to consumption (or goods and services) or saving (although saving often involves an element of earning and hence investment).

The investor – say a company – makes capital outlays in order to generate revenue or reduce costs in the future. Similarly, a research funding body provides funds for projects which will increase revenue, improve the welfare of a target group in some other way, or reduce environmental damage and hence help to maintain productivity, into the future.

The Concept of a Project

The term project is a name given to a single or discrete investment. Sometimes, distinctions are made between the terms proposal, project, program and portfolio. A project proposal is still at the evaluation stage, to determine whether it should be proceeded with. A program and a portfolio are both groups of projects.

A distinction may be made between a private or commercial or investment project and a social project. The motivation for an individual or a firm or company carrying out an investment project is usually to increase the wealth of an individual, or the profitability or size of a firm.

Examples

Some examples of projects which could be subjected to investment analysis include:

- Buying a carabao
- Buying a tractor
- Dispersing breeding livestock to low-income farmers
- Establishing a 5 ha timber plantation
- Setting up a seedling nursery

Social projects are often funded by governments or aid agencies. A social project also involves an investment, but the motivation is generally to improve the welfare of a community, rather than to maximize private profitability. Research projects funded by ACIAR generally fall into the class of social projects.

Techniques for analysis of private investment projects and social projects have a number of features in common, but also some important differences. We will initially consider the financial analysis of private investment projects, because this provides a simpler platform to introduce many of the concepts of project evaluation.

Project Costs and Returns

The financial flows associated with a project include capital outlays, project revenue or benefits and operating costs. Capital outlays include purchase or construction of assets (e.g. land, machinery, buildings). Project benefits include income or revenue (typically from sale of products or services) and costs avoided (e.g. where purchase of more efficient machinery reduces the labour cost). Operating costs include items such as wages, freight charges, raw materials, electricity, maintenance and insurance, and accountancy charges.

Group Task

Identify the costs and benefit items relevant to evaluation of the investment project of establishing a 5 ha timber plantation.

Approach this task in terms of the three components of financial flows, and for the different time periods from plantation establishment through to harvesting.

Identify any important assumptions you make in the identification of cost and benefit categories.

Types of Investment Projects

It is useful to classify investment projects into a number of types, because the types of cash flows and the nature of DCF analysis tends to have similarities within groups.

Some types of investment projects are:

- expansion projects
- infrastructure projects
- equipment replacement and retirement projects
- R&D projects
- environmental projects.

Relationship between Project Types

When considering more than one project, we may be interested in the profitability relationship between projects. Examples of these relationships include:

- Competitive projects
- Relatively independent projects
- Complementary projects
- Contingent projects
- Mutually exclusive projects

In a sense, all projects are competitive because to implement any project uses up a firm's resources, i.e. they compete for labour, managerial time and perhaps other resources. Where two projects are not constrained by resource requirements, the projects are for practical purposes independent. This is most likely to be the case when the projects are small relative to the size of the firm in terms of capital and other resource inputs.

If implementing one project is expected to improve the profitability of another project, should the second project also be implemented, then the second project can be classed as complementary. Can you suggest examples?

If a smallholder was considering purchasing a rotary hoe and increasing their area under irrigated cropping, either of these could be implemented as a single project. However, if both were implemented, each would make the other more financially worthwhile. In this case, the rotary hoe would allow the farmer farm to more intensively the increased area under cropping, thus increasing the returns from that land and thus improving the viability of expanding the land area. Similarly, having more land under cropping makes the purchase of the rotary hoe more viable because the farmer has a greater opportunity to use the new asset to produce income.

A project can be classed as contingent on another project if it is impossible or impractical to carry out the contingent project unless the other project is implemented. For example, there would be no point in a smallholder investing in a plough unless they also

had a draft animal or mechanical source of power with which to pull it.

Two or more projects are mutually exclusive if the adoption of one totally precludes the adoption of the other project or projects. If a farmer were contemplating growing 2 ha or either gmelina or mahogany on the same land, then obviously these two plantation projects would be mutually exclusive. Another example would be if a farmer has the choice of using a field to grow either corn or root crops.

Evaluation of Projects

Projects may be evaluated in terms of a variety of performance criteria, for example, technical difficulty, financial viability (ability of the firm to fund the project), financial profitability, or triple-bottom-line performance. Our interest in this workshop will initially be mainly on financial profitability. However, obviously the project must be technically feasible and affordable, and not violate any environmental regulations, before it can be implemented. In the cost-benefit analysis topic, the analysis will be extended to cover evaluation with respect to non-market (including environmental) benefits and costs.

The Incremental Net Cash Flow Concept

Mention was made above of financial flows. The concept of cash flows will now be introduced, and will be a central theme in some following topics.

The incremental net cash flow, typically expressed on an annual basis, may be defined as

$$C_t = B_t - CO_t - OC_t$$

where C_t is the net cash flow in year t ,
 B_t are the project benefits in year t (e.g. extra income or cost reduction) in year t ,
 CO_t are the capital outlays in year t ,
 OC_t are the operating costs in year t , and
 t represents time in years.

The cash flow is the benefit (generally referred to in financial project appraisal as revenue) net of the costs. The term cash is used to imply that the amounts are attributed to the project at the time when money changes hands. For example, machinery costs at the time of purchase are included, rather than depreciation (consumption of capital) over time.

Cash flows are incremental in that the change in costs and benefits is estimated in the with project case relative to their levels in the without project case. It is only these incremental changes which need to be considered in the analysis, not the total of costs and returns for the firm. That is, we look for how capital outlays, revenues and operating costs would change if the project were implemented, as against what they would be if the project were not adopted.

For example, suppose a firm were to purchase an additional tractor, and this allowed the crop area to be expanded. Then the costs would be those associated with the tractor (purchase price, operating costs including any additional labour needed) and the revenue would be that for the extra crop area but net of what would have been earned on the land had the tractor not been purchased.

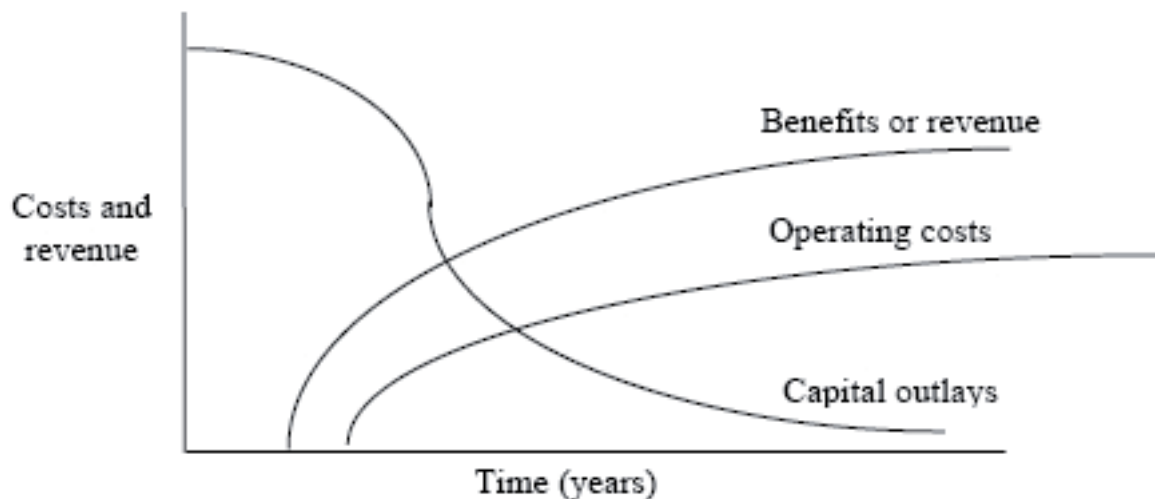
It should be noted that the without project case is not necessarily the current situation, because if a project is not implemented some changes in physical and financial conditions could take place. For example, suppose a farmer is contemplating a conservation project, e.g. strip cropping to reduce soil loss. If the project were not implemented, continuing soil loss could result in reduced crop yields. It would then be inappropriate to extrapolate current crop yields into the future in the without project case.

In project evaluation, the challenge for the analyst is to identify the relevant cost and revenue items for a project over time, derive monetary estimates of these, and then calculate the incremental annual net cash flows. Once these net cash flows are derived, it is a relatively mechanical procedure to derive various financial performance criteria for a project. To understand these criteria, it is necessary to understand discounting and present values, which are the subject of Topic 4.

Project Cost and Benefit Patterns over Time

Projects typically incur costs and generate revenues over a number of years. Often, large capital outlays are involved in the first few years of project life, but increases in revenue may not take place immediately and revenue may increase over several years. Figure 3-1 illustrates a typical pattern of project costs and benefits over time.

Static rate of return measures such as 'per cent return on capital' are sometimes used as criteria for investment profitability. However, when an investment is undertaken, the rate of return on capital may be negative for the first few years, increasing as income increases. In such cases, per cent return on capital fails to provide an adequate single index of project profitability. To consider only the rate of return when income has stabilised fails to take account of the differences in timing between project income and project expenditures. Rather, it is necessary to introduce discounting to bring costs and benefits to a comparable basis with respect to time.



4. Discounted Cash Flow (DCF) Analysis Concepts

The Rationale for Discounting

Consider the following questions:

Suppose you were to receive \$1000, e.g. as a present. Would you prefer to receive it now, or one year from now? Assume that you are certain to get the money in a year.

Suppose you were running your own business, and had the choice of receiving a payment of \$100,000 now or after one year, which would you prefer?

Why do people prefer money sooner rather than later?

The reason why people prefer money sooner rather than later is because in the interim they could use the money for profitable investment or desired consumption .

Compounding and Discounting Procedures

Before defining criteria to measure project performance, it is necessary to introduce some basic concepts and procedures with respect to compounding and discounting. Let us begin with the concepts of simple and compound interest. For the moment, consider the interest rate as the cost of capital for the project.

Suppose a person has to choose between receiving \$1000 now, or a guaranteed \$1000 in 12 months time. A rational person will naturally choose the former, because during the intervening period he or she could use the \$1000 for profitable investment (e.g. earning interest in the bank) or desired consumption (say to buy furniture, a second-hand motor bike or a video camera). If the \$1000 were invested at an annual interest rate of 8%, then over one year it would earn \$80 in interest. That is, a principal sum of \$1000 invested for one year at an interest rate of 8% would have a future value after one year of

$$\$1000 (1.08) = \$1080$$

The \$1000 may be invested for a second year, in which case it will earn further interest. If the interest again accrues on the principal of \$1000 only, this is known as simple interest. In this case the future value after two years will be \$1160. On the other hand, if interest for the second year accrues on the whole \$1080, known as compound interest, the future value will be

$$\$1080 (1.08) = \$1166.40$$

Investment and borrowing situations almost always involve compound interest, although the timing of

interest payments may be such that all interest is paid before further interest accrues.

The future value of the \$1000 after two years may alternatively be derived as

$$\$1000 (1.08)^2 = \$1166.40$$

In general, the future value of an amount \$a, invested for n years at an interest rate of r, is

$$\$a (1+r)^n$$

where it is to be noted that the interest rate r is expressed as a decimal (e.g. 0.08 and not 8 for an 8% rate).

The reverse of compounding – finding the present-day equivalent to a future sum – is known as discounting. Because \$1000 invested at an interest rate of 8% would have a value of \$1080 in one year, the present value of \$1080 after one year, when the interest rate is 8%, is

$$\$1080/1.08 = \$1000$$

Similarly, the present value of \$1000 to be received in one year, when the interest rate is 8%, is

$$\$1000/1.08 = \$925.93$$

If the \$1000 were received in two years time, and the interest rate is 8%, the present value would be

$$\$1000/1.08^2 = \$857.34$$

In general, if an amount \$a is to be received in n years time, and the annual interest rate is r, then the present value is

$$\$a / (1+r)^n$$

Since the interest rate is used in discounting future sums, it is usually referred to as the discount rate. Also, terms of the form $(1+r)^n$ are referred to as discount factors.

The above discussion has been in terms of amounts in a single year. Investments usually incur costs and generate revenue in each of a number of years. Suppose the amount of \$1000 is to be received at the end of each of the next four years. If not discounted (i.e. the discount rate is zero), the sum of these amounts would be \$4000. But suppose the interest rate is 8%. What is the present value of this income stream? This is obtained by discounting the amount at the end of each

year by the appropriate discount factor then summing:

$$\begin{aligned} & \$1000/1.08 + \$1000/1.082 + \$1000/1.083 + \$1000/1.084 \\ & = \$1000/1.08 + \$1000/1.1664 + \$1000/1.2597 + \\ & \quad \$1000/1.3605 \\ & = \$925.93 + \$857.34 + \$793.83 + \$735.03 \\ & = \$3312.13 \end{aligned}$$

The discount factors – $1/1.08^t$ for $t = 1$ to 4 – may be read from published tables, derived on a calculator, or generated on a computer spreadsheet. It is to be noted that the present value of the equal annual amount of \$1000 is progressively reduced for each year further into the future (from \$925.93 after one year to \$735.03 after four years), and the sum is approximately \$700 less than if no discounting (a zero discount rate) had been applied.

The present value formula for a sum of A received at the end of each of t years can be written as:

where A is the amount received in year t , and r is the interest or discount rate.

In the above example, the future amounts were equal, but of course this formula is appropriate for unequal amounts also.

The present value of a perpetual annuity

An annuity is an equal annual amount (revenue or payment) which takes place at the end of each of a number of years. We may be interested in the present value of an annuity, or the size of the annuity which is equivalent to a particular present sum. If an amount PV were invested in perpetuity at an interest rate of r , then the amount earned each year would be the product of PV and r . That is, if A is the annual amount or annuity, then

$$A = PV r$$

Rearranging this formula, if a dollar amount A is received each year in perpetuity, then the present value of this annuity must be

$$PV = A / r$$

Example

Suppose \$1000 is received at the end of each year in perpetuity, and the discount rate is 8%. Then the present value of this annuity is $PV = \$1000/0.08 = \$12,500$.

The present value of a finite annuity

Suppose the annuity of A dollars is only received for a fixed number of years, n . The present value will then be something less than A/r . It can be shown by some arithmetic involving sequences and series that Here, as n becomes larger, the term (or) approaches

zero, so the numerator of the PV formula approaches 1, and the present value approaches A/r .

Note on the discount rate

The discount rate represents the interest rate at which financial amounts in the future are converted to their present values. In financial investment appraisal, the discount rate may be thought of as the time preference for money or the cost of capital or the rate of return required by the firm. For practical purposes, at this stage we may think of the discount rate as the cost of capital for the project. This definition will be defined in more detail later, as a weighted average cost of capital, with allowance for taxation and the rate of inflation.

Project Cash Flows

The concept of annual incremental net cash flows was introduced in Topic 3, where it was stated that:
 $C_t = B_t - CO_t - OC_t$

Capital outlays (C_t) are the 'investment' component in a project in each year t , e.g. the investment in new land, buildings or equipment. It could be that all capital outlays are incurred immediately on commencement of the project, or they could be spread over several years.

Cash inflows are typically the additional annual revenue generated by a project, but can also include the reduction in a firm's costs. Operating costs are the recurrent expenditures of items such as labour, repairs and maintenance, electricity or fuel, seeds and fertilizers, and insurance.

Note on timing of cash flows

The cash flow items take place at various times throughout the year. Sometimes payments must be made by the 'end of the month' and sometimes revenue is paid at regular intervals, but in general the timing of cash flows within any year is irregular. In practice, costs tend to be incurred up front (perhaps with 30 days to pay), whereas often receipts from commodity sales are not paid for some time. In the case of grain crops, for example, there may be a series of payments for the annual harvest over a year or even longer.

For financial analysis, it is necessary to make some simplifying assumptions about the within-year timing of cash flow items. We could assume that cash flows occur at various points in time throughout the year. Sometimes complex timing assumptions are made about cash flows, e.g. 75% of costs are incurred at the beginning of the year and the balance at the end of the year, only 25% of revenue is received at the beginning of the year and 75% at the end of the year.

For simplicity, usually only one time in each year as taken for as the time of cash flow, for each cash flow category. In general, cash flows are assumed to take place at the end of the year. It is not likely that this will introduce much distortion into the financial analysis. The choice of when the year commences and ends

usually is not critical, e.g. this could be January to December, or July to June or some other 12 month period. There can be some advantages in tying the beginning-of-year and end-of-year points in time with the financial year, because this provides a more precise treatment of taxation payments, but this generally is not a critical issue.

As a guideline, both project revenues and operating costs are usually assumed to take place at the end of the year. Capital outlays on the other hand are assumed to take place at the beginning of the year. To maintain our end-of-year time reference, we treat capital outlays as taking place at the end of the year previous to the year in which they are incurred. Hence a capital outlay at the beginning of year 2 would be treated as a capital outlay at the end of year 1. A capital outlay at the commencement of a project would be assumed to take place at the end of 'year 0' this being the end of the year before the project commences (really the beginning of the first year).

Financial Performance Criteria

A number of criteria have been devised as measures or criteria of financial performance of investment projects. The most widely used are the net present value and the internal rate of return. Others include the net future value (rarely calculated), payback period and the peak deficit. For social projects, benefit to cost (B/C) ratios are often computed, though these are not normally

derived for private investment projects.

The net present value (NPV)

The present value formula for a series of payments was defined above. This formula may be applied to the series of annual net cash flows. Specifically, the net present value is defined as:

where n is the project life, C_t is the net cash flow at the end of year t , and r is the discount rate. In other words, the NPV is the sum of the annual net cash flows over the life of a project, all discounted to their present values.

NPV is a measure of the worth of an investment project, or the amount that the project would contribute to the firm's wealth or net worth, in present value terms (i.e. in today's dollars). If the NPV is positive, at the required rate of return, it is predicted that the project will add to the firm's wealth, and the project is said to be financially viable or financially acceptable.

Simple example of calculating the NPV

A project requires an immediate capital outlay of \$25,000, and generates annual revenues of \$15,000 and has annual costs of \$4000, over the three-year life. The discount rate is 8%. It may be assumed that capital outlays occur at the beginning of the year, while project revenues and operating costs occur at the end of the year.

The calculation of the NPV is set out in Table 4-1.

Table 4.1 Example Worksheet for calculating the NPV

Year	0	1	2	3
Capital outlay (\$)	25000			
Project revenue (\$)		15000	15000	15000
Operating costs (\$)		4000	4000	4000
Net cash flow (\$)	-25000	11000	11000	11000
Discount factor	1	1.08	1.1664	1.2597
Present value of net cash flow (\$)	-25000	10185.19	9430.73	8732.15
Net present value (\$)	3348.07			

Explanatory notes in the cash flow table

1. In Table 4-1, the year numbers run from zero to 3. The cash flow timing is taken as the end of the year, e.g. year 2 corresponds to the end of year 2. A special case here is year 0, which represents the beginning of the first year, i.e. the time when the project commences (and typically when capital outlays begin).

2. Following the above formula for net cash flow, the net cash flow row is the difference between the project revenue row and the sum of the capital and operating cost rows. Thus the net cash flow for years 1 to 3 are all \$15,000 - \$4000. In the case of year 0, since there is no revenue or operating cost, the net cash flow is the capital outlay, and the sign in the net cash flow row is negative.

3. A row of discount factors is entered below the net cash flow row. The factor for year 0 is 1, meaning that the immediate capital outlays are not discounted. The discount factors increase progressively for the end of years 1, 2 and 3.

4. A row of present values of net cash flows is obtained by multiplying the net cash flow for each year by the discount factor for that year.

5. The NPV of \$3347 is obtained by adding the present values of net cash flows for the four years (year 0 to year 3).

The internal rate of return (IRR)

The internal rate of return (IRR) is an alternative criterion of financial performance of investment projects. While the NPV provides a measure of the amount of return to the firm, or addition to the firm's wealth, the IRR represents the rate of return. That is, it is interpreted as a percentage rate of return on the capital invested, to allow a comparison against the cost of capital or the return from alternative investments.

The IRR is the discount rate for which the project exactly breaks even, i.e. for which NPV is zero. In other words, it is the highest cost of capital which the project can support. Algebraically, it is the discount rate r such that:

$$NPV = \sum_{t=1}^n C_t (1+r)^{-t} = 0$$

The IRR could be derived by entering various discount rates into the NPV formula, in a trial-and-error approach

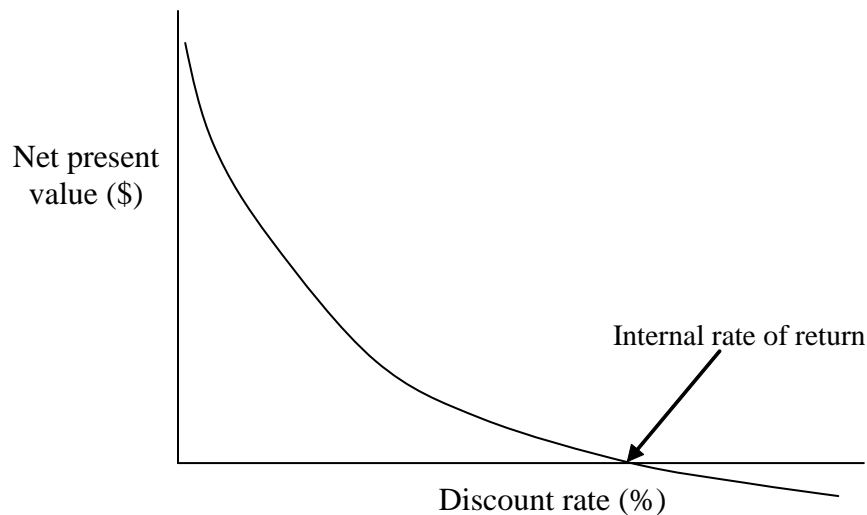
to close in on the approximate discount rate for which NPV is zero. The following NPV values have been calculated for a series of discount rates.

Discount rate (%)	4%	8%	12%	16%
NPV (\$)	5526	3348	1420	-295

From inspection of this table, it is apparent that the IRR is between 12% and 16%, and closer to the latter (probably about 15%). The analysis could be reworked with narrower steps in discount rates. We can conclude that the project will be profitable if the required rate of return is not more than about 15%.

The NPV profile

It is desirable after calculating the net present value to examine how the NPV varies in relation to the discount rate. That is, we compute the NPV for a range of discount rates, and graph the relationship. The resulting graph – called the NPV profile – typically has the shape illustrated in Figure 4-1.



As illustrated in Figure 4-1, the NPV declines as the discount rate increases, because the positive future cash flows have a lower weighting relative to the more immediate capital outlays. Eventually, a discount rate is reached where the project just breaks even.

The internal rate of return can be read off the NPV profile as the point on the horizontal axis (the discount rate axis) where the NPV is zero. The NPV and the IRR will always yield consistent results, in that if the NPV is positive, the IRR will exceed the discount rate used to calculate the NPV. In that these two criteria measure different things – the absolute amount of return and the rate of return – reporting both provides more information that either alone, to the decision-maker.

Potential problems with the IRR

Depending on the pattern of net cash flows, it is

possible that no IRR exists, multiple rates exist, or that the estimated value of the IRR is meaningless (due to a 'perverse' NPV profile).

An inspection of the net cash flow series will indicate if problems in obtaining a sensible IRR are likely.

Consider the NPV profiles of Figure 4-2. In the first part of this figure, the NPV profile cuts the discount rate axis in three places, any of which would be candidates to be the NPV. For the second of these intersections, the NPV is increasing as the discount rate increases (saying the project will be more profitable the higher the cost of capital) which clearly is illogical. The second part of Figure 4-2 has a similar illogical section. In the third part of the figure, the NPV never touches the discount rate axis, so no NPV exists.

These NPV patterns are a consequence of the pattern of positive and negative cash flows. For example, if

all cash flows were positive, there could be no IRR (corresponding to the third part of the figure). In project appraisal, it is always desirable to derive the NPV profile, partly as a form of sensitivity analysis but also partly to check that the profile is 'well behaved'.

The net future value (NFV)

The net future value of a project is calculated by the formula:

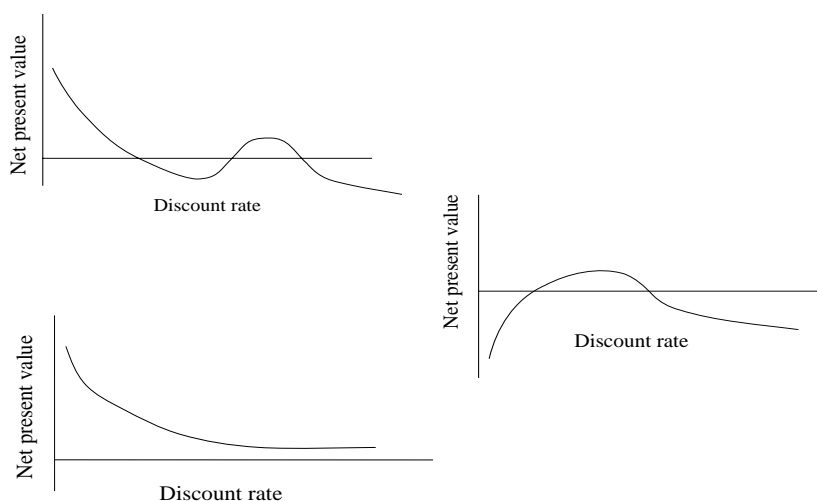
Here, all net cash flows are converted to their values at the end of the project's life, by multiplying by the compounding factor for each time period. This financial criterion is fully equivalent to the NPV, in that if one is positive then the other will be positive also. Further, the NPV could be obtained from the NFV by discounting (dividing by $1+r$ to the power n).

Project balances, the payback period and the peak deficit

To determine the payback period for an investment project – that is, how many years it takes for the project to become 'in the black' and remain there for the remainder of project life – it is necessary to introduce the concept of project balances. A project balance is a measure of how much the project owes the firm, or how much it has contributed to the firm. It is the amount the project is 'in the red' or 'in the black' at the end of any year. Specifically, a project balance is the present value of net cash flows up to the end of any year during the project life. That is, the project balance for year t (PB $_t$) is

$$B_t = \sum_{i=1}^t \frac{C_i}{(1+r)^i}, \quad t = 1 \text{ to } n.$$

Figure 4-2. Badly-behaved NPV profiles



The final project balance (when $t = n$) is in fact the project NPV. An inspection of the project balances will reveal the payback period as the year after the last negative project balance.

For the example project, the cash flow table is extended to report the project balances as in the Table 4-2. The project balance in the year 0 is simply the net cash flow in year 0. The project balance for year 1 is that of year 0 plus the discounted cash flow for year 1, i.e.

$$-\$25,000 + \$ 10,185.19 = -\$14814.81$$

The project balance in year 2 is the project balance in year 1 plus the discounted cash flow for year 2, and so on.

Calculating the project balances also allows the project's peak deficit to be identified. This is the largest negative project balance, and indicates the greatest amount of funds which will be committed to the project throughout the project life, in present value terms. For the example, the peak deficit occurs at the time of the initial capital outlay, because there are not later negative net cash flows.

A complexity in determining the payback period is that if a project were terminated early, there could be a substantial capital inflow from disposal of the plant and equipment acquired for the project plus the release of the working capital tied up in the project. In this context, the payback period as defined above is the number of years taken for the project to break even, given that the project will be continued to the end of the planning horizon or assumed project life.

Table 4-2. Illustration of calculation of project balances

Year	0	1	2	3
Capital outlay (\$)	25000			
Project revenue (\$)		15000	15000	15000
Operating costs (\$)		4000	4000	4000
Net cash flow (\$)	-25000	11000	11000	11000
Discount factor	1	1.0800	1.1664	1.2597
Present value of net cash flow (\$)	-25000.00	10185.19	9430.73	8732.15
Project balance (\$)	-25000.00	-14814.81	-5384.09	3348.07

Benefit/cost ratios

Various alternative definitions of the benefit to cost or B/C ratio are possible. Two of the most simple forms are

$$\text{Gross B/C ratio} = \frac{\text{\$ benefits}}{\text{PV of capital outlays} + \text{\$ operating costs}}$$

greater number of B/C definitions.

The B/C ratio of zero would indicate that the project generates no net benefits. A ratio of 1.0 indicates that the project breaks even. The larger the ratio, the more profitable or desirable the project is, all other things being equal.

In practice, B/C ratios are rarely calculated for private financial investments, and are more appropriate for public sector (government) investments in social projects, as discussed in Topic 13.

$$\text{Net B/C ratio} = \frac{\text{\$ benefits} - \text{\$ operating costs}}{\text{\$ capital outlays}}$$

If project costs and revenue are divided into a greater number of categories, it becomes possible to devise a

Split-group Task

Costs and returns in a forestry seedling nursery

Suppose you have been asked by the forestry service to carry out a financial evaluation of the development of a small seedling nursery to produce 2000 seedlings of timber tree species per season.

Split into three groups (perhaps by country) to tackle this task. One member of each group is to provide a short summary when groups rejoin.

Suggested steps include:

- (1) Identify the category of capital outlays, operating costs and revenues from the nursery project.
- (2) Determine the planning horizon and discount rate for the analysis.
- (3) Place cost and revenue figures on any cash flow items for which you feel confident to make guesstimates.

Takeaway Task 1

1. A project requires an initial capital outlay of \$6000, and generates revenue and incurs annual costs in each of two years of \$5000 and \$1000 respectively. The cost of capital is 15%. On the basis of these data, calculate

- a) the annual net cash flows.
- b) the discount factors for years 1 and 2.
- c) the net present value for the project.

2. For the data in Question 1, derive the NPV for discount rates of 20% and 25%. From inspection of your three NPV estimates, approximately what discount rate could the project support, and still break even?

3. Classify the relationship between each of the following pairs of projects, as competitive, relatively independent, complementary projects, contingent or mutually exclusive.

- a) Purchasing a cow and purchasing a carabao.
- b) Expanding the area under rice and purchasing working cattle.
- c) Installation of a circular saw and a bandsaw as the main log breakdown saw in a timber mill.
- d) Planting gmelina trees and planting pineapples in the same block.

4. Classify the following cash flow items as capital outlays, project revenues or operating costs.

- a) A block of land is purchased for \$2000 to set up a seedling nursery.
- b) A tractor requires expenditure on fuel, at a cost of \$25/hour.
- c) A new tractor reduces fuel costs by \$10/hour.
- d) A group of investors is evaluating the profitability of constructing a timber mill, and an environmental consultant has carried out an environmental impact statement required by the government, at a cost of \$3000.
- e) Timber milling equipment is expected to require a overhaul every three years, including purchase of replacement parts, at a cost of \$4000.

5. Performing a DCF analysis in Excel

This topic presents an example of a simple set of cash flows, and demonstrates how to set up the cash flow data on an Excel spreadsheet, and derive the net present value, internal rate of return and payback period. Derivation of the NPV profile is also demonstrated. Screen shots (images of the computer screen) are provided, and the spreadsheeting steps explained in detail. The example is designed for a self-practice exercise on a computer, and as a device for demonstrating a number of useful spreadsheeting techniques.

Example project

A project requires an immediate capital outlay of \$25,000, generates annual revenues of \$15,000 and has annual costs of \$4000, for three years. The discount rate is 8%. It may be assumed that capital outlays occur at the beginning of the year, while project revenues and operating costs occur at the end of the year.

Required activities

The task statement is set out in the following box.

- (1) Set up an Excel spreadsheet, and derive the NPV and IRR.
- (2) Derive the payback period.
- (3) Determine the NPV for discount rates of 4% to 20% in steps of 4%, using the Table facility in Excel, and plot the NPV profile using the graph facility.
- (4) Use your spreadsheet to answer the following 'what if' questions, in terms of NPV estimates:
 - (a) What if the capital outlays were spread equally over two years?
 - (b) What if the operating costs were 50% higher?
 - (c) What if the discount rate was only 6%?

Note: Enter all of the parameter values at the top of the spreadsheet, with cell references to them in the cash flow table, for convenience in making adjustments to the parameter levels. The cash flow table is not to contain any parameter levels or 'magic numbers'.

Spreadsheeting step 1: calculating the NPV and IRR

The data for this example has been entered into Excel, and the financial functions used to obtain two performance criteria. The spreadsheet image as presented in Figure 5.1.

Some points to note in relation to use of the spreadsheet are:

1. The cost and revenue parameters (including units of measurement) are set up in rows 5 to 8 inclusive of the parameter block, at the top of the spreadsheet. The discount rate could be written as either '=8%' or '=0.08'.
2. The years are set up as columns, and the cash flow items are in rows in the cash flow table, placed immediately below the parameter block. The first year is labeled year '0'. This is because capital outlays are assumed to take place at the beginning of the year, and the beginning of the first year is equivalent to the end of the previous year. In effect, year 0 means 'right now'.
3. The cash flows are defined by formula. Cell B13 contains the cell reference '=B5'. Cell C14 contains the reference '=\$B6'. This value is then copied into cells D14 and E14, but clicking on the cross in the lower right corner of cell C14 and dragging it rightwards to the adjacent two cells. The dollar sign has to be inserted before

the copying process; this indicates an absolute cell reference, ensuring that the column identifier B does not change in the copying process. Cell references are used to generate the entries in row 15 in a similar way.

4. The net cash flow row is calculated by formula, as the differences between corresponding cells in the capital outlay, project revenue and operating cost rows. That is, the entry in cell B16 is obtained as the difference B14-B13-B15, and this formula is copied (relatively, no dollar sign) into cells C16 to E16.

5. As shown in the input window (just under the toolbar, alongside fx above the spreadsheet), the net present value (of \$3348) is derived in cell B20 using the NPV financial function available in Excel. The cell reference for the net cash flow for year 0 (in cell B16) is placed outside the NPV formula, so that it will not be discounted. The NPV formula includes the cell reference for the discount rate, a comma, and then the cell range for discounting (first and last cell, separated by a colon). The range of cells is entered by clicking with the mouse of the first cell and extending the selected area with the mouse. Note that there is no need to calculate discount factors because these are calculated automatically in the NPV function.

6. Finally, the IRR is calculated by placing in cell B21 the entry '=IRR (B16:E16)'. Here all four annual net cash flows are included within the IRR function.

	A	B	C	D	E
1	Example of DCF analysis				
2					
3	Cash flow parameters				
4					
5	Capital outlay (\$)	25000			
6	Project revenue (\$)	15000			
7	Operating costs (\$)	4000			
8	Discount rate	8%			
9					
10	Cash flow table				
11					
12	Year	0	1	2	3
13	Capital outlay	25000			
14	Project revenue		15000	15000	15000
15	Operating costs		4000	4000	4000
16	Net cash flow	-25000	11000	11000	11000
17					
18	Performance criteria				
19					
20	NPV(\$)	3348			
21	IRR (\$)	15.3%			

Spreadsheets step 2: deriving the payback period

To derive the project balances and hence payback period, a new row (row 17) labeled 'project balance' is inserted into the spreadsheet as in the following screen shot. The entry in cell B17 is '=B16', i.e. the project balance for year 0. The entry in cell C17 is this initial cash flow plus the next cash flow discounted back one year, the formula which can be read in the data entry window as '=B17+C16/(1+\$B8)^C12'. (The inverted V or caret means raise to the power, this power being the number of years. An absolute column reference is used for the discount rate.) This formula is then dragged into cells D17 and E17, to derive the project balances for years 2 and 3.

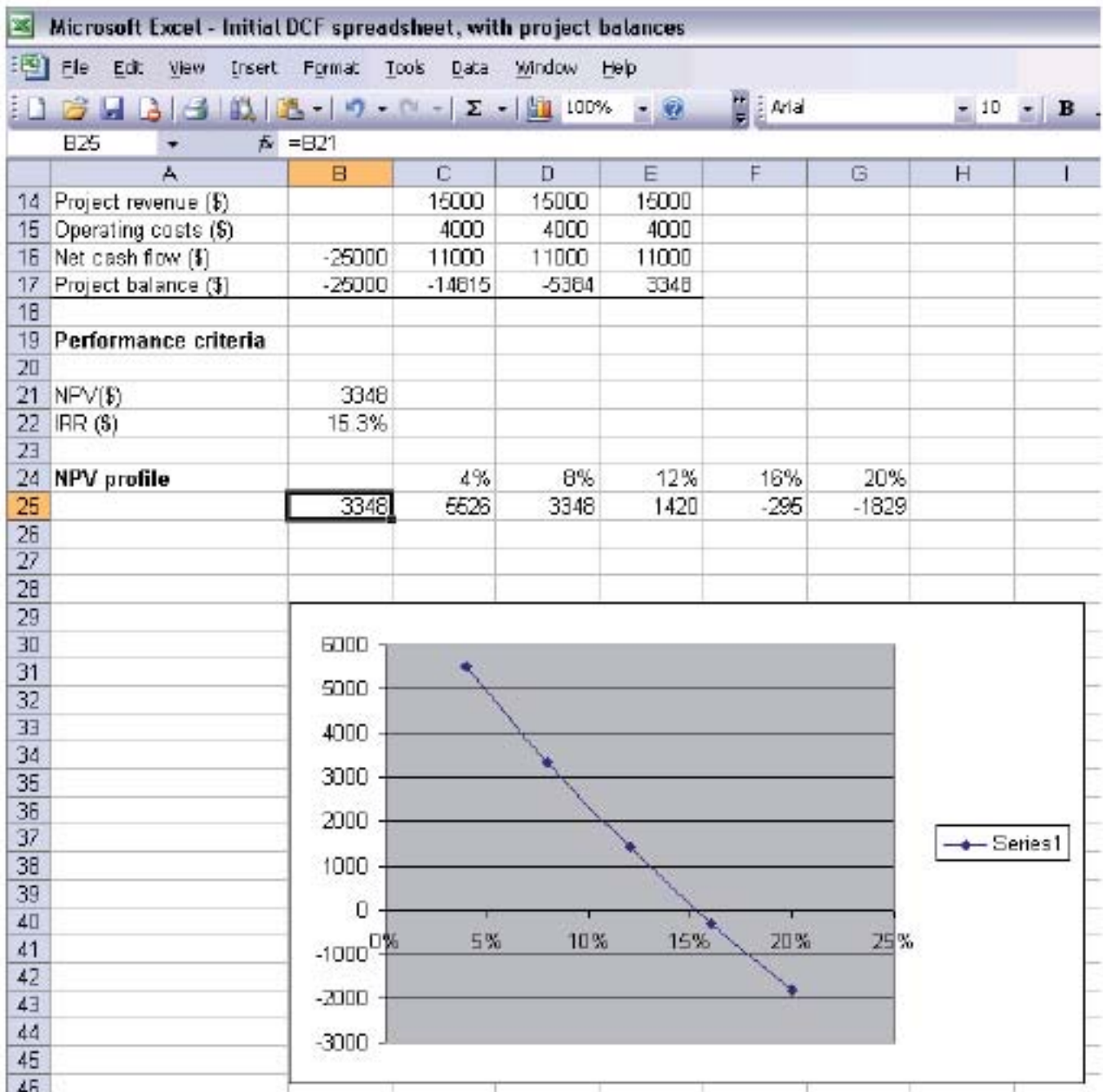
	A	B	C	D	E
1	Example of DCF analysis				
2					
3	Cash flow parameters				
4					
5	Capital outlay (\$)	25000			
6	Project revenue (\$)	15000			
7	Operating costs (\$)	4000			
8	Discount rate	6%			
9					
10	Cash flow table				
11					
12	Year	0	1	2	3
13	Capital outlay (\$)	25000			
14	Project revenue (\$)		15000	15000	15000
15	Operating costs (\$)		4000	4000	4000
16	Net cash flow (\$)	-25000	11000	11000	11000
17	Project balance (\$)	-25000	-14915	-5384	3348
18					
19	Performance criteria				
20					
21	NPV(\$)	3348			
22	IRR (\$)	15.3%			
23					

It is apparent from this screen shot that the peak deficit (lowest project balance) is at the commencement of the project, and the project balance does not become positive until year 3, hence the payback period is interpreted as three years.

Spreadsheets step 3: deriving the NPV profile

The simplest way to deriving the NPV profile is using the Table facility in Excel. The NPV profile is illustrated in the following screen shot; the steps in obtaining this profile are now explained.

1. Enter the heading 'NPV profile' in cell A24.
2. To commence setting up the NPV table, enter the discount rates 4% to 20% in cells C24 to G24.
3. Indicate what variable is to be calculated in the table, i.e. the NPV. To do this, in cell B25, type '=B21', or type the equals sign then simply click on cell B21. The contents of this cell are reported in the fx data input window in the above screenshot.
4. Using the mouse, highlight the block of cells B24 to G25.
5. From the menu, select Data then Table, and the Table dialogue box will appear, with the cursor in Row input cell. Click on cell B8 to indicate that the parameter which will be varied in the table is the discount rate. Skip the column input (because a one-way table only is needed), and click on OK. The table values should then appear as in cells C25 to G25.
6. To graph this table, select the cells C24 to G25, and click on the Chart Wizard icon on the toolbar. Select the XY (Scatter) graph form, and then the second chart sub-type, then select Next and then Finish. The graph should then appear, and may be dragged down to about row 25 to be clear of the table. Various refinements can be made to the presentation of the graph. Inspection of the graph reveals that the IRR is slightly above 15%.



Spreadsheets step 4: 'what if' analysis

To address the 'what if' questions listed above, changes are made in the parameter block. Thus, example the 4000 with 6000 in cell B7 reveals that a 50% increasing in operating costs reduces the NPV to \$-1806, and the IRR to 3.9%. The effect of a discount rate of 6% could be similarly investigated by changing the entry in cell B8 from 8% to 6%.

To spread the capital outlay over two years, an extra parameter would need to be introduced in the parameter block. Specifically, 12,500 would be entered into cells C4 and C5, and cell references to these would be made in cells B13 and C13 respectively.

Avoiding magic numbers

It should now be apparent why no numbers were entered into the cash flow table section of the spreadsheet. If all the parameters are placed at the top of the spreadsheet, these can be easily adjusted for deriving the NPV profile or asking 'what if' questions. No change has to be made to the cash flow table in this process.

Takeaway Task 2

1. An investment requires an initial outlay of \$5000 and pays \$480 at the end of every year in perpetuity. If the interest rate is 8%, what is the NPV?
2. What is the present value of \$1000 received at the end of each of the next 7 years, if the discount rate is 12% per annum?
3. A project with a five-year life has an immediate capital outlay of \$40,000, incurs operating costs of \$5000 a year and generates revenue of \$17,000 a year. The discount rate is 12%.
 - (a) Set up these data as parameters in a spreadsheet, set up a table of annual cash flows, and determine the annual net cash flows.
 - (b) Calculate the net present value and internal rate of return.
 - (c) Calculate the project balances and read of the peak deficit and the payback period.
 - (d) Graph the NPV profile for discount rates of 12%, 16%, 20% and 24%.

6. Relevant Cash Flows for Financial Project Appraisal

What types of cash flows are relevant to financial project appraisal? Those that decrease or increase the firm's overall cash or wealth position as a direct result of the decision to accept or reject the project, or are 'incremental' as a result of adopting the project. Incremental cash flows are determined by measuring cash flows with and without the project. This is not the same thing as before and the project; the before-project situation may not continue even if the project is not adopted.

Relevant cash flows include capital outlays – which may include an 'initial capital outlay' or 'capital expenditure' as well as additional 'mid-term' investments and also terminal flows – and operating cash flows – e.g. inflows from proceeds of product sales, and outflows from expenses such as electricity and vehicle fuel, wages and raw materials, repairs and maintenance for project vehicles and buildings, transport costs and advertising expenses.

Asset expansion projects are investments in additional assets, in order to for example expand an existing product or service line, enter a new line of business, increase sales or reduce costs.

Asset replacement projects involve retiring one asset and replacing it with another (and usually more efficient) asset. Sometimes a chain of replacements will take place over time, such as where tractors are replaced say every 10 years or draught animals are replaced when they become too old for their tasks. Assets may also be disposed of in decisions concerning asset retirement and asset abandonment.

Some important areas in relation to determining relevant cash flows include:

- Opportunity cost principle
- Sunk costs
- Overhead costs
- Allowance for salvage values
- Allowance for working capital
- Treatment of taxation
- Treatment of depreciation
- Investment allowances
- Financing flows
- Treatment of inflation

Opportunity Cost Principle

When a firm undertakes a project, various resources will be used up and not available for other projects. The cost to the firm of not being able to use these resources for other projects is referred to as an 'opportunity cost'. For example, if a firm owns land or a building which

will be needed if a project proceeds, then even though there will be no purchase transaction (because the asset is already owned by the firm), going ahead with the project denies the firm of the opportunity to cash in by selling the asset. That is, there is an opportunity cost to the firm of committing the asset to the project, and this is treated as a capital outlay.

Exclusion of Sunk Costs

A sunk cost is an amount spent in the past in relation to the project, but which cannot now be recovered or offset by the current decision. Sunk costs are (1) past and irreversible, and (2) not contingent upon the decision to accept (or reject) a proposed project. Therefore, they should not be included in the cash flows.

An example of a sunk cost would be where a technical feasibility study or environmental impact statement had been commissioned before a project commenced. At the time of making the decision whether to proceed with the project, the expenditure has already been incurred. If the project were not to proceed, the expenditure has already been 'sunk', and cannot be retrieved. So it is a cost both 'with' and 'without' the project, rather than a cost which differs if the project proceeds, and therefore is not an incremental cash flow.

Relevant and Irrelevant Overhead Costs

Overhead costs relate typically to costs of utilities (electricity, gas, water) and executive salaries. Cost accounting allocates various overheads to particular production units. However, overheads are treated differently in project appraisal. What is relevant is incremental overhead costs. This does not include overheads which will be incurred both with and without a project. We have to be guided by 'opportunity cost' and 'sunk cost' principles. Only incremental changes in overheads should be included. If expenses would be incurred anyway then they are not included. Executive salaries would be relevant if the project involved diversion of executive staff from other duties, or hire of additional executives, but not otherwise.

Allowance for Salvage Values of Capital Assets Acquired in the Project

Often projects will involve purchase or construction of physical assets (land, buildings, machinery), and at the end of the assumed project life or planning horizon the firm will still have these extra assets, if in depreciated state, which constitutes an increase in wealth of the firm. It is appropriate to place values on such residual

assets. This is done by making the assumption that the assets are sold at their market value, and the revenue generated, net of taxation paid on the sales, is a capital inflow at the end of the final year of the project life.

Making an Allowance for Working Capital

A firm's working capital may be defined as the difference between current assets (including cash holdings and amounts owed to the firm) and current liabilities (payments due). The term 'current' has a particular meaning in this context, relating to the financial transactions of the firm, and working capital should not be confused with the firm's balance sheet. Also, it should be noted that it is the incremental change in current assets and liabilities in relation to the project that is relevant for financial evaluation.

Current assets include cash, inventories, raw materials, finished products and accounts receivable (customers' unpaid bills). Current liabilities include accounts payable (unpaid bills) and wages payable. The timing of these cash flow items is often uncertain. The firm may have to hold greater inventories than expected, or there may be unexpected expenses or late payment of accounts by customers. The firm needs to have the some funds which can be used flexibility, in what is often called a float, to meet such contingencies. If they did not, the project would have to be supported by the rest of the firm as a kind of banker providing short-term funds. In other words, working capital is capital tied up during the life of the project.

Working capital could be regarded as an opportunity cost – the capital is tied up and cannot be used for anything else. Note that it is treated as a capital flow not an operating flow. In project evaluation, it is desirable to make an allowance for working capital throughout the life of the capital. This allowance is treated as a capital outlay early in the life of the project, when expenditure takes place on capital assets, and as a capital inflow at the end of the project's life. As to the amount, a guideline is to add 2% to the project capital outlays as working capital.

Treatment of Taxation

In financial project appraisal, it is usual to calculate before-tax net cash flows, and then after-tax net cash flows. Tax is a payment to a government authority (federal, state or local), and is a cash outflow. The amount to be paid is based on taxable income of the individual or firm. Taxable income is defined as assessable income less allowable deductions. The tax payable is the taxable income multiplied by the average rate of tax. For each dollar of tax deductions generated by a project, the tax payable is reduced by one dollar times the marginal rate of tax. For simplicity, we sometimes assume a constant marginal and hence average tax rate. For example, in Australia the company tax rate is a flat 30% of taxable income. Tax rates and allowances often change over time, but we need to

make assumptions about the rate for the life of the project, and generally a constant rate is assumed.

Where a project is subject to particular or special tax laws or rulings, expert tax advice may be needed. It could be that the project is only viable after tax benefits are taken into account. This is a risky basis on which to accept a project, because governments frequently change tax legislation, and sometimes do so retrospectively.

Note that when the net cash flow is negative, the project expenses including depreciation allowances can still generate a financial benefit for the firm, if the firm is making a profit in its other operations. That is, from the perspective of taxation, the project is not a stand-alone entity.

Treatment of Depreciation

Depreciation is NOT a cash flow. Depreciation is an accounting allocation of capital costs, where the book value of an asset is reduced over time according to some formula which may not closely match the income generated by the asset or the decline in asset value. Various methods are used to calculate depreciation, especially the straight line and diminishing value methods. In project appraisal, accounting depreciation is not relevant, but tax-allowable depreciation is relevant with respect to its effect on the amount of income tax which has to be paid. Depreciation allowances as described above form a 'depreciation tax shield', which is treated as a cash inflow.

Inclusion of Special Investment Allowances

Governments may provide special temporary incentives for investment in specific industries, e.g. oil and mining exploration incentives, ethanol subsidies. These can have a major impact on NPV. The tax rules governing investment allowances are often complex, but the tax benefits of these should be included in the financial analysis.

Financial versus Financing Flows

Often considerable confusion arises between project cash (of financial) flows and financing flows concerned with borrowing loan funds and making repayments (interest and redemption). Care is needed to distinguish between project cash flows and financing cash flows, i.e. between the investment decision and the financing decision.

Financial investment appraisal determines whether a project is profitable or adds value to the firm, i.e. it guides the investment decision. On the other hand, the financing decision involves deciding what proportion of the cash needed to fund the project is provided by debt holders and what proportion is provided by equity holders (i.e. from cash already held by the firm). The decision about the particular mixture of debt and equity

used in financing the project is a management decision concerning the trade-off between financial risk and the cost of capital.

In general, interest charges or other financing costs (e.g. dividends and loan repayments) are not relevant cash flows. In project appraisal, we are interested in cash flows generated by the assets of the project. Interest is a return to providers of capital. It is not included in cash flows because the discount rate used in calculating the NPV accommodates the required returns to both equity and debt providers. Inclusion of interest charges would thus result in double counting of the interest cost.

Interest is tax deductible, and therefore provides a tax shield for any investment. However, this benefit is also accounted for in the discount rate – the after-tax rate discount rate being used – rather than as a cash inflow. That is, tax savings on interest expenses are not included in discounted cash flow analysis. There are some exceptions to this rule, e.g. property investment analysis.

Whether to Adjust the Discount Rate for Inflation

Inflation or decline in the value of a currency will be present in the cash flows over time for an investment project. Both cash inflows and cash outflows could be affected by inflation. Market rates, such as interest rates and equity returns, will also rise with the inflation rate; as the market rate rises the required rate of return by investors will also rise. To deal with inflation appropriately, the project analysis must recognize expected inflation in the forecast of future cash flows and use a discount rate that reflects investors' expectations of future inflation.

If all cash flows as well as the discount rate change at the same rate due to inflation, the net present value is the same whether inflation is included or excluded in the analysis. However, most projects will consist of a multitude of cash flow items over a number of years, and it may be inappropriate to assume that prices of all of the cash flow items will change at the same rate over time, or to assume the same effect on the discount rate.

Some cash flow items are unaffected by inflation, examples being:

(a) depreciation tax shield – tax-allowable depreciation is totally unaffected by inflation. A depreciation tax shield is calculated by applying a fixed formula to the historical cost of an asset at the time of its acquisition, e.g. depreciation on a tractor at 20% of the initial outlay for each of five years.

(b) long-term raw-material contracts or the purchase of a commodity in the forward or futures markets, which may lock in the present prices thereby insulating the cash flow from inflationary effects.

Similarly, the rate of increase in prices of some project inputs or outputs may be greater than the general rate of price increase (the inflation rate). This might for example be the case with:

(a) water for irrigation, where there is a move to a more 'user pays' policy by government as supply agency due to recognition of the growing shortage of water resources.

(b) hardwood timber from native forests, which due to increasing scarcity may increase in price more rapidly than other commodities or project inputs.

In these cases, we say that there has been a real price increase, meaning that the price has increased more rapidly than the general inflation rate, as measured for example by a country's consumer price index or producer price index.

The analyst in project appraisal is faced with the choice of carrying out the analysis in real (current price) or nominal (constant price) terms, i.e. with price changes over time excluded or with price changes included. The former approach is easier to carry out; we simply use today's prices for all cash flow variables, and a discount rate from which inflation has been removed.

Given the differential impact of inflation on different cash flow components, cash flow forecasts in nominal terms – incorporating the inflationary effect – have an advantage over cash flow forecasts in real terms – excluding the inflationary effect. Nominal cash flow forecasts can incorporate different predicted trends in selling price, wages, material costs, and so on, into cash flow estimates by applying different inflation rates for different components of the cash flow. The choice then revolves around whether this additional complexity in the analysis is justified, i.e. whether we think that assuming the same price changes in all inputs and outputs will reduce the reliability of the analysis.

7. Project Evaluation Under Certainty

A starting point for project evaluation is to assume all costs and return are known into the future with certainty, or at least to rely on single-point estimates. We also assume that decisions makers are wealth maximizers. A project is judged to be financially viable if the NPV is positive, which is consistent with the requirement that the IRR is greater than the required rate of return or cost of capital, and the payback period does not exceed the project life.

Under this topic, we will consider:

- predicting future cash flows
- choosing between a constant price and current price analysis
- calculating the cost of capital
- determining the planning horizon
- calculating salvage values of capital assets acquired for the project, and
- comparing financial performance of two or more projects.

Predicting Future Cash Flows

In that a project may have a life of 20 years or more, many of the cash flow items are by nature forecasts about future costs or prices. This introduces a need for using forecasting techniques. The forecasts may be simply subjective judgments by the analyst or by experts that he or she contacts. Alternatively, one of the many business forecasting techniques may be adopted. This tends to be a specialist field, where expert assistance may be required. Some of the more important of forecasting approaches can be categorized in the following groups: naïve forecasting methods; elicitation of expert group consensus; balance sheet methods; time-series (including regression) methods; leading indicators; and econometric and simulation models.

Naïve forecasting methods include forecasts of no change, extrapolation of current trend (using linear regression analysis), and forecasts derived using moving averages and exponential smoothing. Group forecasting techniques involve a number of experts coming together (e.g. in the same room, by a researcher visiting and corresponding with each, using phone conferencing facilities, as an email group) and arriving at a consensus view. A well-known example of a group technique is the Delphi method, where estimates of some forecast variable are obtained from experts individually, and then experts are presented with a summary of the individual estimates and invited to make revisions to their own estimates.

In balance sheet models, a picture is built up of the

supply and demand of a commodity, and likely changes in these in the near future, from which to predict market clearing price. This approach is used effectively in predicting prices of internationally traded commodities such as minerals, wool and sugar.

It has been observed that as economies expand or contract, some time-series variables tend to change ahead of others and provide early warning of the direction of change. This has led to considerable research into comparing the timing of movements in economic variables and identifying leading indicators. Housing starts, retail sales, new motor vehicle registrations and inventories of business firms are typical leading indicators.

Time series models rely on regular movements in series in the past and extrapolate these into the future, perhaps with some modification to allow for factors that are recognized to influence supply and demand. The simpler time series models involve multiple regression equations, perhaps including time-lagged variables. More complex procedures include autoregressive integrated moving averages (ARIMA) and fitting of cointegration models.

Highly sophisticated econometric and simulation models have been developed, particularly by national treasury departments and major consulting firms, to predict the behaviour of economies and the impact that changes in policy instruments (such as government spending and interest rates) will have on the level of economic activity. Sometimes a team of econometricians spends several years developing, validating and refining these models.

Computation of the Discount Rate

Arriving at a discount rate for project evaluation can be a highly complex task. This involves

- choosing between a real and nominal price analysis.
- adjusting interest rates for taxation impacts.
- determining the weighted average cost of capital, where capital is used from various sources.
- adjusting the discount rate to remove inflation, in a constant price analysis.
- adjusting for a required rate of return.

Choosing between a real and nominal price analysis

As discussed in Topic 6, project appraisal may be carried out in today's dollars (constant or real prices) or in the prices which are predicted to apply in each year of the project life (current or nominal prices). In the first case, we simply use today's prices for inputs and

products for each year of the project life. The constant price is the real price, after the component for inflation has been removed. While no doubt inflation would occur during the life of the project, we assume that all cash flow items would change in price at the same rate, hence it is not necessary to adjust cash flows for inflation, and no distortion will be introduced by not doing so.

If it is believed that the prices of some cash flow items will change at different rates than others, then it becomes necessary to use a current price analysis. This would be the case, for example, for a forestry investment for which it was believed that log prices would increase at a greater rate than plantation input costs.

In general, a constant price analysis is to be preferred where it is appropriate, because it is simpler to carry out than having to inflate all cash flows by differential rates when calculating the annual net cash flows.

Adjusting interest rates for taxation

The payment of interest charges on loan funds and the earning of interest on invested funds have taxation implications. Suppose money is borrowed at an interest rate of 10%. Interest payments could then be deducted from income when determining the taxable income. If the rate of tax was 30% (the constant marginal rate of tax for companies in Australia), then claiming interest payments as a tax deduction would lead to 30% of the payments being a reduction in tax payable or part of the tax refund. The real rate of borrowing is then only 7%. Similarly, if the firm's own money were placed in an interest bearing deposit and earned 7%, then the interest earned would be taxable and 30% of the interest would be lost through tax. The real cost of using the firm's savings (in this case the opportunity cost of earnings foregone) is $0.07(1-0.3) = 4.9\%$.

Determining the weighted average cost of capital (current price analysis)

In funds from different sources are used to support a project, then the discount rate is the weighted average cost of capital (WACC), in which the interest rate from each source of capital is weighted by the proportion of project funds obtained from that source. As an example, suppose a project requires \$20,000 in funding, including \$5000 in the firm's own funds and \$15,000 in borrowings. Suppose also that the firm could invest its savings in interest bearing deposits with an after-tax earning rate of 7% per annum (so 7% is the opportunity cost of using its own savings), and can borrow funds at an interest rate after tax allowances of 10% per annum. Suppose also that current prices are to be used in the project evaluation. The weighted average cost of capital would then be:

$$\begin{aligned} \text{WACC} &= (5000/20000)(0.07) + (15000/20000)(0.10) \\ &= (0.25)(0.07) + (0.75)(0.1) \end{aligned}$$

$$\begin{aligned} &= 0.0175 + 0.075 \\ &= 0.0925 \text{ or } 9.25\% \end{aligned}$$

If the interest rates were reported on a pre-tax basis, then a further step of adjustment for taxation would be required in calculation of the WACC. For the above example, if the 7% and 10% were not adjusted for taxation, and the tax rate was 30%, then the WACC would be obtained as:

$$\begin{aligned} \text{WACC} &= (5000/20000)(0.07)(1-0.3) \\ &\quad + (15000/20000)(0.10)(1-0.3) \\ &= 0.07(0.25)(0.7) + (0.75)(0.1)(0.7) \\ &= 0.01225 + 0.0525 \\ &= 0.06475 \text{ or about } 6.5\% \end{aligned}$$

Adjusting the discount rate to remove inflation

The required rate of return used for discounting cash flows is normally derived from observed market rates such as interest rates and the rate of return on equity. In an efficient financial market, investors' required rate of return will include a component, $(1+p)$, to compensate for expected inflation. That is, observed market rates are usually quoted in nominal terms (as opposed to real terms). The use of observed or nominal market-required rates implies that we should incorporate inflation into cash flows to be consistent. If a real rate is to be used for discounting, the market rate must be adjusted (reduced) to remove the inflation component.

It is usually assumed that the relationship between interest and inflation rates is a multiplicative one, i.e. $(1+n) = (1+r)(1+p)$, where n = the annual nominal interest rate (expressed as a decimal value), r = the annual real interest rate (expressed as a decimal value), and p = the expected annual inflation rate. The real rate can be obtained by solving this expression for r , given known n and p .

Nominal rates can be converted into real rates using Fisher equation:

$$(1+n) = (1+r)(1+p)$$

$$1+r = (1+n)/(1+p)$$

$$r = (1+n)/(1+p) - 1$$

For example, suppose the borrowing rate is 11% and the inflation rate is 2%, then the real interest rate is: $r = 1.11/1.02 = 1.088$

If an additive model were used, $r = 11\% - 2\% = 9\%$

Note that because inflation is not built into the cash flows (they are in today's dollars), a lower discount is used than would be applicable for a current price analysis.

If the project's cash flows are in nominal terms then

they should be discounted by nominal discount rates. If the project's cash flows are in real terms they must be discounted by real discount rates. Real and nominal prices cannot be mixed and matched.

Adjusting for a required rate of return

The appropriate discount rate for project evaluation is the required rate of return by the firm. In using the cost of capital as the discount rate, we have assumed that this is the firm's required rate of return. That is, we assume the firm requires that the cost of borrowing be just met. In practice, there could be a difference between the required rate of return and the WACC. For example, the firm may not wish to invest unless it can make somewhat more than the cost of capital, e.g. it may require a rate of return of WACC+2%. This premium is not associated with risk (in that the current analysis is for project evaluation under certainty) or with administrative effort and transactions costs (which we assume are covered in the cash flows), but rather is a function of the attitude of management towards the rate of return.

Summary of steps in arriving at the discount rate

The above discussion on determining the appropriate discount rate for financial evaluation of a project may be summarized in the following steps:

- i. For each source of capital, determine the after-tax interest rate
- ii. If there is more than one source of capital, determine the weighted average cost of capital
- iii. If a constant price analysis is to be carried out, adjust the WACC for inflation (i.e. apply the Fisher equation to remove the inflation component).
- iv. If necessary, add or subtract a component to arrive at the firm's required rate of return.

Determining the Planning Horizon

The project life or planning horizon for the financial analysis can be distinguished from the physical life of assets purchased in the project. It will in general be much shorter than the life of some of the assets purchased or constructed, e.g. a project life of 15 years could be adopted where buildings are constructed which with suitable maintenance would last for 100 years or more.

A number of considerations are relevant when determining the number of years for which to estimate cash flows in project evaluation.

- One such factor is the discount rate. Because discounting reduces the contribution of cash flows further into the future on the NPV, it is generally not necessary to run the analysis for more than 20 to 30 years. The period may be shortened if the discount rate is high (say over 10%).
- Another factor is project profitability. If the

project can be clearly demonstrated to be profitable in say 10 years, then there would be little point in running the analysis for 30 years; a shorter project life (say 15 years) may be adopted.

- If the capital investment is spread over a number of years (say 10 or more years), this may necessitate using a relatively long project life or planning horizon.
- Also relevant will be the planning horizon of the decision-maker, and someone who is approaching retirement age may choose to require a short payback period, hence running the analysis for many years is not relevant to them.
- Where the project evaluation is used as part of a case in seeking bank funding for a project, the requirements of the funding body (e.g. a bank for a commercial project) may dictate the number of years for which cash flows need to be estimated.
- If a project has high risk (discussed in the next section) and the decision-maker has high risk aversion, a short relatively project life may be appropriate.

While there is no 'correct answer' as to what project life or planning horizon to adopt for the analysis, a period of 15 – 20 years is likely to be appropriate in most cases. In practice, the project life is usually a somewhat artificial number of years, in that the project will continue to operate beyond this period, and the assets will continue to be used. As long as the payback period has been reached, there is no need to estimate cash flows beyond this number of years if the analysis is used only to make a 'yes/no' decision about whether to implement the project.

Calculating Salvage Values of Capital Assets Acquired in the Project

As noted in Topic 6, often investment projects involve purchase or construction of physical assets (land, buildings, machinery), which continue to have a market value beyond the assumed project life. These assets may in fact continue to be used, and assist in generation of revenue, for many years beyond the period for which we calculated cash flows. We do, however, need to place a value on the additional assets at the end of the assumed planning horizon, so as to include this component of the increase in the firm's wealth in our financial analysis.

Salvage values are normally computed by estimating the decline in market value of assets over the life of the project, and making the assumption that they are sold at the end of the last year of the project life. Note that the decline in value is not the depreciation rate allowed in the calculation of taxable income, because depreciation rates are generally artificially rapid relative to the fall in market value. For example, it may be allowable to write off a tractor for taxation purposes over a period of five

years, yet the tractor may have a working life on 10 or more years.

Two models may be used to estimate market value – a linear price decline or the diminishing balance method. Suppose a tractor is purchased for \$50,000. In Figure 7-1, the market value over 15 years is plotted, following a linear model with fall in value of 10% per year, and a diminishing balance method of 15% per year. In the latter model, the value at the end of each year is 15% of the residual value at the end of the previous year. It is clear that the diminishing balance method provides a more realistic schedule of resale values, allowing for a rapid decline in the first few years, but a continuing salvage value beyond 10 years.

When a capital asset is sold, taxation will normally be payable on the revenue less the book value. If the asset has been 'written off' (has zero book value) through depreciation allowances, all of the sales proceeds would then be treated as taxable income. But suppose a tractor is sold at age three years, and depreciation is only allowed at 20% per year; tax will then be payable on the sale proceeds less the 40% of the purchase price for which no depreciation allowances have been claimed.

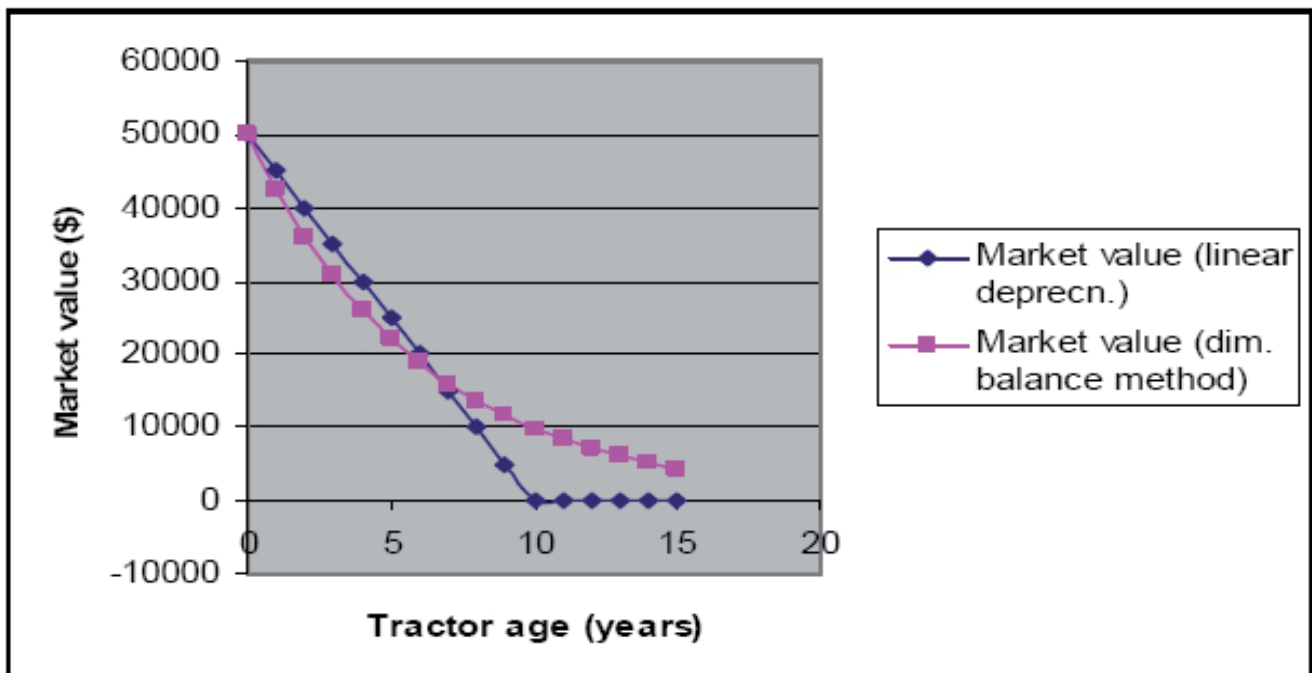
Comparing Financial Performance of Two or More Projects

When evaluating a single project, in general, we can decide whether a project is financially viable on the basis of either the NPV or the IRR, and these two criteria will lead to a consistent accept or reject decision for the project. Some managers and other business people prefer a rate of return measure rather than an absolute payoff measure. In general, both criteria are often calculated, because they do provide different information – the NPV predicts the increase in the firm's wealth while the IRR provides a rate of return measure. It should be kept in mind that the IRR can occasionally have conceptual and computational problems, which can be detected by examining the NPV profile.

For some investors, the payback period is also an important consideration, though this is not generally an issue when deciding whether to accept a forestry investment because the payback period is inevitably the harvest age.

When comparing the desirability of two or more mutually exclusive projects competing for the firm's resources, the NPV and the IRR do not always lead to a consistent indicator or the better project. The relevant approach differs between types of projects, e.g. asset expansion, replacement or retirement projects.

Figure 7.1 Comparison of linear and diminishing value models for tractor resale value



Comparing mutually exclusive projects with size or cash flow timing disparities

The ranking of projects according to NPV and IRR can be inconsistent when there are major differences in the magnitude of cash flows. For example, consider two projects with the following cash flows.

Project	Year			NPV	IRR
	0	1	2		
Project A	-20,000	0	30,000	5,720	22%
Project B	-5,000	0	10,000	3,573	41%

Here Project A, being a larger project, has a larger NPV, but the IRR is only about half of that of Project B. Similar examples of inconsistent rankings can be devised for projects of similar cash flow magnitudes and the same project lives, where one generates mainly early cash inflows and the other generates most of the cash inflows near the end of the project life. In general, the project with the highest NPV is considered the superior project, because it adds the most to the firm's wealth.

Comparing projects with unequal lives

Often two projects will have different project lives, and this can make the comparison of financial performance difficult. An important example is that one tree species may have a much greater NPV but also longer rotation than another species. For example, suppose a mahogany plantation has a 20-year rotation and an NPV of \$40,000/ha, and a gmelina plantation has a harvest age of 8 years and an NPV of \$25,000. If we were to choose the mahogany plantation because of its higher NPV, we would be overlooking the fact that the land where the gmelina is grown becomes available for another use after 8 years. It would be possible to grow 2½ rotations of gmelina or to follow on gmelina rotation with other crops for 12 years, while the mahogany was reaching harvest age.

The way to overcome this problem is to assume the land is devoted permanently to forestry, and that each rotation has identical financial performance to each previous rotation. While the performance of successive rotations will in fact differ, this assumption of identical rotations is usually a reasonable approximation for the financial analysis.

The NPV for a perpetual rotation is can be calculated by the formula:

$$NPV_p = NPV_n + \frac{NPV_n}{[(1+r)^n - 1]}$$

where NPV_n is the NPV for the initial rotation, NPV_p is the NPV for the perpetual rotation, and r is the discount rate. When applied to forestry, this formula defines the site value or land expectation value (LEV) for forestry, i.e. the total earning capacity of the land when committed permanently to forestry.

Suppose for the above example that the discount rate is 8%. As demonstrated in the Table 7-1, the LEV for gmelina is higher than that for mahogany, indicating that growing gmelina is the more profitable investment.

Table 7-1. Perpetual NPV for two tree species with different rotation lengths

Species	Rotation length (years)	NPV of a single rotation	NPV of subsequent rotations NPV/((1+r) ⁿ -1)	Perpetual NPV
Gmelina	8	25,000	29,380	54,380
Mahogany	20	40,000	10,926	50,926

Summary of Discounting Formulae

1. Net present value:

$$NPV = \sum_{t=1}^n C_t (1+r)^{-t}$$

where C_t is the incremental net cash flow in year t , n is the project life or planning horizon, and r is the discount rate.

2. Project balance:

$$B_t = \sum_{i=1}^t \frac{C_i}{(1+r)^i}$$

where C_t is the incremental net cash flow in year t and r is the discount rate.

3. Salvage value, diminishing balance formula: $SV = A(1-d)^n$

where A is the purchase price of an asset, d is the percentage decrease in price in each year relative to the price in the previous year, and n is the project life.

4. Present value of a finite annuity:

$$P = A \frac{1 - (1+r)^{-n}}{r}$$

where A is the annual annuity, n is the number of periods for which the annuity is received or paid, and r is discount rate.

5. Perpetual NPV:

$$NPV_p = NPV_n + \frac{NPV_n}{[(1+r)^n - 1]}_{NPV}$$

where NPV_n is the NPV for the initial rotation, NPV_p is the NPV for the perpetual rotation, and r is the discount rate.

8. Project Evaluation Under Uncertainty

In the field of finance, risk usually refers to the probability of a loss of money (downside risk). Statistical measures of risk in finance and economics also include better (upside) risk. When dealing with risk, probabilities are often used, e.g. 75% chance of earning \$0.5 to \$1 M, 25% chance of earning less than \$0.5 M. Risk arises when probabilities of all outcomes are known, e.g. based on past records, as could apply to rainfall events. Uncertainty refers to the situation when empirical probabilities of outcomes are not known, e.g. when there is no history (in terms of relative frequencies) to draw upon.

In practice this distinction is largely irrelevant. The term risk is used in everyday conversations to refer to any situation involving the possibility of an undesired outcome (which means only downside risk), whether or not probabilities are known. It is rare in a real-world business environment, other than the gaming table, for probabilities to be known. Hence in practice the terms 'risk' and 'uncertainty' tend to be used interchangeably.

Qualitative methods involving judgment are sometimes used to identify risks, e.g. the risk that some catastrophic event may occur, e.g. the risk to tourism from an outbreak of SARS disease. The following discussion focuses on quantitative methods for taking risk account in financial evaluation of projects. Methods of project analysis under risk include:

1. Risk-adjusted discount rate (RADR)
2. Certainty equivalents (CE) for project cash flow variables
3. Sensitivity analysis
4. Breakeven analysis
5. Scenario analysis
6. Risk or venture analysis

The first five of these are now discussed, while the fifth, which involves attaching probability distributions to cash flow variables, will be covered in Topic 11.

The Risk-Adjusted Discount Rate (RADR)

Suppose in the formula

$$NPV = \sum_{t=1}^n \frac{C_t}{(1+r)^t}$$

for NPV — the term r represents the risk free discount rate.

This could be replaced by an NPV formula

$$NPV = \sum_{t=1}^n \frac{C_t}{(1+k)^t}$$

where k is the risk adjusted discount rate.

Conceptually 'k' has three components:

- (i) A risk free rate (r) to account for the time value of money;
- (ii) An average risk loading (u) to compensate investors for the fact that the company's assets (or investments) are risky. This, in other words, is a risk loading to account for the business risk of the firm's existing business, being the average risk loading for the firm.
- (iii) An additional risk factor (a) which could be zero, negative, or positive, to account for the difference in the risk between the firm's existing business and the proposed project.

'k' may be expressed as the sum of these three components, i.e. $k = r + u + a$.

The risk-free discount rate ' r ' is the rate which could be obtained on government bonds or insured bank term deposit, which have a similar term (duration) to the project.

The average risk loading for the firm ' u ' is the firm's weighted average cost of capital. The WACC may be used as the firm's risk adjusted discount rate RADR (equal to $r + u$). The cost of capital is rate of return required by investors in the firm's debt and equity. The higher the risk of the activities of the firm, the higher the cost of capital. The cost of capital is weighted average of the components of the project funds. For a private firm, these could include accumulated savings and debt. For example, for a public (listed) company the components could include ordinary shares, preference shares, and debt.

The additional risk factor for the project may be greater than or less than the WACC. If the project has a similar risk level to the firm's other activities, then ' a ' is zero. The project loading is usually determined subjectively. We could for example, add two or three percentage points to the WACC for a project with high risk.

Certainty Equivalents of Project Cash Flow Variables

In the RADR method, we adjust the denominator in the NPV formula, i.e. ' r ' is replaced by ' k '. By contrast, the certainty equivalent (CE) method works by adjusting the numerator of the basic NPV equation by including a weighting factor on the net cash flow for each year, ' b_t ', i.e.

$$NPV_{ce} = \sum_{t=1}^n \frac{b_t C_t}{(1+r)^t}$$

The uncertain cash flows are first converted into their certainty equivalents using CE coefficients. These certainty equivalent cash flows are then discounted by a risk-free rate.

A certainty equivalent may be defined as the certain amount we would be willing to accept in exchange for an expected uncertain cash flow. For example, if the expected uncertain cash flow in the first year of the project is \$20,000 and if, in exchange of this, we are prepared to accept \$15,000 with certainty, then the certainty equivalent of uncertain \$20,000 is \$15,000. The CE coefficient 'bt' in this case is 0.75 (i.e. $15,000/20,000$).

Sensitivity Analysis with Respect to Cash Flow Parameters

Sensitivity analysis, which is more frequently used than the RADR or CE methods, involves testing how performance criteria vary in response to changes in the levels of cash flow parameters. The project evaluation is first carried out with what is regarded as the best estimate (best-bet value, most likely value) of all of the cost and revenue parameters. Then, for each parameter the value of which is considered uncertain, higher and lower values are selected, and the DCF analysis is repeated to determine how sensitive NPV is to the change. This analysis reveals how much the performance criterion (usually NPV) changes when the level of each parameter is changed. Note that the parameter values are usually adjusted individually, not in combination.

In that project revenue is often highly uncertain, the level of the annual project revenue (or some component of it) is usually included in the parameters varied. Forecasting techniques are sometimes used to predict future product prices, and product price is a typical candidate parameter for sensitivity analysis.

Often three points are taken for levels of each parameter, which can be labeled pessimistic, modal (referring to a 'mode' or middle value) and optimistic. A higher than expected price or lower than expected cost would be an optimistic estimate. Typically fixed percentage adjustments are made to parameter levels, say $\pm 20\%$ or $\pm 30\%$ relative to the best estimate. An alternative it to use subjective confidence levels, e.g. one standard error below and above the best-bet levels (corresponding to about the 68% confidence interval) or two standard errors (95% confidence interval).

If a consistent adjustment (say in percentage terms) is made to the level of each parameter, then it becomes possible to rank the parameters in terms of their impact on NPV, and declare which are the parameters for which the level of NPV is most sensitive. This information may lead to further efforts to estimate the levels of critical parameters.

Breakeven Analysis

Breakeven analysis is similar to sensitivity analysis, except that the level of each parameter considered uncertain is adjusted to determine the point at which the project breaks even, i.e. has an NPV of exactly zero. If the breakeven level of a parameter is near the best-bet level, then there will be concern about the financial viability of a project.

Scenario Analysis

In scenario analysis, the parameter levels are adjusted in combination, i.e. as a set of values. We may for example take the most likely set, the pessimistic scenario (where all parameters are set at adverse levels) and the optimistic scenario (where all are assigned favourable levels). Usually, only a few parameters are varied in this way, these being the parameters to which NPV is most sensitive or the ones which have most uncertain levels. Some care needs to be taken in applying breakeven analysis, because the estimated financial performance under the alternative scenarios can vary greatly, from a large negative NPV in the pessimistic scenario to a huge positive NPV in the optimistic scenario.

9. Performing Sensitivity, Breakeven and Scenario Analysis in Excel

The various tests on the sensitivity of the model to parameter levels, singly and in combination, are readily accomplished using Excel. The steps for the three types of tests area set out below, for the data from Topic 5. To restate the example, a project requires an immediate capital outlay of \$25,000, generates annual revenues of \$15,000 and has annual costs of \$4000, for three years.

Performing a Sensitivity Analysis

Sensitivity analysis may be conducted with respect to the three annual cash flow aggregates (capital outlays, project revenue and operating costs). Often more detailed cash flow information would be available, such as product price and production level, and these more specific parameters would be used in the sensitivity analysis.

The sensitivity analysis is carried out for the above cash flow data by setting up three one-way tables, stacked vertically, as illustrated in the following screen shot. As before, a heading is first set up, in this case 'Sensitivity analysis'. Three levels of capital outlays are then set up, in cells D25 to F25. The first entry is the best-bet estimate of \$25,000 placed in cell E25. The two extremes are then set up as 30% lower and 30% higher than this best-bet level. That is, the optimistic level is entered in cell D25 as '=E25*0.7', and the pessimistic level is entered in cell F25 as '=E25*1.3' in cell F25. The performance criterion is then entered in cell C26, by typing and '=' sign in this cell then pointing and clicking on cell B20, which will cause the number 3348 (the NPV in dollars) to appear in this cell. The contents of cell C26 are apparent in the data entry window on the right of the fx symbol, but cannot be seen in cell C26, because this cell has been hidden (by giving it a colour of white). Next, the name 'Capital outlays (\$)' is entered in cell B25.

The same approach has been adopted for the other three one-way tables making up the sensitivity analysis table. The NPV figure of 3348 has again been hidden in these tables. Finally, lines are entered at the top and bottom of the sensitivity analysis table.

Note that the optimistic levels are higher values for project revenue (here the optimistic revenue is \$19,500) whereas optimistic levels are lower capital land operating costs (\$17,500 and \$2800 respectively). It is clear from inspection of the sensitivity analysis table that NPV is most sensitive to annual project revenue, falling to \$-8249, and least sensitive to operating costs, remaining positive for the pessimistic level of \$2800 per year.

	A	B	C	D	E	F
3	Cash flow parameters					
4						
5	Capital outlay (\$)	25000				
6	Project revenue (\$)	15000				
7	Operating costs (\$)	4000				
8	Discount rate	8%				
9						
10	Cash flow table					
11						
12	Year	0	1	2	3	
13	Capital outlay	25000				
14	Project revenue		15000	15000	15000	
15	Operating costs		4000	4000	4000	
16	Net cash flow	-25000	11000	11000	11000	
17						
18	Performance criteria					
19						
20	NPV(\$)	3348				
21	IRR (\$)	15.3%				
22						
23	Sensitivity analysis					
24						
25		Capital outlay (\$)		17500	25000	32500
26				10848	3348	-4152
27						
28		Project revenue (\$)		10500	15000	19500
29				-8249	3348	14945
30						
31		Operating costs (\$)		2800	4000	5200
32				6441	3348	256

Figure 9.1 Performing a sensitivity analysis in Excel

Performing Breakeven Analysis

To perform breakeven analysis with respect to the three parameter values, place the cursor on a convenient cell near the top of the spreadsheet, say cell D5. Then click on Tools, and then Goal Seek. A dialogue box will appear, with the cursor on the top cell, to the right of the caption 'Set cell:'. Now click the cursor on the NPV to replace the contents of this window by \$B\$20. Next click on the next cell, immediately on the right of 'To value:', and enter a zero in this cell. Next click on the final line, on the right of 'By changing cell:', and click on the capital outlay figure of 25,000 (i.e. click on cell B5). This stage is illustrated in the following screen shot.

Next, then click on 'OK'. The value in cell B5 will now change from 25,000 to 28,348, meaning that the capital outlay could increase to \$28,348 and the project would still cover costs. Finally, click on the 'Cancel' button below the OK button to restore the capital outlay figure to 25,000. The same procedure can be carried out for the other two cash flow parameters, with the breakeven level being recorded for each in turn.

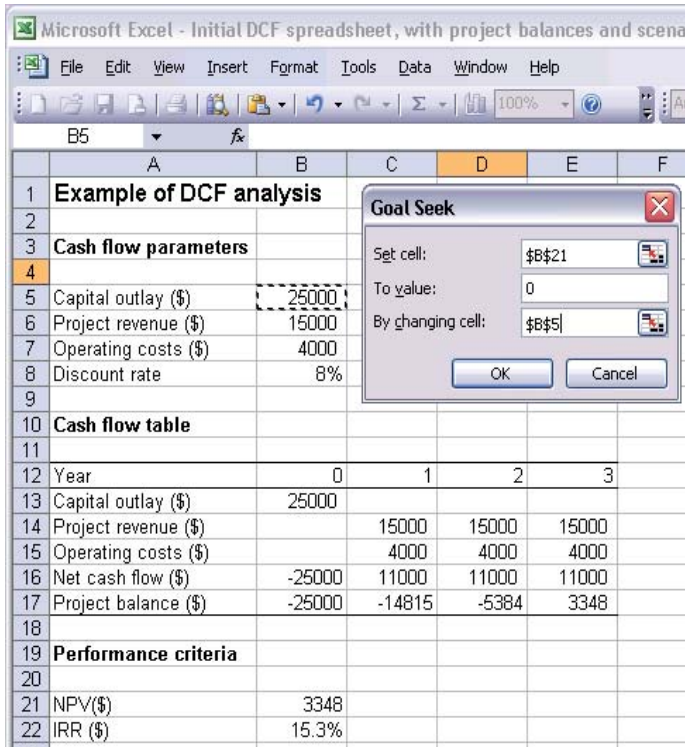


Figure 9.2 Performing a Breakeven analysis in Excel

Performing Scenario Analysis

Suppose we want to examine how the NPV and IRR will change under more optimistic and more pessimistic combinations of levels of the four parameters in the spreadsheet (the three cashflow parameters and the interest rate). The required steps are as follows:

1. On the Excel menu, choose Tools, then Scenarios, and a dialogue box will appear, called Scenario Manager, as illustrated below.



Figure 9.3 Scenario Manager

2. Click on Add, and then click on 'Scenario name:', and add the name 'Pessimistic'.

3. Next, click on 'Changing cells:' and then select the cells as 'B5:B8' with the cursor, as illustrated below.



Figure 9.4 Adding a scenario

4. Now click on 'OK' and the 'Scenario Values' window will appear, listing the normal (i.e. best estimate) values of the four parameters. Change the listed values to the pessimistic values – of say 27000, 13000, 5000 and 0.10, as listed in the following screen shot, then click 'OK'. (Note that the discount rate is entered as 0.10 and not 10%.)

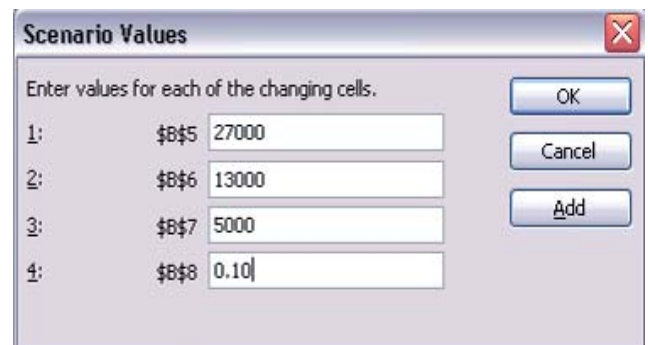


Figure 9.5 Scenario Values

5. The Scenario Manager dialogue box will again appear. Click 'Add' and the Add Scenarios dialogue box will appear. Enter the name 'Optimistic'. Click on OK and the Scenario Values dialogue box will again appear, listing the best-bet parameter values. Enter the optimistic scenario values, say 23000, 17000, 3000 and 0.06. Click on OK.

6. Click on Summary. You will then be asked to indicate the results cells. Select cells B21 and B22 (the NPV and IRR). Finally, click on OK, and the Scenario Summary will appear, on a different sheet to the spreadsheet (Sheet 1) called Scenario Summary, as illustrated below.

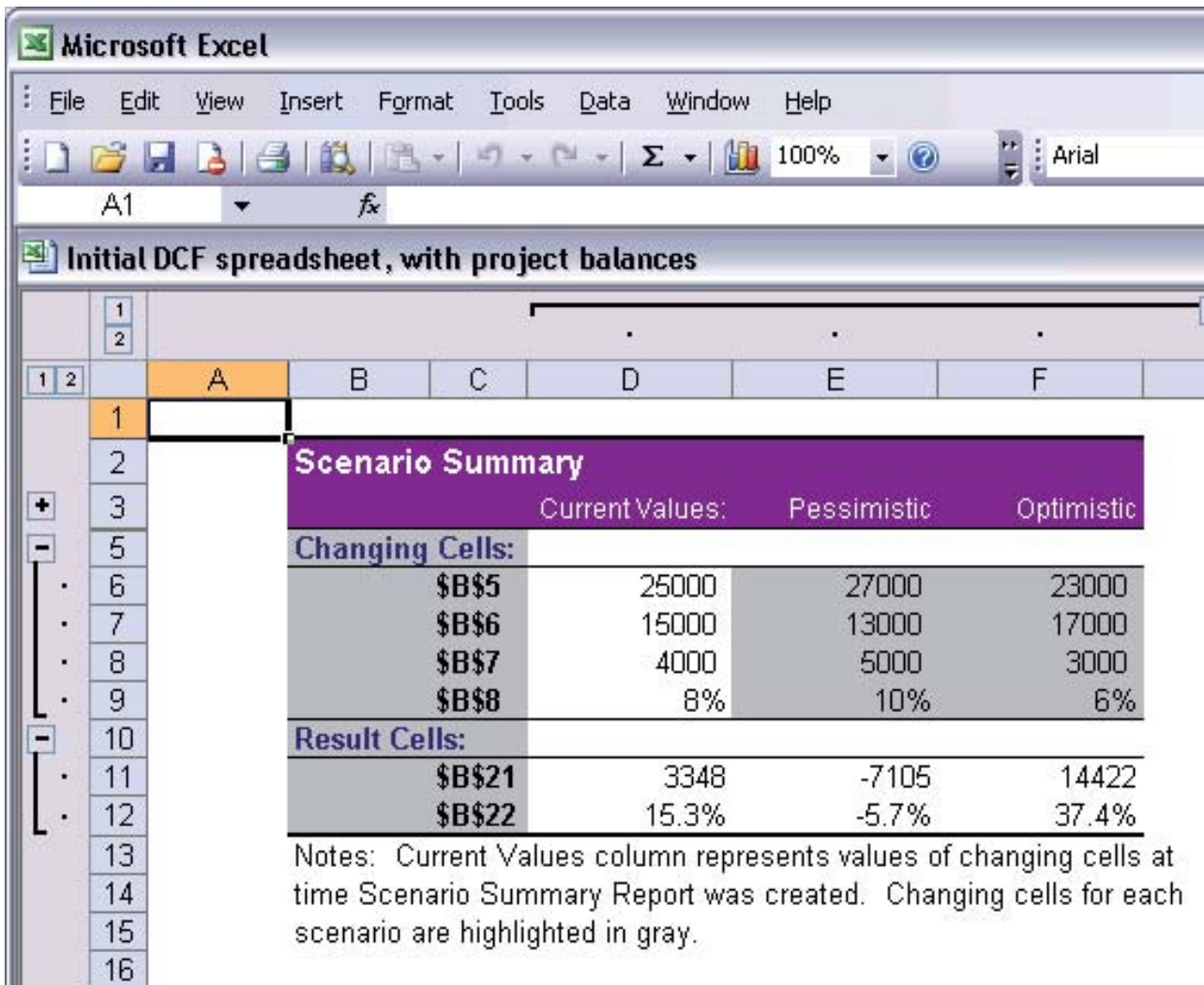


Figure 9.6 Scenario Summary

Note the parameter values which have been chosen in the pessimistic and optimistic scenarios here. In the former, the capital outlay, operating costs and discount rate are increased while the project revenue is decreased; in the latter the project revenue is increased and the other three parameters are reduced.

It will be apparent in the Scenario Summary that although the changes in the individual parameter levels are not great, the change in the overall project performance relative to the best-bet parameter levels (or Current Values) is dramatic, with the NPV ranging between a loss of \$7105 and a gain of \$14,422 and the IRR ranging between -5.7% and 37.4%.

Takeaway Task 3

1. When deriving the weighted average cost of capital, under what circumstances should the borrowing rate be adjusted for

- i. taxation?
- ii. inflation?

2. If the nominal interest rate is 15% and the inflation rate is 6%, what is the real interest rate.

3. A firm is planning to finance an investment project using \$200,000 of accumulated savings invested in government bonds earning 6% per year, together with \$300,000 of loan finance for which interest is charged at the rate of 10% per annum.

(a) Determine the WACC if a 'current price' financial analysis is to be performed, and the firm pays income tax at a constant marginal rate of 30%.

(b) Determine the WACC if a 'constant price' analysis is to be conducted, and the company tax rate is 35%.

4. Which of the following factors are in general not relevant cash flow items in investment appraisal:

- i. purchase of machinery items;
- ii. salaries of a company's executive staff;
- iii. costs of transporting logs grown in a forestry project;
- iv. interest payments on loan finance for a project;
- v. raw materials costs;
- vi. depreciation on farm machinery;
- vii. expenditure on seeds and fertilizers;
- viii. sunk costs;
- ix. salvage values of assets acquired for the project.

5. For the project in Q. 3 in Takeaway Tasks 2

- (a) Calculate the project balances, and hence determine the payback period.
- (b) Carry out a sensitivity analysis with respect to capital outlays, operating costs and project revenues, taking plus and minus 30% of best-bet estimates for optimistic and pessimistic levels.
- (c) Determine the breakeven levels of each parameter individually.
- (d) Carry out a scenario analysis in which the level of each parameter is adjusted up and down by 20%.

10. Case Studies in Financial Project Appraisal

This section presents three examples of financial project evaluations, to demonstrate the types of cost and return categories included in the analysis and the way in which spreadsheets are typically set out.

Example 10-1: Upgrading farm machinery

A cotton growing company wishes to evaluate an investment to expand their irrigated cotton plantation area. The expansion will require replacement of three two-row cotton picking machines each three years old and originally costing \$280,000 each. These will be replaced by three new four-row pickers each costing \$400,000. Also, \$500,000 will be spent on leveling new land for furrow irrigation. Annual revenue will increase by \$600,000 and annual operating costs other than labour by \$400,000. The new four-row pickers will reduce the annual labour cost by \$120,000. Cotton pickers can be depreciated for tax purposes at 20% per year for five years (straight line method), and decline in resale value by 12% per year (diminishing value method). The marginal taxation rate is 30%. Set up the table of capital outlays, project benefits, operating costs and net cash flows, for a project life of five years. (No discounting is required.)

Year	0	1	2	3	4	5
Capital outlays (\$1000)						
New pickers	1200					
Salvage value on old pickers	-572.4					
Salvage value on new pickers						-633.3
Land levelling	500					
Operating costs (\$1000)						
OC excluding labour		400	400	400	400	400
Labour		-120	-120	-120	-120	-120
Project revenue (\$1000)						
Production revenue		600	600	600	600	600
Pre-tax cash flow (\$1000)	-1127.6	320	320	320	320	953.3
Taxable Income Increase (\$1000)						
Project operating revenue		320	320	320	320	320
Depreciation allowance		240	240	240	240	240
Salvage value of cotton pickers		572				633
Book value of cotton pickers		336				0
Change in taxable income		316	80	80	80	713
Extra tax payable (\$1000)	0	95	24	24	24	214
Net cash flow (\$1000)	-1127.6	225	296	296	296	739
Net present value (\$1000)	205.3					

Example 10-2: Installation of a finger-jointing line in a timber mill

A timber processor is considering installing a finger jointing line, to increase output of sawn and dressed softwood timber. The project would involve purchasing new equipment to dock defects in sawn timber, and to join short lengths into a saleable product. The timber processor mills 30,000 m³ of roundlog timber per year (48 working weeks), log supply being assured by a long-term contract with a plantation owner. The current sawn timber recovery rate is 46% of the roundlog timber. The FJ machine would allow the recovery rate to be increased to 50%, with the additional timber being made into mouldings for the housing industry.

The defect docking and finger jointing equipment can be obtained from a European manufacturer, at a cost of \$2.2 million, including delivery, installation and staff training. A new building will be required, at a construction cost of \$200,000. An overhaul of the defect docking and finger jointing equipment is expected to be needed every five years, at a cost of \$200,000, which will take the line out of operation and interrupt output of finger-jointed timber, for four weeks, including time for resetting and testing.

Five extra staff will be required to operate the defect docking and finger jointing line, and handle the additional administrative load, at an average wage rate of \$900 per person per week, plus 20% on-costs. Additional electricity for the FJ line is expected to cost \$2000 per week, and repairs and maintenance (excluding major overhauls) are expected to cost \$50,000 per year.

The mouldings are sold as 3 m lengths with cross section 10 cm by 1.5 cm. The market is sufficiently large to absorb the additional sales quantity, at a mill-door price of \$6 per 3m length.

The resale value of the FJ machine declines by 8% per year on a diminishing value basis (i.e. the value at the end of each year is only 92% of the value at the beginning of that year). For tax purposes, the firm may depreciate the new plant at a rate of 20% per year for five years (straight line method). Tax on net taxable income is paid at the rate of 30 cents in the dollar.

The timber processor has \$600,000 in accumulated funds which can be devoted to the project (currently earning 7.75% per year), and is able to borrow the balance of the purchase price at an interest rate of 11%. The annual inflation rate is 2%.

N17 =N5*(1-F19)^15

Minor project 06 spreadsheet

	A	B	C	D	E	F	G	H	I	J	K	L	M	N
1	Minor Project 2006 - Finger jointing investment project													
2														
3	Physical parameters							Discount parameters						
4														
5	Annual log throughput (1000 m ³)					30		Total outlay on plant and equipment (\$1000)						2400
6	Initial sawn timber recovery rate (%)					46%		Extra annual volume of mouldings produced (m ³)						1200
7	New sawn timber recovery rate (%)					50%		Number of mouldings per cubic metre of timber						322.32
8	Moulding cross section (cm ²)					15		Total annual number of mouldings						266867
9	Moulding length (m)					3		Revenue from mouldings (\$/m ³)						1333.3
10	Extra number of employees					5		Total revenue from mouldings, normal year (\$1000)						1500
11														
12	Financial parameters													
13														
14	Outlay on defect docking and FJ equipment (\$1000)					2200		Total revenue from mouldings, overhaul year (\$1000)						1464.6
15	Outlay on new building (\$1000)					200		Extra annual labour cost (\$1000)						280.8
16	Price of mouldings (\$/length)					6		Extra annual electricity cost (\$1000)						96
17	Cost of a plant overhaul (\$1000)					200		Weighted average cost of capital (%)						7.13%
18	Annual R&M cost of new plant (1000)					50		Discount rate (%)						5.03%
19	Fall in plant resale value (dim. Bal. method)(%)					0%		Working capital requirement (\$1000)						660
20	Weekly wage rate (\$)					900		Salvage value of plant and equipment (\$1000)						607
21	On-cost rate (%)					20%								
22	Extra weekly electricity cost (\$1000)					2								
23	Amount of equity funds (\$1000)					600								
24	Opportunity cost of the firm's savings (%)					7.75%								
25	Amount of loan funds (\$1000)					1800								
26	Borrowing rate (%)					11%								
27	Amount of funds to be borrowed (\$1000)					800								
28	Company tax rate (%)					30%								
29	Inflation rate (%)					2%								

Example 10-3: Financial evaluation of two-species plantation mixture

A consulting company has used the Delphi survey of forestry experts to identify an appropriate silviculture (tree growing) system. They recommend that trees be planted at a density of 660 stems per hectare. It is expected that extensive weed control will need to be undertaken in the first year, with further weed control required in the second and third year. Pruning of the trees to ensure good form will be required in years 2, 4 and 6. It is also recommended that each pruning event be certified by an external party because this will increase the likelihood of being able to obtain a premium price for knot-free wood. A non-commercial thin is required at year 8, at which time 320 trees will be removed.

The estimated project costs and revenue are set out in the following tables, followed by the DCF spreadsheet.

Main cash flow categories and timing

Cashflow category	Nature of cashflow	Timing (yr)
1. Establishment (capital) costs	Planning and design	0
	Incidental clearing	0
	Site preparation and cultivation	0
	Cover crop establishment	0
	Pre-plant weed control	0
	Cost of plants	0
	Planting and refilling	0
	Post plant weed control	0
	Fertilizer	0
	Fencing	0
2. Maintenance costs	Post plant weed control (1)	1
	Post plant weed control (2)	2
	Post plant weed control (3)	3
	First prune(plus certification)	2
	Second prune (plus certification)	4
	Third prune (plus certification)	6
	Thinning – non commercial	8
3. Annual costs	Protection and management	
	Land rental (if applicable)	
4. Cash Inflows	Thinning revenue	17
	Revenue from poles	26
	Revenue from 1st harvest	34
	Revenue from 2nd harvest	60

Capital outlays by year

Cost group	Nature of cash outflow	Timing (yr)	Cost (\$/ha)
1. Establishment costs	Planning and design	0	74
	Incidental clearing	0	158
	Site preparation and cultivation	0	265
	Cover crop establishment	0	88
	Pre-plant weed control	0	92
	Cost of plants	0	450
	Planting and refilling	0	645
	Post plant weed control	0	540
	Fertilizer	0	83
	Fencing	0	560
	Sub-total		2955
2. Maintenance Costs	Post plant weed control (1)	1	1300
	Post plant weed control (2)	2	800
	Post plant weed control (3)	3	200
	First prune(plus certification)	2	800
	Second prune (plus certification)	4	800
	Third prune (plus certification)	6	800
	Thinning – non-commercial	8	500
3. Annual costs	Protection and management		40
	Land rental		0

Project revenue

Activity resulting in cash inflow	Year of harvest	Density (sph)	Yield (m3/ha)	Stumpage (\$/m3)	Revenue (\$1000)
First thinning	17	170	170	\$30	\$5,100
Second thinning (poles)	26	85	–	\$148/pole	\$12,580
1st harvest (sawlogs)	34	42	100	\$200	\$20,000
2nd harvest (sawlogs/veneer logs)	60	43	270	\$300	\$81,000

As evident in the following table, a constant price (real price) analysis has been conducted – for example the annual protection cost is clearly the same for each year, and is not inflated over time. Looking at the financial performance criteria, the IRR is almost 7% and the NPV is close to zero. In other words, this project would be financially viable if the weighted average cost of capital, after tax, was less than about 7%.

11. Risk or Venture Analysis

Risk analysis is a specific type of a broader group of techniques known under the general heading of systems modeling and simulation. Proponents of the systems approach think of a system as a group of interdependent objects, which interact to perform some particular function. In other words, any system consists of a number of interrelated and interacting parts; further, these parts should not be studied in isolation but rather in the context of the overall system and its complex interdependencies. The whole is more than just the sum of the parts. Any change to one part of the system may cause unexpected changes elsewhere, so a holistic view must be adopted to study the system and its management. This is a contrasting philosophy of research to the reductionist approach of examining specific components in isolation, which is often adopted by scientists.

A challenging task in systems modeling is to identify the boundaries, variables and relationships of the real system, sometimes called systems analysis. The systems approach typically requires construction of an algebraic or abstract model of the real system under study, and programming this model to simulate or mimic the behaviour of the real system over time. The model may be deterministic (assuming certainty) or stochastic (with uncertainty built in). Some form of validation of the model to ensure that it accurately mimics the real system is desirable. In practice, confidence is often built up in a model over time, as it proceeds through a number of prototypes and is refined in response to feedback from early users. Once the model is judged to be acceptable, it is then used to perform computer-based simulation experiments, to predict how the real model would behave under particular management policies. If a stochastic model is used, then some form of replication is required in the design of the simulation experiments.

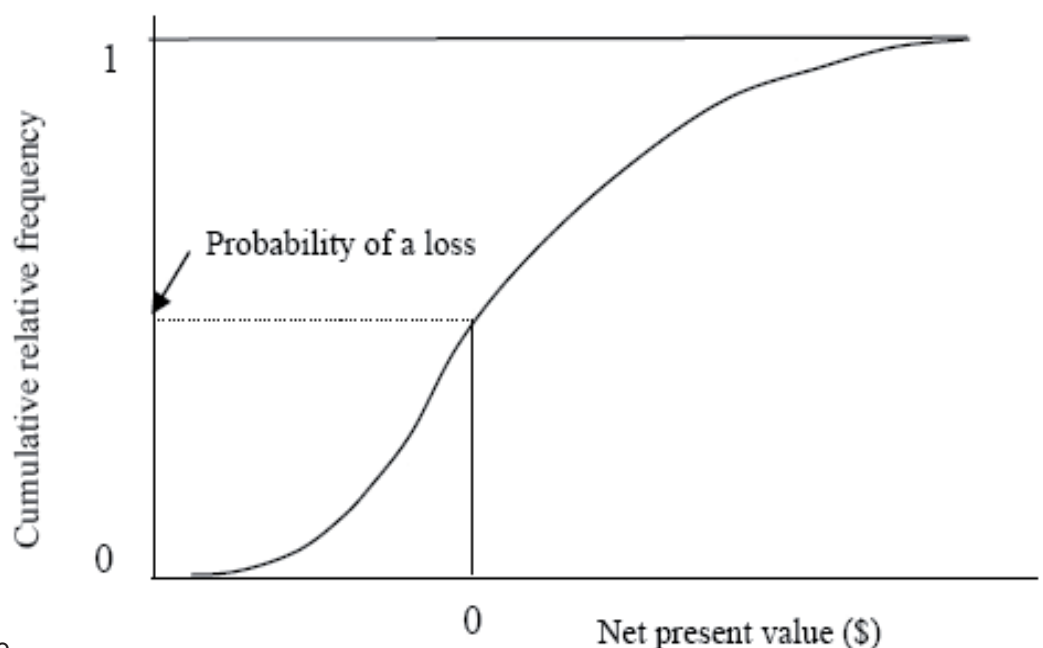
In business and economics, we frequently create models, or abstract, simplified and typically symbolic representations of real business or economic systems. In the specific application of the systems approach to project evaluation, the system under study is the project, and the systems model is the model of incremental cash flows over time.

Nowadays, financial models take the form of Excel spreadsheets. This model includes a number of financial relationships, e.g. net cash flow = project benefits less capital outlays less operating costs.

Normally, financial models for DCF analysis are deterministic models. However, in risk analysis a stochastic model is adopted. In this form of simulation, the uncertainty in the system is simulated through the Monte Carlo sampling. The Monte Carlo method refers to a random process which may be likened to spinning a roulette wheel, to generate some of the values of the cash flow variables. To undertake this form of sampling, we attach probability distributions to parameters determining the annual net cash flows. There are a wide variety of probability distributions which could be used. Four examples of probability distributions are presented in Figure 11-1. The distributions are often estimated on a subjective basis, drawing on the opinions of an expert (i.e. someone who is familiar with the system under study).

Once probability distributions are estimated, we generate random values from these distributions through synthetic sampling. These values are then entered into the calculations to derive a project performance criterion, usually the NPV. This sampling is performed for each year of the planning horizon, and the NPV derived. The process is repeated for each replicate in the risk analysis, to generate a number of sample observations of the NPV for the particular investment system, i.e. for the proposed project.

Figure 11.2 Typical shape for a cumulative relative frequency curve

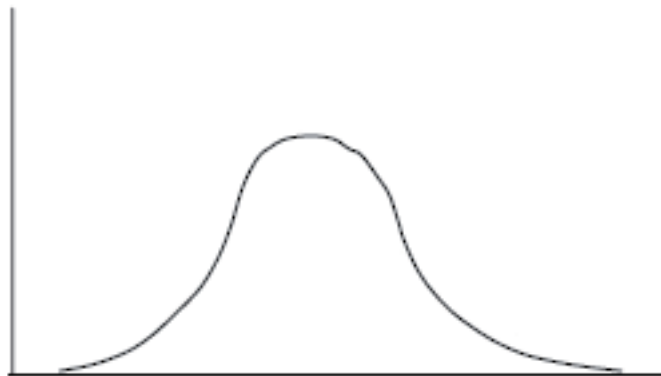


Once all the NPV observations are generated, these are ranked into ascending order, and converted to cumulative relative frequencies, and the relative frequency distribution is graphed. If there are only a few replicates of the NPV calculation, the cumulative relative frequency graph will be rather erratic in form. But if the number of replicates is sufficiently large, a smooth curve will be obtained, in Figure 11-2, and the relative frequencies can be considered as estimated probabilities.

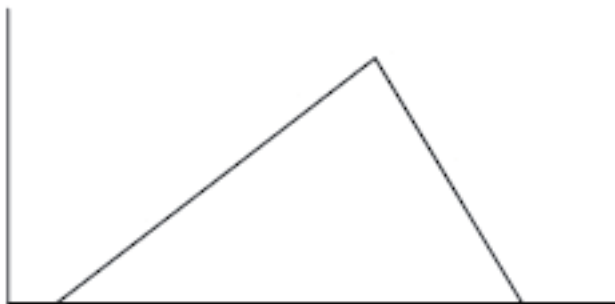
Lower class limit	Upper class limit	Probability
200	400	0.1
400	600	0.6
600	700	0.3

Figure 11-1. Some examples of probability distributions

Empirical distribution, setting out frequency classes and probability of values occurring in each class



The normal distribution – a continuous distribution with a range of $-\infty$ to $+\infty$



The triangular distribution – which can be specified in terms of three values (pessimistic, modal and optimistic) values



The uniform distribution – where a range can be specified, but not which values are most likely

From the graph, it is possible to read off estimates of the probabilities of the project achieving an NPV of various levels. The value of the NPV is read off the horizontal axis, and the corresponding value on the vertical axis is the probability of this level of NPV. Where the NPV is zero, the corresponding point on the vertical axis is the probability of breaking even on the project.

This form of analysis provides more information about project performance than sensitivity analysis. In sensitivity analysis, the possible values which the NPV could take are identified. Risk analysis goes a step further, and provides estimated probabilities of achieving a particular particular ranges of payoff levels. The downside is the difficulty of estimating the probability distributions for the cash flow parameters. Another problem can be communicating the results to someone who does not understand the concepts involved (perhaps your boss!).

Computer Implementation of Risk Analysis

Several computer packages are available for carrying out risk analysis, the best known being @RISK. This is a rather expensive package, but is recommended where serious risk analysis work is to be undertaken. Fortunately, Excel has some functions to assist in sampling, and graphics capabilities for presentation of the cumulative relative frequency curve, and with a little patience risk analysis can be carried out using Excel.

Random numbers from a uniform distribution between zero and 1 are generated in Excel by entering '=RAND()' into a cell. These random numbers are obtained by taking two large numbers, dividing one into the other, and then multiplying the divisor by a third large number. This process is repeated to generate a chain of random numbers, with a long cycle before a repeat set of numbers commences. Once the seed or initial number is chosen, the entire series of numbers is predetermined, hence these are more precisely called pseudo-random numbers.

The random numbers from a uniform 0 – 1 distribution are used to generate random numbers from any target distribution. For example:

- values from a normal distribution with a mean of A and a standard deviation are generated by entering '=NORMINV(RAND(), A, B)'.
- values for a uniform distribution over the range A to B are generated by the Excel statement '=A + (B – A) RAND()'.

12. Setting Up a Risk Analysis Model in Excel

This topic presents a worked example of risk analysis, for a smallholder upland farmer. Each of the above steps is demonstrated, by way of an Excel spreadsheet.

Example of risk analysis

An uplands smallholder grows wet season corn crops which are planted in May and harvested in October, producing enough corn for the farm household plus one tonne of surplus corn which is sold in the local market. Corn prices are typically lowest at harvest time, and increase until early dry season crops are harvested in March. He can sell the excess corn at harvest, but is considering setting up storage facilities and holding corn for four months to attract a higher price, and has come to you for advice on whether this would be profitable. Storage facilities – basically shelter hanging space – will cost \$200 to set up, and will have a life of three years. The variable costs of corn storage are 2.5 cents/kg per month, mainly for protection from pests. The increase in grain price in the four months after harvest is uncertain, and varies from year to year. A market expert has estimated that the price increase follows a normal distribution, with a mean of 20 c/kg and a standard deviation of 10 c/kg. Some corn is likely to be lost through deterioration during storage. The smallholder thinks that losses of anywhere in the range of 5% to 15% are equally likely. The cost of capital to the smallholder is 14%. Develop a risk analysis model, in which corn storage is simulated over a three year period. Carry out 30 replicates of the risk simulation, and derive the cumulative relative frequency for the NPV of the corn storage project. What would your advice to the smallholder be?

Carrying out the risk analysis

The starting point is the random number generator, which produces numbers from the uniform (0-1) distribution may be obtained through the function '=RAND()'. Excel also has the facility to sample from a variety of probability distributions. The NORM function allows probabilities under the normal distribution to be obtained, while an inverse transformation NORMINV (the opposite or inverse transformation for the normal distribution) allows values of a normal variable to be generated.

Values of a normal distribution for price increase with a mean of 20 and a standard deviation of 10 can be obtained using the cell entry '=NORMINV(RAND(), 20, 10)'. Values for the storage loss from a uniform distribution are obtained by taking the range of the distribution (15% - 5% = 10%), multiplying this by a random number, and then adding the lower value of the distribution (5%).

Storage price and corn price increase and hence incremental revenue are obtained for each of the three years of project life, for each replicate. The NPV is then computed for each replicate. Once the 30 observations of NPV are obtained, these are sorted in ascending order, and then converted to a cumulative relative frequency distribution, which is graphed. The spreadsheet model and the cumulative frequency distribution are presented in the following two figures. From the latter, it is possible to read off estimated probabilities for various levels of estimate NPV. For example, the probability of obtaining an NPV of \$100 is about 0.3 or 30%, and that of obtaining an NPV of over \$200 is about 1 - 0.75 or 25%.

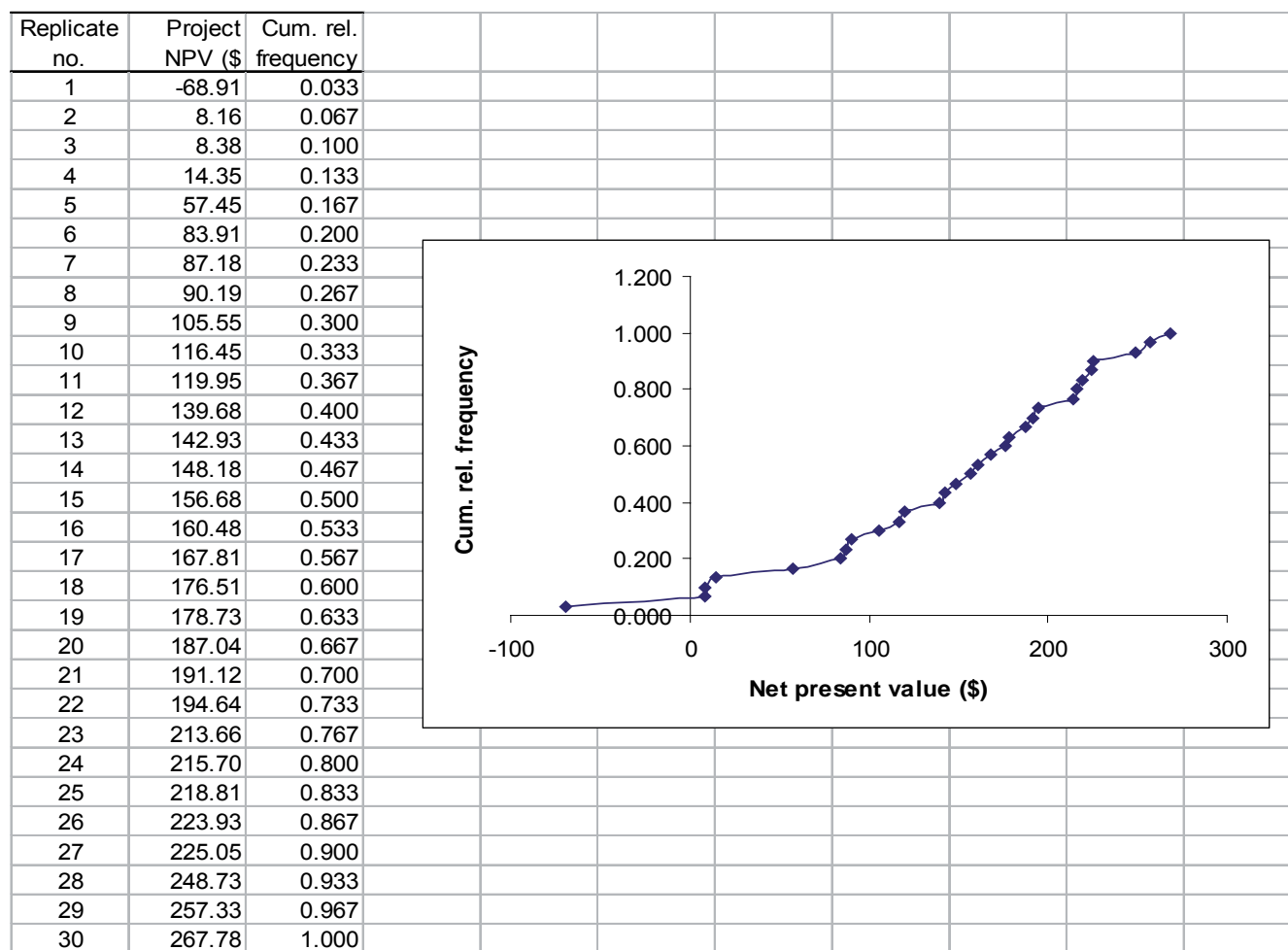
To summarise, the steps in risk analysis are:

1. Identify the project cash flow variables, and estimate their parameter levels, including estimation of the probability distribution parameters for the uncertain variables.
2. For each replicate of the DCF analysis, and for each year of the planning horizon within each replicate, generate random values of the uncertain variables, and hence for each replicate derive an NPV estimate.
3. Arrange the NPV observations into ascending order, and attach cumulative relative frequencies to the NPV observations.
4. Graph the cumulative relative frequency curve of NPV, and hence read off probability estimates for selected NPV ranges.

Figure 12.1 Spreadsheet for carrying out risk analysis of smallholder corn storage decision problem

Corn storage simulation model											
Parameters											
Capital outlays (\$)	200	Mean price increase (c/kg)	20								
Quantity stored (kg)	1000	Std. devn of price increase	10								
Price without storage (c/kg)	20	Minimum storage loss (%)	5%								
Storage period (months)	4	Maximum storage loss (%)	15%								
Storage costs (c/kg/month)	2.5										
		Revenue without storage (\$)	200								
Discount rate (%)	14%	Storage cost (\$/season)	100								
Simulation of net present value											
Replicate	Storage loss (kg)	Price increase, yr 1 (c/kg)	Revenue with storage, yr 1 (\$)	Incremental net revenue, yr. 1 (\$)	Price increase, yr 2 (c/kg)	Revenue with storage, yr 2 (\$)	Incremental net revenue, yr. 2 (\$)	Price increase, yr 2 (c/kg)	Revenue with storage, yr 3 (\$)	Incremental net revenue, yr. 3 (\$)	Project NPV (\$)
1	86.10	35.60	508.16	308.16	18.93	269.31	69.31	22.77	398.05	198.05	257.33
2	103.02	3.25	208.59	8.59	29.58	491.49	291.49	19.12	277.16	77.16	83.91
3	142.28	1.41	183.60	-16.40	7.70	281.51	81.51	15.12	322.61	122.61	-68.91
4	93.46	14.97	317.06	117.06	33.36	471.14	271.14	28.24	351.64	151.64	213.66
5	86.78	22.39	387.12	187.12	11.04	252.34	52.34	34.62	517.63	317.63	218.81
6	144.88	6.89	229.92	29.92	14.20	331.80	131.80	30.26	436.34	236.34	87.18
7	124.31	20.08	350.94	150.94	29.54	420.62	220.62	18.14	297.26	97.26	167.81
8	60.55	24.71	420.06	220.06	38.30	454.70	254.70	22.49	316.68	116.68	267.78
9	136.05	19.71	343.07	143.07	14.35	294.39	94.39	17.14	336.39	136.39	90.19
10	111.24	28.14	427.88	227.88	29.29	380.58	180.58	5.15	206.06	6.06	142.93
11	74.13	27.12	436.27	236.27	4.14	184.36	-15.64	1.61	219.49	19.49	8.38
12	70.81	18.07	353.74	153.74	22.00	355.45	155.45	12.64	275.68	75.68	105.55
13	138.87	21.89	360.69	160.69	5.41	213.30	13.30	28.57	479.26	279.26	139.68
14	147.98	9.49	251.24	51.24	22.40	402.24	202.24	27.24	376.87	176.87	119.95

Figure 12.2 Cumulative relative frequency distribution for smallholder corn storage risk analysis



13. Cost-Benefit Analysis

Like financial project appraisal, cost-benefit analysis involves discounted cash flow analysis of individual investment projects. However, the analysis is from a social (community, taxpayer, public-sector) viewpoint, rather than the viewpoint of the private company or individual. Much of the methodology which has been covered in earlier modules is relevant, but there are important differences. CBA involves a broader evaluation than financial project evaluation, including for example non-market costs and benefits, which are regarded as externalities when conducting an analysis from the viewpoint of the individual firm. That is, we carry out a broad economic as distinct from narrow financial analysis. Sometimes the term social CBA is used, to indicate that the evaluation is from the perspective of all of society. Another term sometimes used is extended CBA, indicating that the cash flow coverage is extended to include for example non-market benefits.

CBA had its genesis in the economic evaluation of public sector watershed management projects involving large public sector outlays, in the USA in the 1960s. There its use was mandatory, and was designed to ensure greater accountability in the use of public funds. A major resurgence of interest in this methodology took place in the 1980s, associated with tighter public sector budgets and increased requirements of agencies to demonstrate the economic viability of their programs, and also with new developments in valuation of environmental and other non-market costs and benefits. The CBA approach is well suited to economic evaluation of large-scale public sector programs.

Cost-benefit analyses are performed for a number of reasons. The analysis may be needed to determine whether a particular program is worthwhile, or to compare alternative ways of carrying out the program, or to compare the payoff from expenditure in a particular project or program with expenditure in other areas. Also, it may be necessary for one department to demonstrate to another (particularly to a Treasury department) that a program should be funded, i.e. to justify the funding.

Cost-benefit analysis is only one of a variety of techniques used by economists. However, it is more than simply an analysis technique. Rather, it provides a framework for applied economic analysis of policy issues, within which survey data collection and analysis, systems simulation, econometrics, non-market valuation methods and other techniques can assist in compilation of cost and revenue data.

Some government-funded project areas to which CBA may be applied include infrastructure projects

(e.g. irrigation, water supply, energy, airport or bridge construction), research projects (or more broadly research, development and technology transfer projects), land titling, livestock dispersal, and environmental protection.

How does this relate to ACIAR projects as a form of investment projects? How would we go about preparing a CBA for an ACIAR project proposal, if required to do so by ACIAR? These projects are funded by the Australian government (though perhaps with in-kind contributions by both collaborating country and Australian researchers), and designed to provide benefits to a number of low-income people in the collaborating country, to 'make a difference' to their lives. Clearly, a social CBA is needed. A number of further complexities arise relative to financial evaluation of private projects. Particular types of cash flows arise in the research, development and technology transfer cycle, and particular evaluation methods are relevant. Also, the evaluation of welfare benefits, particularly to the rural poor, calls for specific evaluation methods. Before discussing these issues, it is useful to review some economic theory underlying CBA.

Cost-Effectiveness Analysis as an Alternative to CBA

An alternative approach to CBA is cost-effectiveness analysis (CEA) in which costs only are estimated in detail. Here, costs may be compared on a unit of physical benefit basis, e.g. dollars spent per beast vaccinated, megalitre of water stored, kilowatt of electricity generated, or cubic metre of furniture timber produced. Many infrastructure projects have clearly defined outputs, which will be more-or-less constant regardless of how they are brought about provided essential design specifications are met, and hence are candidates for CEA. Note however that CBA would be the relevant technique to use when determining whether it is in the national interest to make the infrastructure improvement in the first place. In that project benefits are typically much more difficult to estimate than project costs, if CEA can be used instead of CBA then there may be a large saving in cost and time in project evaluation.

Economic Concepts Relevant of CBA

Cost-benefit analysis has strong theoretical underpinnings in microeconomics and welfare economics. An understanding of some background economic concepts is necessary if the technique is to be used correctly. Situations frequently arise where decisions have to be made about what variables to include in an analysis, and how the variables should

be measured. To answer these questions correctly, it is necessary to understand the economic logic upon which the technique is based.

The role of the economist

Economists typically take an anthropocentric or human-centred approach. Goods and services are valued in terms of what people are prepared to pay for them. The principle of consumer sovereignty is adopted, in which people are regarded as the best judge of what is good for them. This approach implies, for example, that more crop or timber or production, reduced livestock diseases, improved environment or other project outcomes are worthwhile only inasmuch as people derive benefit from them and have willingness-to-pay for that benefit.

Some people reject the anthropocentric perspective, arguing that other perspectives should govern decision-making. One alternative approach is a biocentric approach which would imply that life forms other than humans have rights independent of human goals and aspirations. Another alternative is stewardship, i.e. that humans have a responsibility to maintain biological resources and the environment in good condition for the benefit of future generations. This raises questions of whether man-made capital can substitute for natural capital.

Sometimes, various social, religious and ecological goals are placed ahead of economic rationalism. This should not be of great concern for economic analysis because economists can assist policy-makers by pointing out tradeoffs, to be balanced against other objectives in the political process. Further, if desired their analysis can incorporate these other objectives in the form of constraints placed on the range of options over which optimisation of economic performance can be pursued.

Economists can play an important role by examining the economic implications of various alternative course of action, and pointing out these implications to decision-makers. Decision makers (in this case government) can combine this economic information with other information (e.g. about national expenditure priorities, the likely success in achieving project objectives, the community acceptability of the recommendations) using judgment and intuition to arrive at a decision. In other words, the input of the economics is information to augment other information already held or being gathered by decision makers. Economists provide decision support information. Usually, economists do not make the decision, or take the consequences of that decision. But by pointing out the economic payoffs involved, they can assist managers in government or private enterprise to make better decisions.

Market failure

Market failure is said to occur when too little or too much of a good or service is produced because the

market for the good or service a does not provide the correct market signals to sellers and buyers. When market failure is present, there may be a case for government intervention, to bring about a more socially efficient outcome. An important case of market failure is when an activity generates environmental benefits, but producers are not rewarded for these benefits and have insufficient incentive to produce them. For example, plantation forestry can provide a number of goods and services for society (such as watershed protection, flood mitigation and carbon sequestration) but in general tree farmers are not rewarded for these benefits. CBA can then be applied to estimate the social benefit of the activity (in this case tree farming), to provide the case for government intervention, and to guide government intervention policy (e.g. provision of free seedlings or technical advice, market facilitation, a carbon subsidy).

The Pigou and Kaldor-Hicks criteria

There was considerable debate among economists about criteria by which to judge if a project should be implemented. A principle was put forward by Pigou that a project should be accepted if it makes at least one person better off and no-one worse off. However, this soon became recognized as overly restrictive: in most projects (particularly large government projects) there are invariably winners and losers, so some people will be worse off. A more realistic criterion was devised by Kaldor and Hicks, which states that a project is acceptable if those who gain are potentially able to compensate those who lose and still be better off. This is the criterion generally accepted by governments nowadays. Note that the compensation may not actually take place. When a government decides to build a large dam to store water for irrigation or domestic consumption, there may be a huge battle by the losers to prevent to dam from being constructed or obtain adequate compensation!

Willingness-to-pay and consumer surplus

Economists examine markets for commodities and services in terms of supply and demand relationships (a topic in microeconomics). They usually consider that the most correct measure of community economic wellbeing of producers and consumers in a community or country as a result of a policy change is the so-called economic surplus. This includes the producer surplus (approximating the profits of producers) and the consumer surplus (or consumer 'profit') in a market. A change in the conditions of production (e.g. increased crop or livestock production) will lead to shift in supply of a commodity, with a consequent change in the overall economic surplus.

The laws of supply and demand

The starting point for a discussion of microeconomic theory is the market. In a market, producers and sellers come together to trade in a particular product. An example would be the market for seedlings of timber trees in Leyte province in the Philippines.

For convenience, we will consider a single and homogeneous product (e.g. mahogany seedlings), and ignore marketing costs (advertising, transport, taxes).

In a market, those who supply a good or service come together with those who have a demand for that good. Economic theory asserts propositions or laws' about supply and demand. The law of supply states that the quantity of any particular good or service (say for seedlings of timber trees) an individual producer (nurseryman) will be willing to sell in a particular time interval increases as price increases. This is best illustrated by way of a diagram. In Figure 13-1, price on the vertical axis is graphed against quantity on the horizontal axis. The line labelled S, representing the supply schedule, slopes upward to the right. According to this supply 'curve' or line, a nurseryman would be willing to place some seedlings on the market at low prices, as indicated towards the left hand end of the curve. To justify expanding production and supply, the producer would require higher prices, i.e. price must rise to induce increased supply quantity. At price p_1 a quantity q_1 is supplied; when the price increases to p_2 the quantity offered increases to q_2 .

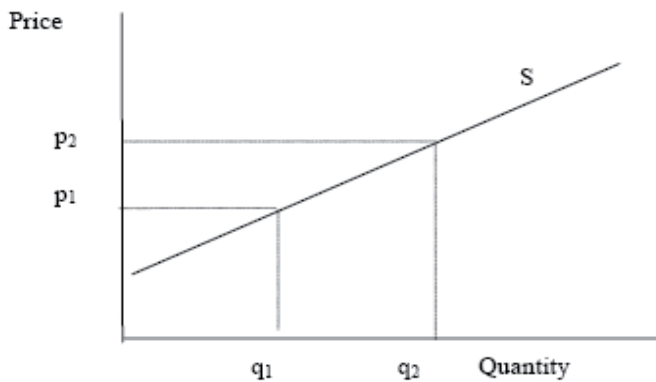


Figure 13.1 An individual producer's supply curve

Economic theory suggests that a producer's supply curve is that producer's marginal cost curve, i.e. the schedule of extra cost of providing an extra unit of production, e.g. an extra seedling for market. The logic is that if the price were sufficient to warrant the extra or marginal cost of producing another unit, it would be rational for the producer to do so.

If production costs were to fall, as would be the case with improved seedling production techniques, the producer could supply the same quantity for a lower market price. Viewed another way, output would increase for the same costs level, i.e. there would be a shift to the right in the producer's supply curve.

The market supply curve for any particular area or district is the sum of the individual producers' supply curves, e.g. the seedling market in a municipality. If there is a shift to the right in the supply schedule for the typical producer, there will also be a shift to the right in the market supply curve. This is illustrated in Figure 13-2, where improved seedling production techniques shift the market supply from S to S1.

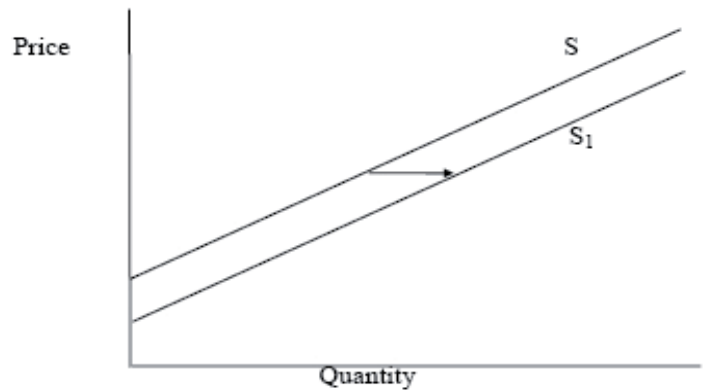


Figure 13.2 Rightward shift in market supply due to improved seedling production technology

The 'law' of demand states that as price of a good or service falls, a consumer will purchase more of it. In the case of the seedling market, the consumer is the purchaser of seedlings, i.e. the smallholder. The increase in demand by an individual consumer arises both because at a lower price the particular good becomes more attractive than substitute goods (the substitution effect), and because as price falls the consumer is able to afford more of it (the income effect). An illustration is provided as Figure 13-3, where the demand curve D implies that quantity demanded increases as price falls, i.e. the consumers demand curve slopes down to the right. This of course means that if price of a commodity such as seedlings or wildlings falls, a consumer will tend to purchase more of it. For example, if price falls from p_1 to p_2 , a consumer's demand will increase from q_1 to q_2 . The market demand curve is the sum of the demand curves of all individual consumers in a market.

Just as the industry supply curve can shift left (decrease in supply) or right (increase in supply), so can the community demand curve. A change in tastes or in incomes could cause a shift. For example, if smallholders developed an interest in growing more dipterocarp tree species, or could afford more dipterocarp seedlings, this would lead to a shift to the right in the demand for these seedlings.

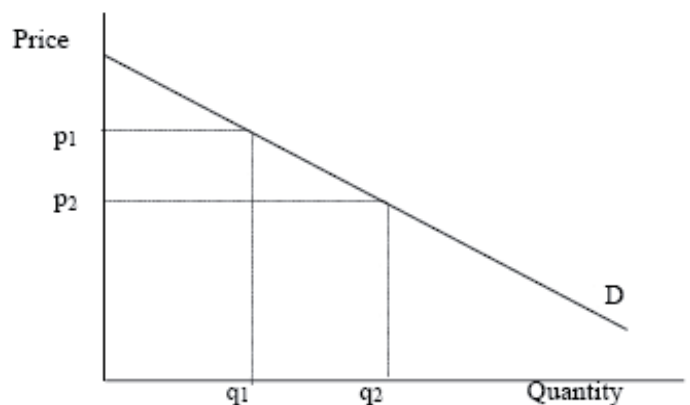


Figure 13.3 Stylized shape of an individual consumer's demand curve or market demand curve

The market supply and demand curves may be drawn on the same diagram, as in Figure 13-4. Where the two curves intersect, the quantity producers are willing to supply and the quantity consumers wish to purchase are equal. The corresponding price, labelled p , is the market clearing price, and there is no unsatisfied supply or demand. At this price, q units are sold.

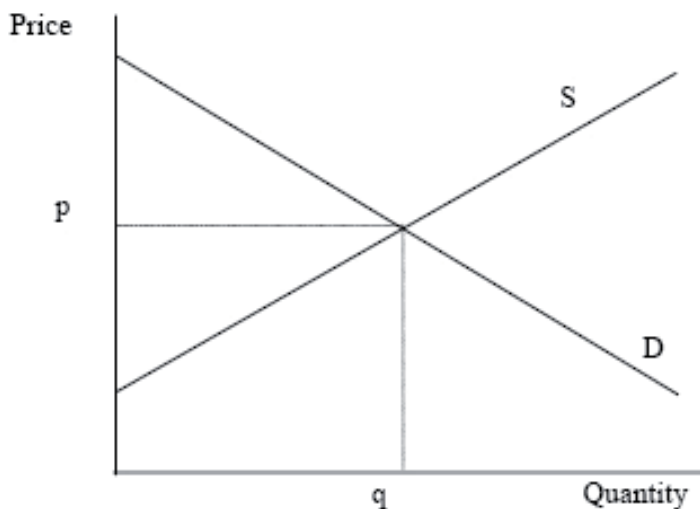


Figure 13.4 Market equilibrium, where supply equals demand

Elasticity of supply and demand

An important characteristic of supply and demand curves is their 'elasticity'. The elasticity of supply with respect to price is the percentage change in quantity supplied for a one percentage point change in price. The greater the price elasticity of supply the flatter the supply curve. The elasticity of demand with respect to price is the percentage change in demanded in a market in response to a one percentage point change in price. Again, elastic demand approximates to a relatively flat demand curve.

Economists distinguish between long-run and short run supply and demand. The long run is the shortest period of time in which producers can expand their production facilities (which could be as short as a year for seedling production). Elasticity, particularly of supply, is likely to be much larger in the long run than in the short run. Obtaining resources (funds, water supply, pots and potting medium) and government approvals would take some time.

Economic surplus

Having covered this rather abstract economic theory, we are now ready to consider the concept of economic surplus, which provides the economic rationale for much of the economic analysis of investment projects. With reference to the aggregate market supply curve of Figure 13-5, since the market price is p , consumers pay this price for all units purchased. However, consumers are not homogeneous in their demand, and some are willing and able to pay higher prices than others. Some consumers would have been prepared to pay a higher amount for the first few units purchased (near the

left-hand end of the demand curve). The area of the triangle under the demand curve but above the price line represents an amount of money consumers save collectively for the quantity of the good traded. This area is known as the consumer surplus or consumer profit. (Note that areas in the diagram represent the product of price on the vertical axis and quantity on the vertical axis, and therefore represent values or amounts of money.)

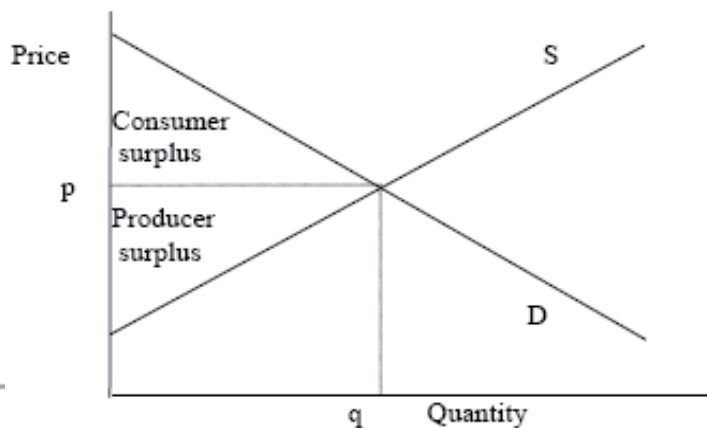


Figure 13.5 Producer and consumer surplus

Consider now the aggregate industry demand curve. Even at very low prices, producers would be prepared to place some goods on the market, particularly the low-cost producers. Provided the price is greater than that at which the supply curve hits the price axis, some supply will be forthcoming. At a somewhat higher price (but still below p), producers would be prepared to supply a larger amount. If producers receive the price p for all units they supply, then they are receiving an amount above that which would have been necessary to call forth supply. The difference – represented by the area of the triangle above the supply curve but below the price line – is the producer surplus. If the supply curve corresponds to the marginal production cost curve, then the area is in fact the profit earned by producers in the market. The consumer surplus and producer surplus together make up the economic surplus. This is a measure of aggregate community gain from a market.

Effect of a shift in supply on economic surplus

Suppose a research project leads to a shift to the right in supply, as in Figure 13-6. What then happens to the producer and consumer surpluses? The shift in supply leads to a new equilibrium price p_1 and quantity q_1 . The consumer surplus clearly is increased, since a new area (between the lines p and p_1) is added. For the producer surplus, an area between the price lines p and p_1 is lost. However, the new producer surplus triangle both has a greater height (the distance between the new intercept on the price axis and p_1) and is longer (up to q_1 rather than q), and so has a greater area, i.e. producer surplus is increased. Overall, there is an increase in economic surplus, or in community welfare.

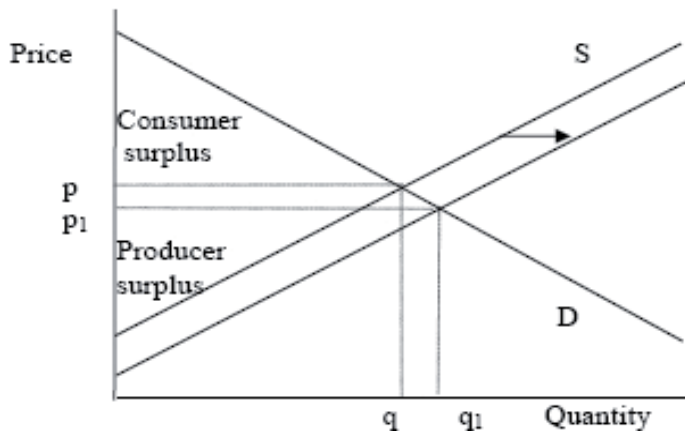


Figure 13.6 Producer and consumer surplus with a shift in supply

The share of the gain from a shift in supply between producers and consumers will depend on the elasticities of supply and demand. If demand is highly elastic (steep demand curve), a large increase in supply will lead to a large fall in price, to the benefit of consumers rather than producers.

Figure 13-6 illustrates a very important point. A decline in nurserymen's production costs leads to a gain or 'profit' not only to producers but also to consumers. In fact, consumers can be the main beneficiaries. This fact is often lost sight of in economic analysis on agricultural projects.

Differences between CBA and Evaluation of Private Sector Projects

There are a number of differences in approach between private (or financial) and social (or economic) project evaluation, some of the main ones relating to:

1. scope of costs and benefits included in the analysis
2. use of 'dilution' factors in relation to research success and technology adoption
3. estimation of non-market costs and benefits
4. identification of stakeholders
5. exclusion of transfer payments
6. the way in which prices are defined
7. relative values of imports versus exports
8. impact on income distribution
9. choice of discount rate

Types of costs and benefits

In CBA an attempt is made to measure not only the financial costs and benefits, but also the wider social and environmental costs and benefits. In this context, a seedling nursery project or a reforestation project could be recognized as having benefits in erosion control in the catchment, wildlife habitat, carbon sequestration, prevention of mudslides, flood mitigation, reducing wear on hydropower generators, and protecting fisheries habitats.

Dilution factors in success of research, development and technology transfer

For a research project, there can be uncertainty that the research will achieve its stated goals, about the success in converting research findings to practical technology (the 'D' in 'R&D'), and the potential number of adoptors and rate of adoption. Some times probability factors will be attached to benefit levels, to allow for underachievement in these areas.

Estimating non-market costs and benefits

Various techniques have been developed, mainly since the early 1980s, for estimation of non-market costs and benefits, and particularly environmental benefits, in terms of consumers' demand or willingness-to-pay. These methods may be grouped under the headings of benefit transfer (from findings of previous studies), revealed preference (from observation of market behaviour) and stated preference methods. Two of the important revealed preference methods are the travel cost method (which is used to value recreation benefits) and the hedonic price method (which applies regression analysis to value components of value in observed sales of real estate or consumer products). Two of the more important of the stated preference methods (where a survey approach is used to elicit consumer willingness-to-pay) are contingent valuation and choice modeling.

Relevant stakeholders

In private analysis, the concern is only with maximizing benefits to the firm, although decisions are constrained by laws and regulations, and by the commercial importance of the firm being regarded as a 'good citizen'. In CBA, it is desirable to take into account at least the main stakeholder groups affected by the project. For example, in a project concerned with the production of commodities, the input suppliers to the firm, all members along the supply chain including the consumers, and the environment may all be considered. For a forestry project, the main beneficiaries could be identified in terms of the timber supply chain and the stakeholder groups gaining from the environmental benefits listed above.

Exclusion of transfer payments

Some payments by producers – notably taxes and subsidies – are really transfers between different members of a community, and do not represent any real gain or loss to society (though administration of these taxes and subsidies may be a real cost). In CBA, transfer payments are regarded as irrelevant cash flow items. Governments typically charge import duties on imported plant and machinery, which is in effect a tax, and this should be removed when placing a value on plant and machinery in CBA.

Relevant prices for CBA

In financial analysis, prevailing or forecast market prices are adopted. However, when applying CBA in cases where there is considerable market distortion, it is desirable to replace these with shadow prices, i.e. prices which would prevail in an efficient or highly competitive market. For example, suppose a developing country has price control on rice, and if this price control were lifted then the consumer rice price would double. The latter is the shadow price, and represents the real resource cost of growing rice. In effect, price control amounts to a subsidy to consumers. For internationally traded commodities, the import and export parity prices provide a good indication of shadow prices.

Determining an appropriate price of labour (i.e. the allowance for wages) often presents a problem when evaluating projects where smallholders are required to increase their labour input, e.g. forestry investments. If labour is hired to assist in tree planting or plantation maintenance, then the wage rate for the hired labour is used, including the value of any meals or other food allowance and accommodation. However, if the smallholder carries out the work themselves, then the opportunity cost of their labour needs to be estimated. In the case of forestry, much of the work can be done at slack times in the work cycle for rice and other crops, so determining an appropriate opportunity cost can be difficult. An approach sometimes used is to take as labour cost the minimum wage rate for (off-farm) labouring work.

Relative values of imports versus exports

The question can be posed: 'Is a dollar of domestic income as valuable as a dollar of export revenue?'. In that governments spend large amounts of money to finance trade missions and promote exports, particularly when the country has a balance-of-payments problem, there would seem to be a de facto weighting in favour of exports, and perhaps also in favour of import replacement. This weighting could be as high as 10% to 20%.

Impact on income distribution

Other things being equal, a project which improves the welfare of the very poor members of society would be preferred to a project which improves the incomes of

the middle class or very-well of members of a society. Some CBA studies have taken income distribution into account, by placing higher value weights on benefits to the poorer members of society. However, economists now try to avoid interpersonal welfare comparisons, arguing that this is the task of the political system. That is, there should be a statement of income distribution effects accompanying the CBA, but no factoring of income distribution effects into the analysis.

Choice of discount rate

Often a lower discount rate will be appropriate for CBA than for evaluation of private investments, for projects with the same level of risk. This is because governments, which carry out large numbers of projects, in effect pool their risks, and are less vulnerable to an individual project crashing.

Uses and Abuses of CBA in Relation to Research Projects

CBA is normally applied to a proposed project before it is accepted for implementation, referred to as ex ante analysis. The analysis is designed to determine whether the project is worthwhile in economic terms, and hence a justifiable use of public funds. Sometimes an ex post (or after-the-event) CBA is carried out, the purpose usually being to determine whether the project has lived up to expectations. As well, CBA calculations may be reworked periodically as a project proceeds, referred to as a life-of-project evaluation. The latter approach is obviously more demanding of resources, but is useful for public accountability, improving the analysis procedure, project monitoring, and determining what features characterise successful projects (picking winners).

While CBA is a highly useful technique for generating decision-support information about the economic desirability of a project at the planning stage, there is always the risk that the proponents of a project will use overly optimistic estimates of benefits, and turn the CBA from a project evaluation to a project justification effort. For this reason, it is particularly important to make all assumptions of the analysis transparent, and to carry out a comprehensive sensitivity analysis of uncertain cash flow variables.

Takeaway Task 4

1. Suppose a research project is being conducted to increase the quality of seedlings in smallholder nurseries. List some of the cost and benefit categories which may be relevant in a CBA of the project.
2. A government has decided to plant trees in a watershed as a conservation project. List some of the cost and benefit categories which may be relevant in a CBA of the project.
3. For the above two questions, identify some of the differences in the way the analysis would be conducted if the project were a private investment and if it were a government (social) investment.

14. Conducting CBA on Research Projects

Examples of CBAs or Research Proposals and Project

The following examples present some insights into the types of cost-benefit analyses applied to research projects.

Example 14.1. CBA of the smallholder forestry project

The benefits shown in table 14.1 were estimated for a smallholder forestry project in Leyte as part of the funded application submitted to the Australian Centre for International Agricultural Research (ACIAR).

Key Assumptions for the Analysis

No accurate data exists for many of the key variables. Data were obtained from a number of sources including DENR staff in Region 8, an ICRAF project on Mindanao, data collected by project researchers on a recent visit and LSU faculty. In addition, a number of assumptions have been made in undertaking the analysis of the benefits of improvements in timber prices as a result of project activities. These are outlined below.

Discount rate and time periods

A real discount rate of 5% was used in the analysis. This is the standard rate used by ACIAR in its impact assessment work. Benefits accruing to existing tree farmers from the impact of both better management and higher prices are assumed to occur evenly over the next ten years – the average rotation length assumed for Gmelina – and are discounted back to present value. A perpetuity has been used to calculate the benefits

associated with better establishment and management of subsequent rotations and for the benefits of increased areas of tree farms.

Number, size and nature of tree farms

The 523 tree farms registered in CENRO Maasin and 207 in CENRO Tacloban compared with only 24 in CENRO Baybay and 42 in CENRO Albueria. The recorded area of tree farms in Maasin and Tacloban is 3551 ha, and this area is likely to be larger. According to DENR and LSU staff all four CENROs have large numbers of tree farms within their boundaries despite the differences in registered tree farms. It is reasonable to assume that the recorded tree farms represent less than 50% (and probably much less) of the total tree farms. For the CBA, a conservative estimate of 50% has been used i.e. the total area of existing tree farms has been estimated at 7102 ha over the four CENRO areas. Tree farms data obtained from DENR indicate that Gmelina constitutes the great majority of plantings. As such growth and price data used in the CBA relate to this species. Mahogany is the next most common species planted. There is a skewed size distribution of registered tree farms towards those of a larger size. This is consistent with owners of larger farms being wealthier and more educated and thus in a better position to understand the relevant regulations and deal with DENR. The number and total area of smaller tree farms is very difficult to estimate.

Yield estimates

While growth models exist for key species such as Gmelina and mahogany, these have largely been

Table 14.1 Financial benefits expected to be realised by smallholders from project activities

Benefit source (treefarm intervention)	Net present value (\$)		
	Immediate incremental benefits to existing tree farmers	Incremental benefits to existing tree farmers from future tree rotations	Net Income generated by additional plantings of 500 ha per year for 10 years
Additional income from improved management of tree farms (5% of tree farmers affected)	596,267	2,133,268	Not estimated separately
Additional income from higher prices from better market access (30% of tree farmers affected)	1,771,926	1,747,536	Not estimated separately
Total benefit expected to be realised	\$2,368,193	\$3,880,804	\$23,243,870

Source: Herbohn and Harrison (2005).

developed based on data collected from well managed industrial plantations or in some cases, based on expected growth rather than actual growth. No reliable data exist on yields of timber from tree farms. Current yields appear to be around 7.5 m³ ha⁻¹ y⁻¹ or even less for Gmelina from smallholder tree farms (Bertomeu 2004, Baynes 2004). This compares with estimates of potential yields of 20 to 30 m³ ha⁻¹ y⁻¹ from well managed plantations reported in the literature.

Price data

Little information exists on roundlog stumpage prices that smallholders receive – as most sales are based on board feet prices of flitched timber. It is assumed that the current stumpage price is 4 pesos per board ft (\$43.50 m⁻³) which is the current price received for Gmelina in Mindinao (Bertomeu 2004, Cramb 2004), although advice from Filipino collaborators indicate that the actual price received by smallholders in Leyte from timber buyers from Cebu is likely to be about half of this amount.

Impact on yield and prices received by existing tree farmers

In the analysis it has been assumed that improved management of existing plantations will result in an average improvement in yield from 7.5 to 10 m³ ha⁻¹ y⁻¹ and that this will be achieved on 5% of the total area of tree farms on Leyte. The estimate is reasonable given that staff will make at least one visit to approximately 500 tree farms and extension materials and advice will be provided directly to each of these smallholders. Further smallholders will be reached through radio segments and field days. In addition, a substantial proportion of the total area of registered tree farms is owned by a relatively small number of smallholders. Smallholders with larger tree farms will be targeted for more intensive extension and management advice.

It is assumed that a total of 30% of tree farmers will benefit from higher stumpage prices achieved through accessing more formal markets. The benefit achieved conservatively estimated as being the difference between current estimates of stumpage of 4 pesos per board ft (\$43.50 m⁻³) to the 2002 roundlog price (\$56.40 m⁻³) reported in the Philippines forest industry statistics on the DENR website. The 5% of smallholders achieving increased yields through better management are included as part of the 30% receiving higher prices. In addition, it is assumed that the 5% of tree farmers who take up better management practices will receive a 25% increase in stumpage price due to improved log quality.

Example 14-2. CBA of a controlled traffic farming project

A CBA has been carried out for a research project into controlled traffic farming. CTF is a package of technology built around all of the farm machinery for dryland grain cropping using the same hardened wheel-track locations every year. This reduces the traction

required relative to driving over ploughed land, allows cultivation and weed control to be more timely, and reduces soil erosion. Tables 14-2 summarizes the costs and benefits.

15. An Introduction to Linear Programming

Linear programming (LP) is a highly versatile mathematical optimization technique which has found wide use in management and economics. It is used both as a research technique and as a planning tool, particularly at the individual firm and industry level.

The Application of Linear Programming to Resource Allocation Problems

An important application is to choose the combination of enterprises of a firm so as to maximize the firm's annual revenue.

Example decision problem

A cabinet maker produces dining room suites and grandfather clocks out of Australian red cedar timber. He can obtain annual supplies of up to 5000 board feet (bft) of red cedar. Up to 6000 hours of labour a year are available for operations such as sawing, joining and polishing. Each dining room suite requires 120 bft of timber, each grandfather clock requires 50 bft of timber and each roll-top desk requires 70 bft of timber. One hundred and eighty hours of labour are required to produce a dining room suite, 40 hours to produce a grandfather clock and 120 to produce one roll-top desk. The profit from each dining room suite is \$900, that from each grandfather clock is \$400 and that of one roll-top desk is 600. The cabinet maker wishes to know how many units of each furniture line to produce in order to maximize profits. Formulate this decision problem as a linear programming model.

Algebraic formulation of the decision problem

Before this problem can be solved by graphical or other means, it must be expressed in algebraic form, i.e. as a model. The first step is to introduce an 'x' notation for the decision variables, here numbers of suites and clocks to be produced. Thus we let

- x1 = number of dining room suites produced
- x2 = number of grandfather clocks produced
- x3 = number of roll-top desks produced

It is now possible to formulate an objective function which in this case is an equation defining total profit. The term 'profit' is used loosely here, in that the figures of \$900, \$400 and \$600 are more correctly called 'gross margins' for the three activities, i.e. they are returns net of variable but not fixed costs. In obtaining these figures, allowance is made for allocatable costs such as materials, labour and marketing costs, but not for overheads such as rent on premises or rates, depreciation of equipment, and accountancy. In this lecture the term net revenues will be used and the

objective function will be referred to as a revenue function. If each dining room suite has a net revenue of \$900, then the total of net revenues from producing (and selling) x1 dining room suites will be 900 x1 dollars. Similarly, the total net revenue from producing x2 grandfather clocks will be 400 x2 and that from producing x3 roll-top desks will be 600 x3. If the symbol Z is used to represent total net revenue, the objective function may be written as

$$Z = 900 x1 + 400 x2 + 600 x3$$

The objective can now be identified more precisely as finding those values of x1 to x3 for which Z is a maximum, bearing in mind the restrictions on production imposed by limited supplies of timber and labour.

Resource restrictions also can be expressed in algebraic form. If x1 dining room suites are produced, each requiring 120 bft of red cedar timber, then dining room suites will consume a total of 120 x1 bft of timber. Similarly, if x2 grandfather clocks are produced these will consume 50 x2 bft of timber, and 120 x3 bft of timber will be required for x3 roll-top desks. The total amount of timber consumed cannot exceed the supply, so the production plan is constrained by the inequality expression

$$120 x1 + 50 x2 + 70 x3 \leq 5000$$

The left hand side of this expression indicates the amount of timber which will be used for any production policy (combination of levels of x1 to x2); the right hand side indicates timber supply. This timber constraint ensures that the demand for timber cannot exceed the supply; any production plan consuming more timber would violate this constraint and would therefore be infeasible.

Similar reasoning can be applied to derive a labour constraint. Since suites, clocks and desks require 180, 40 and 120 manhours of labour respectively, and since the labour supply is 6000 manhours, feasible levels of x1 to x3 are bounded by

$$180 x1 + 40 x2 + 120 x3 \leq 6000$$

Three further constraints are necessary to define the decision problem fully. These are that the numbers of suites, clocks and desks produced cannot be negative

$$\text{i.e. } x1 \geq 0, x2 \geq 0 \text{ and } x3 \geq 0$$

Non negativity constraints may at first appear unnecessary in a practical sense; after all, it is not

possible to produce negative numbers of suites or clocks. However, they must be included for mathematical completeness, to delineate fully the feasible region of production. The cabinet maker's decision problem may now be summarized as a linear programming model with three activities (production of dining room suites, grandfather clocks and roll-top desks), two resource constraints (timber and labour) and two non negativity constraints, as follows:

maximize the revenue function
 $Z = 900 x_1 + 400 x_2 + 600 x_3$

subject to the resource constraints
 $120 x_1 + 50 x_2 + 70 x_3 \leq 5000$
 $180 x_1 + 40 x_2 + 120 x_3 \leq 6000$

and the non negativity constraints
 $x_1 \geq 0, x_2 \geq 0, x_3 \geq 0$

General algebraic formulation of resource allocation models

In general, LP is designed to maximize or minimize a linear objective function subject to a set of linear constraints. An LP problem may be formulated algebraically in terms of activities and constraints and of resource supply inequalities. Suppose levels are to be determined for n activities (x_1, x_2, \dots, x_n) yielding individual net revenues c_1, c_2, \dots, c_n . Limited supplies are available of m resources, the supply levels being represented by the symbols b_1, b_2, \dots, b_m . Each activity uses fixed amounts of resources; in particular, the requirement of resource i by one unit of activity j is a_{ij} . The elements of the matrix of a_{ij} values (for $i=1$ to m

and $j=1$ to n) are known as technical or input output coefficients. The linear programming model may now be written as
 maximize $Z = c_1 x_1 + c_2 x_2 + \dots + c_n x_n$

subject to the linear resource constraints

$a_{11} x_1 + a_{12} x_2 + \dots + a_{1n} x_n \leq b_1$
 $a_{21} x_1 + a_{22} x_2 + \dots + a_{2n} x_n \leq b_2$
 :
 $a_{m1} x_1 + a_{m2} x_2 + \dots + a_{mn} x_n \leq b_m$

and the non negativity constraints

$x_1 \geq 0, x_2 \geq 0, \dots, x_n \geq 0$

Here Z is the total net revenue, and the equation in Z is known as the objective function.

Solving the cabinet maker's decision problem

The LP model may be entered onto an Excel spreadsheet as in Figure 15.1.

The solution to this problem, obtained using Solver in Excel, is as in Figure 15.2.

The optimal activity mix is to produce 56.25 grandfather clocks and 31.25 roll top desks, but not dining room suites.

The particular features of the spreadsheet setup in Excel for linear programming problems (e.g. the 'Activity level' row and the 'Resource use' column as in the above screen image), and the use of Solver, will be explained in Topic 16.

Figure 15.1 The LP model in an Excel spreadsheet

	A	B	C	D	E	F	G
1	Cabinet maker's decision model						
2							
3	Constraint or objective	Dining room suites	Grandfather clocks	Roll top desks	Resource use	Sign	Resource supply
4	Activity level	0	0	0	0	≤	0
5	Timber (bft)	120	50	70	0	≤	5000
6	Labour (hrs)	180	40	120	0	≤	6000
7	Net revenue (\$)	900	400	600	0		

Figure 15.2 The LP model with Excel solver solutions

	A	B	C	D	E	F	G
1	Cabinet maker's decision model						
2							
3	Constraint or objective	Dining room suites	Grandfather clocks	Roll top desks	Resource use	Sign	Resource supply
4	Activity level	0	56.25	31.25	0	≤	0
5	Timber (bft)	120	50	70	5000	≤	5000
6	Labour (hrs)	180	40	120	6000	≤	6000
7	Net revenue (\$)	900	400	600	41250		

Application of LP to Minimization Problems

Linear programming can also be used in applications for which the objective is to minimize the value of the objective function. Important applications are

1. Fuel blending – to achieve a particular octane level by blending components at least cost
2. Feedmix preparation – to produce a ration which meets nutrient requirements (e.g. at least minimum levels of energy, protein and amino acids and not more than an acceptable salt level) from a number of feedstuffs of varying compositions and prices
3. Critical path scheduling – to schedule a project which as a number of interrelated tasks for completion in the minimum time.

Other Mathematical Programming Techniques

A number of other mathematical programming techniques use different solution algorithms to the standard LP form described above, including:

- Goal programming
- Stochastic programming
- Quadratic programming
- Integer and mixed integer programming

In goal programming (i.e. multiple goal programming), the single objective of maximizing profit or minimizing cost is replaced by a number of objectives or goals, where the goals may have different weights or priorities. Some goal programming problems can be solved using a standard linear programming package, while others require special software. Goal programming has been found particularly useful in natural resource management, where multiple-use resources require multiple goals to be achieved. An interesting application was to native forest utilization by the indigenous community in Cape York Peninsula in Australia, where goals included job creation, outdoor or 'on country' jobs, protecting hunting and gathering areas, maximizing revenue from timber harvesting and processing, and minimizing expenditure on logging and milling equipment. The software package GAMS was used for the analysis.

Stochastic and quadratic programming are techniques for incorporating risk into the analysis of resource allocation. These are not particularly widely used, because risk is often recognized in the form of constraints on risky activities using standard LP, and because where explicit recognition of risk is required simulation is a more flexible technique to apply.

In integer programming, the levels of one or more activity are confined to integer (whole number) or binary (i.e. zero or one only) levels. In practice, it is usually not necessary to confine all activities to integer levels,

so mixed integer programming is more widely used. For many LP applications, a non-integer solution is acceptable because the activity levels can be rounded or truncated. This is the case with the cabinet maker's decision problem above. Similarly, if an activity is the growing of a crop, then this can be defined in terms of number of hectares planted, and the optimal solution could include fractional numbers of hectares of crop. The level of the activity can then be any real number.

In contrast, the levels of some types of activities can only occur in whole-number values. This is the case in particular when the activities are investment projects, which we can describe as indivisible or lumpy. The level at which a project can be implemented can only be zero (don't implement the project) or 1 (implement the project). Rounding or truncation is not acceptable. A variable which can only take a number of zero or one is known as a binary variable. In some cases, an activity may be limited to integer levels. For example, if the project is to purchase a new set of disk harrows, then the farmer might for example purchase one, two or three gangs of harrows.

A further feature of mixed integer programming is that binary variable facility allows some extra features to be built into the analysis, including threshold activity levels and mutual exclusive activities.

Mixed integer and quadratic programming are available when using Solver in Excel.

16. Portfolio Selection as an Application of Mixed Integer Programming Using Excel

This module explains the nature of portfolio selection and then explains the application of mixed-integer programming to solve portfolio selection problems.

The Portfolio Selection Problem

The portfolio selection problem can best be illustrated with reference to a few examples.

Example 16-1

Suppose three investment projects have capital demands and net present values as in the following table. What combination of projects would maximize the growth in wealth of the firm?

Project	A	B	C	Total budget
Capital requirement (\$M)	6	9	12	20
NPV	10	25	30	

In this case, it is not possible to implement all three projects, because the budget is not sufficiently large. Fairly obviously, the firm will maximize the aggregate NPV if it implements projects A and C, for which the total payoff (in terms of NPV) is \$40 M.

Example 15-2

Suppose a firm is faced with the following investment options. What combination of projects would maximize the growth in wealth of the firm?

Project	A	B	C	D	E	Total budget
Capital requirement, year 1 (\$M)	9	16	27	32	40	60
Capital requirement, year 2 (\$M)	4	3	8	9	12	20
NPV	18	23	35	38	44	

In this case, the combination of projects (the portfolio) which maximizes the aggregate NPV is not immediately obvious. However, we could list which combinations are financially feasible, and hence identify the optimal combination. Project E (with the highest NPV) could be combined with project B, for a combined NPV of \$67 M. Projects A, B and C could be combined, with an aggregate NPV of \$76 M. Project D could be combined with projects A and B for a combined NPV of \$79 M. This latter combination is probably optimal.

More complex decision problems could be defined, for which it would become increasingly difficult to

determine the optimal portfolio. For example, there may be interactions between the projects (discussed below), we may wish to distinguish between equity and borrowed capital, capital not used in year 1 could be available to use in year 2, and there could also be a labour constraint on which projects are introduced. Fairly obviously, it would soon become impossible to determine the optimal portfolio by inspection.

Application of MILP to Portfolio Selection

Our concern here will be with application of LP to the allocation of a firm's capital, labour or other resources into investment projects.

In the application of LP to portfolio selection, the investment projects are treated as separate activities, and the objective function is defined in terms of net present values (i.e. NPV row becomes the Z or objective function row).

As an illustration of the algebraic formulation, Example 1 could be written as:

$$\begin{aligned} \text{maximize } & Z = 10x_1 + 25x_2 + 30x_3 \\ \text{subject to } & 6x_1 + 9x_2 + 12x_3 \leq 20 \\ \text{and } & x_1 \geq 0, x_2 \geq 0, x_3 \geq 0 \end{aligned}$$

and x_1 to x_3 must take integer levels.

Mutually exclusive and contingent projects

Often the projects being considered are not independent of each other. Two or more projects are mutually exclusive if selection of one precludes selection of the other project or projects. If a farmer wished to purchase a new tractor, and was comparing a number of different tractor models, then the various tractor purchase options would be mutually exclusive investments.

A contingent project is one which can only be adopted if another has been adopted. For example, suppose a dryland farmer was considering construction of a farm dam, and purchase of an irrigation plant. If the dam were constructed, it could be used for irrigation, to supply stock water, for fish or prawn farming, or for some other activity. However, there would be no use for the irrigation plant unless the dam was constructed. In this case, the irrigation project is contingent of the new dam project (but not conversely).

Resource use and generation of resource

The a_{ij} coefficients represent the number of units of scarce resource i used by one unit of activity j . In the special case where an activity produces or generates units of a resource, the a_{ij} coefficient will have a negative sign. For example, a borrowing activity would generate a supply of capital, and a pasture activity would supply stock feed; in both these cases the coefficient for the resource would be negative.

Transfer activities

A transfer activity transfers unused amounts of a resource from one period to the next. For example, capital, irrigation water or stockfeed could be transferred from one year to the next.

Formulation of a Portfolio Selection Problem in Algebraic Form

Having outlined the LP formulation, we are now ready to apply this to the portfolio selection problems outlined above. Consider the decision problem of Example 15.2 above.

Project	A	B	C	D	E	Total budget
Capital requirement, year 1 (\$M)	9	16	27	32	40	60
Capital requirement, year 2 (\$M)	4	3	8	9	12	20
NPV	18	23	35	38	44	

This decision problem can be written in algebraic form as:

$$Z = 18x_1 + 23x_2 + 35x_3 + 38x_4 + 44x_5,$$

where x_1 to x_5 are the levels of projects A to E, which can only take binary values.

The capital requirement rows becomes constraint rows:

$$9x_1 + 16x_2 + 27x_3 + 32x_4 + 40x_5 \leq 60 \text{ and}$$

$$4x_1 + 3x_2 + 8x_3 + 9x_4 + 12x_5 \leq 20$$

Here the left-hand-sides are the amounts of capital used, and the right-hand-sides are the amounts of capital available.

In an integer linear programming model, the non-negative requirement is assured because the x values can only take values of zero or one.

Solving a Portfolio Selection Problem Using Excel

The solver facility in Microsoft Excel can be used to determine the optimal project mix. The following screen shot presents the linear programming formulation for Example 15.2, set up on a spreadsheet ready for solution using Solver. This is known as the initial linear programming tableau. The activities are represented by columns of the tableau (columns B to F), and the scarce resources as rows (rows 5 and 6), with the objective function as row 7

The technical coefficients form the body of the tableau (cell B5 through to F6). Column G lists the initial resource supplies or constraint right-hand-sides.

Prior to using Excel Solver, it is necessary to introduce a row for activity levels (row 4); these activity levels are initially set at zero. It is also necessary to introduce a column for resource use (column G). When all activity levels are zero, the resource levels must also be zero. A column for signs of the constraints is also introduced (column H), in this case containing only a ' \leq ' sign.

Figure 16.1 Excel spreadsheet for example 15.2 with resource use included

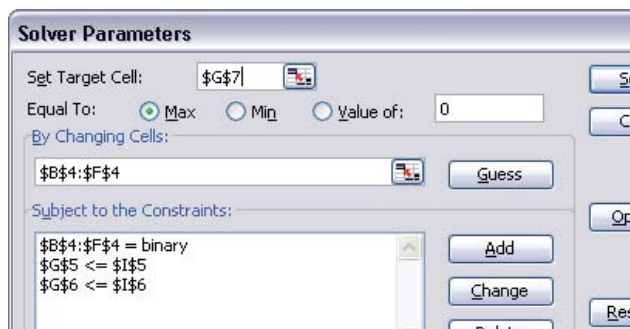
	A	B	C	D	E	F	G	H	I
1	Example 1 - portfolio selection LP model								
2									
3	Constraint or objective	Project A	Project B	Project C	Project D	Project E	Resource use	Sign	Resource supply
4	Activity level	0	0	0	0	0	0		
5	Capital, year 1	9	16	27	32	40	0	≤	60
6	Capital, year 2	4	3	8	9	12	0	≤	20
7	Net revenue	18	23	35	38	44	0		

The most complex step in setting up the initial LP tableau is to enter formulae in the 'Resource use' column, i.e. column G:

1. the resource use for the year 1 capital constraint (cell G5) is entered as the formula '=SUMPRODUCT(B\$4:F\$4,B5:F5)'. Cell ranges are entered into the formula by selecting the range with the cursor, and then clicking with the mouse. Cell G5 initially takes a level of zero, because the activity levels in row 4 are zero. Note that absolute cell references are required for row 4.
2. the contents of cell G5 are then copied to cell G6 and G7. The values in cell G5 and G6 represent 'resource use' with respect to the other constraints, while the value in cell G7 is the level of the objective function. Initial values in these cells are again zero.

Once these data have been entered onto the spreadsheet, Solver can be called up to further set up the problem for solution. Solver is to be found under the Tools menu of Excel. (If it is not currently available, seek assistance on how to access it.)

A dialogue box for Solver is illustrated in the following screen image.

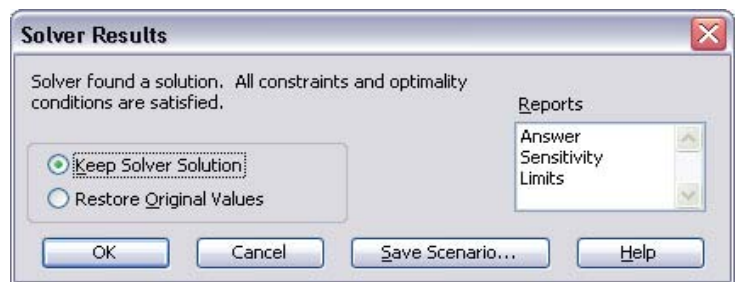


Note that it is necessary to specify the Target Cell (holding the value of the objective function), specify that the problem is a maximization one, identify the Changing Cells (the activity levels), and add the constraints rows (here the two capital constraints plus the constraint that all activity levels can only take binary or zero-one values). No non-negativity constraints

are required for activities which are confined to binary values. To add constraints, first click on the Add button, after which an Add Constraint dialogue box opens with three fields, to represent the constraint left-hand-side, sign and right-hand-side. The activity is confined to a binary level by selecting 'bin' in the sign field.

When the information in the Solver dialog box is judged to be correct, the Solve button is pressed. A new dialogue box opens, called the Solver Results dialogue box. Hopefully, this will report that Solver has found a solution, and all constraints have been satisfied. If not, then it is likely that there is an error in the tableau or in the information entered in the Solver dialogue box. (It could also be the case that no feasible solution exists for the decision problem.)

In the Solver Results dialogue box (illustrated below) the default 'Keep Solver Solution' is normally selected. Under Reports, only 'Answer' is required; the 'Sensitivity' and 'Limits' reports do not have any sensible meaning in the case of integer and mixed-integer LP models (the latter being models with both integer or binary and continuous activity levels). This is because relative to models with only continuous variable, solution of integer models requires setting up a lot of additional constraints to force activities to take discrete values, which distorts the sensitivity analysis.



The final tableau for this decision problem is presented in the screen image below. As indicated by the activity levels in row 4, projects A, B and D are selected. Column G reveals that \$57 M of capital in year 1 and \$16 in year 2 are consumed. Cell G7 reports a total return to the firm (aggregate NPV) of \$79 M.

Microsoft Excel									
File Edit View Insert Format Tools Data Window Help									
G7 fx =SUMPRODUCT(B\$4:F\$4,B7:F7)									
LP Example 1 - solution									
	A	B	C	D	E	F	G	H	I
1	Example 1 - portfolio selection LP model								
2									
3	Constraint or objective	Project A	Project B	Project C	Project D	Project E	Resource use	Sign	Resource supply
4	Activity level	1	1	0	1	0			
5	Capital, year 1	9	16	27	32	40	57	≤	60
6	Capital, year 2	4	3	8	9	12	16	≤	20
7	Net revenue	18	23	35	38	44	79		

More Complex Example of Applying Linear Programming to the Portfolio Selection Problem

Example 16-3 provides some additional complexities in the formulation of the portfolio selection problem.

Example 16-3

A timber company has identified four options for value-adding so as to increase revenue. These options are to install a peeler or slicer line (removing thin timber sheets from logs by rotary or cross-section cutting) and installation of a plywood or veneer production plant. The capital requirements and NPVs of these projects are estimated to be as below. It is decided that at most two of these projects can be adopted. The peeler would provide resource for the plywood plant, hence installation of the plywood plant is contingent upon installing the peeler. \$20 M in capital is available for new investment.

Resource or objective	Peeler	Slicer	Plywood plant	Veneer plant
Capital, year 1	2.3	3.4	8	11
Capital, year 2	0.3	1.2	2	2.8
Net revenue	5	8	20	25

Solution to Example 16-3

This decision problem has been set up as a LP model, as in the following screen image. (This is the final tableau – in the initial tableau row 5 and column G contain zeros only.) The information in the above table has been copied directly into rows 6, 7 and 10. Also, provision has been made for capital not used in year 1 to be available in year 2, through a capital transfer activity (column F) which takes up capital in year 1 (+1 coefficient) and makes it available in year 2 (-1 coefficient). The constraint of row 8 ensures that not more than two activities are selected in the portfolio. A plywood permission row have been added (row 9); the peeler activity supplies this permission and the plywood activity can only be selected if some permission 'resource' is available.

Note that the resource supplies for capital in year 2 and for permission for the plywood plant (in cells I7 and I9) are zero. The negative coefficients in cells F7 and B9 represent contributions to supplies of these resources if the corresponding 'supply activities' are selected.

The optimal solution to the LP problem is to adopt the slicer and veneer plants, with an aggregate NPV of \$33 M. \$4 M is transferred from year 1 to year 2. Including this \$4 M, the amount of the \$20 M in capital used is \$18.4 M. The figure of -3E-09 in cell G7 is really zero (-3 multiplied by 10⁻⁹) (see spreadsheet below).

	A	B	C	D	E	F	G	H	I
1	Timber processing portfolio model								
2									
3	Constraint or objective	Peeler (bin)	Slicer (bin)	Plywood (bin)	Veneer (bin)	Capital transfer 1->2	Resource use	Sign	Resource supply
4									
5	Activity level	0	1	0	1	4			
6	Capital, year 1 (\$M)	2.3	3.4	8	11	1	18.4	≤	20
7	Capital, year 2 (\$M)	0.3	1.2	2	2.8	-1	-3E-09	≤	0
8	Mutual exclusion	1	1	1	1		2	≤	2
9	Permission, plywood	-1		1			0	≤	0
10	Net present value (\$M)	5	8	20	25	0	33		

Review Questions

The following questions are provided to help consolidate you practice the financial mathematics used in the course materials. They are extracted from FINM 7960 Agribusiness Project Appraisal Lectures Notes prepared by Drs Herbohn, Slaughter and Cameron (2005).

1. \$1000 is invested for 15 years. What sum will be received after 15 years at the following interest rates: 3%, 6%, 9%, 12%, 15%.
Plot these data graphically.
2. Calculate the present value of an annuity of \$2000, for 8 years, at 5% discount rate.
3. You have \$10000 in cash today. Assume you can earn 10% interest on this money. You wish to purchase a house in four years time which you expect to cost \$40000. Assuming you can borrow 50% of the cost, what annual amount would need to be saved to enable you to achieve your objective?
4. I plan to expand my nursery in 5 years time, and expect to pay \$20000 for the additions. If I can earn a nominal interest of 12% p.a. on my savings, how much need I save per year to reach my target?
5. For a mortgage of \$420000 over 15 years at 12% interest (nominal) per annum, calculate the equal installments of interest and principal assuming payments are required every six months.
6. You have won \$30000. You wish to grant each of your three children an annuity for 15 years. Using an interest rate of 9% what annual sum will each receive?
7. You are saving \$5000 per annum towards the purchase of a farm. The rate of interest on your savings is 10%. What sum of money will you have accumulated after 6 years?
8. A sum of \$10000 is invested in an account earning interest at a nominal annual interest rate of 12%. The interest is calculated and credited every 3 months. Calculate the amount in the account after 4 years.
9. In four years time you are to take over the running of the family farm, and at that time must pay out your sister's share of \$100000. You have just invested \$60000 at 12% p. a. to go toward the payment. How much need you save each year for the next four years so as to accumulate the remaining balance?
10. You invest \$25000 in an investment account earning 18% p.a. Interest will be credited to your account each month for 4 years. Assuming you make no withdrawals, what amount will be in the account after 4 years?
11. Calculate the monthly payments for an installment loan of \$50000 borrowed for 4 years at 18% p.a.
 - (a) Calculate the effective annual interest rate of the loan.
 - (b) What would the payout figure be if the loan was paid back at the beginning of year 3? (Assume there is no penalty attached to loans paid out early.)
12. A farmer takes out a loan of \$20000 to be paid off by equal annual instalments (interest and principal), over 15 years. The interest rate is 12 per cent per annum.
 - (a) Calculate the annual instalments.
 - (b) Apportion the instalment for the twelfth year into interest and principal.
 - (c) Assuming that inflation averages 8 per cent per annum, re-express that total instalment for the fifteenth year in constant value dollars as at the start of year one.
13. Calculate the monthly payments for an installment loan of \$55000 borrowed for 4 years at an interest of 18% p.a.
 - (a) Calculate the effective annual interest rate of the loan?
 - (b) What would the payout figure be if the loan was paid back at the beginning of Year 3? (Assume there is no penalty attached to loans paid out early.)
 - (c) Apportion the first payment in Year 2 into interest and principal.

14. You have four financing opportunities to choose from to lend \$60000 for home extensions. Which option should you choose?
Option A — 16% p.a. with monthly payments over 4 years.
Option B — A flat-rate loan requiring monthly payments of \$1850 over 4 years.
Option C — 10% flat rate of interest with monthly payments over 4 years.
Option D — 16.4% p.a. with quarterly payments over 4 years.

15. If you are comparing the following two investments which are mutually exclusive, which would you recommend, and why?

	NPV	IRR
Project A:	\$13000	16.3%
Project B:	\$10500	16.9%

16. Calculate payback period, net present value at 10%, and the internal rate of return of the following projects:

	Year 0	1	2	3	4
Project A:	(\$2000)	\$400	\$700	\$700	\$850

	Year 0	1	2	3 to 10	
Project B:	(\$1000)	(\$1000)	\$200	\$350	

Which project would you recommend if the projects are independent, i.e. not mutually exclusive?

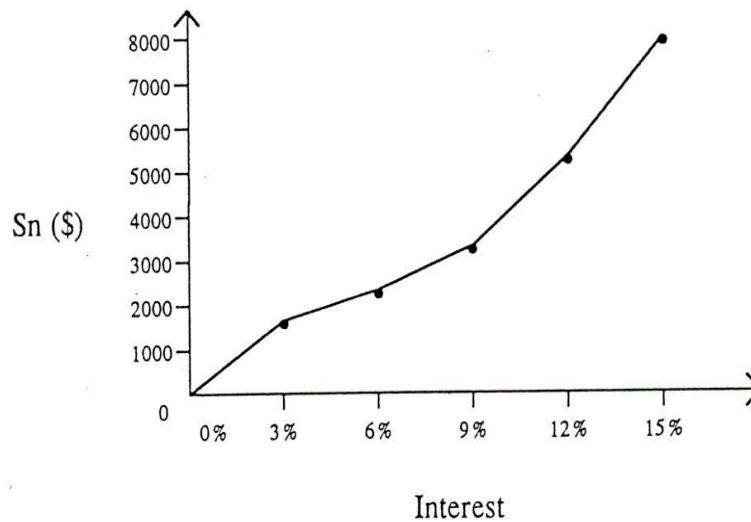
17. Calculate net present value at 10%, payback period and internal rate of return for the following projects. If the investments are mutually exclusive, which would you recommend?

	Year 0	1	2	3	4 to 20
Net cash flow nominal \$					
Project A:	(4000)	350	500	600	650
Project B:	(6000)	(200)	300	450	850

Review Questions - Feedback

Question 1. PV = \$10000
 n = 15
 i = 3%, 6%, 9%, 12%, 15%
 FV = ?

'i'	Compounding Factors (n - 15)	'FV'
3%	1.5579	\$1558
6%	2.3966	\$2397
9%	3.6425	\$3643
12%	5.4736	\$5474
15%	8.1371	\$8137



Question 2. A = \$2000
 n = 8
 i = 5%
 PV = ?

Present value of an annuity factor (n - 8, i - 5%)= 6.4632

PV = A x factor
 = 2000 x 6.4632
 = \$12926

Question 3. Cost of \$40000 is funded by:

Borrowing \$20000
Investment
Saving

Investment:

PV = \$10000
n = 4
i = 10%
FV = ?

Compounding factor (4, 10%) = 1.4641

FV = PV x factor
= 10000 x 1.4641
= \$14641

Cost \$40000
Borrow \$20000
Investment \$14641

= Amount to be saved \$5359 (FV)

FV = \$5359
n = 4
i = 10%
FV = ?

Annuity of future sum factor (4, 10%) = 0.2155

A = FV x factor
= 5359 x 0.2155
= \$1155 per year

Question 4. FV = \$20000
n = 5
i = 12%
A = ?

Annuity of a future sum factor (5, 12%) = 0.1574

A = FV x factor
= 20000 x 0.1574
= \$3148

Question 5. PV = \$420000
n = 30 (15 yrs x 2
payments p.a.)
i = 6% (12% p.a./2
payments p.a.)
A = ?

Annuity of present value factor (30, 6%) = 0.0726

A = PV x factor
= 420000 x 0.0726
= \$30492

Question 6. PV = \$10000
(\$30000/ 3 children)
n = 15
i = 9%
A = ?

Annuity of present value (15, 9%) = 0.1240

A = PV x factor
= 10000 x 0.1240
= \$1240 per year

Question 7. A = \$5000
n = 6
i = 10%
FV = ?

Future sum of an annuity factor (6, 10%) = 7.7156

FV = A x factor
= 5000 x 7.7156
= \$38578

Question 8. PV = \$10000
i = 3% (12% p.a./4
payments/yr)
n = 16 (4 yrs x 4
payments/yr)
FV = ?

Compounding factor (16, 3%) = 1.6047

FV = PV x factor
= 10000 x 1.6047
= \$16047

Question 9. Cost of \$100000 is funded by:

$$i = 1.5\%$$

$$A = ?$$

Investment
Saving

Annuity of present value factor
(48, 1.5%) 0.0294

Investment:

$$PV = \$60000$$

$$n = 4$$

$$i = 12\%$$

$$FV = ?$$

$$A = PV \times \text{factor}$$

$$= 50000 \times 0.0294$$

$$= \$1470$$

Compounding factor

$$(4, 12\%) = 1.5735$$

(a) $i = 1.5\%$ (1.5%/payment)
 $n = 12$ (12 payments/year)

$$FV = PV \times \text{factor}$$

$$= 60000 \times 1.5735$$

$$= \$94410$$

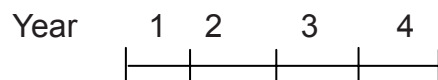
$$ie = (1 + i)^n - 1$$

$$= (1.015)^{12} - 1$$

$$= 0.1956 \text{ or } 19.56\% \text{ p.a.}$$

Cost	\$100000
Investment	\$94410
= Amount to be saved	\$5590

(b)



$$FV = \$5590$$

$$n = 4$$

$$i = 12\%$$

$$A = ?$$

2 years remaining – 24 payments

Annuity of a future sum (4, 12%) = 0.2092

$$A = \$1470$$

$$n = 24$$

$$i = 1.5\%$$

$$p = ?$$

$$A = FV \times \text{factor}$$

$$= 5590 \times 0.2092$$

$$= \$1169 \text{ per year}$$

Present value of an annuity factor (24, 1.5%)
20.0304

Question 10.

$$PV = \$25000$$

$$n = 48$$

$$i = 1.5\%$$

$$FV = ?$$

$$PV = A \times \text{factor}$$

$$= 1470 \times 20.0304$$

$$= \$29445$$

Compounding factor (48, 1.5%) = 2.0435

$$FV = PV \times \text{factor}$$

$$= 25000 \times 2.0435$$

$$= \$51088$$

Question 11.

$$PV = \$50000$$

$$n = 48$$

Question 12.

(a) PV = \$20000
n = 15
i = 12%
A = ?

Annuity of present value factor (15, 12%) = 0.1468

A = PV x factor
= 20000 x 0.1468
= \$2936



A = \$2936
n = 4
i = 12%
PV = ?

Present value of an annuity (4, 12%) = 3.0373

PV = A x factor
= 2936 x 3.0373
= \$8918

Interest component = 12% of \$8918
= 0.12 x 8918
= \$1070

Principal component = Payment - Interest
= 2936 - 1070
= \$1866

(c) FV = \$2936
n = 15
l = 8%
PV = ?

Discounting factor (15, 8%) = 0.3152

PV = FV x factor
= 2936 x 0.3152
= \$925

Question 13.

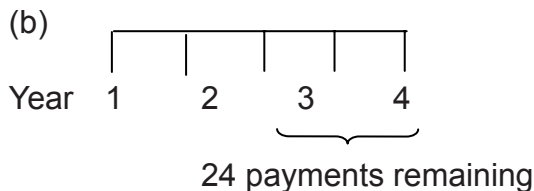
$$\begin{aligned} PV &= \$55000 \\ n &= 48 \\ i &= 1.5\% \\ A &= ? \end{aligned}$$

Annuity of present value factor (48, 1.5%)
0.0294

$$\begin{aligned} A &= PV \times \text{factor} \\ &= 55000 \times 0.0294 \\ &= \$1617 \end{aligned}$$

(a) $i = 1.5\%$ (1.5,70/payment)
 $n = 12$ (12 payments/yr)

$$\begin{aligned} i \text{ eff p.a.} &= (1 + i)^n - 1 \\ &= (1.015)^{12} - 1 \\ &= 0.1956 \text{ or } 19.56\% \text{ p.a.} \end{aligned}$$



$$\begin{aligned} A &= \$1617 \\ n &= 24 \\ i &= 1.5\% \\ PV &= ? \end{aligned}$$

Present value of an annuity factor (24, 1.5%)
20.0304

$$\begin{aligned} PV &= A \times \text{factor} \\ &= 1617 \times 20.0304 \\ &= \$32389 \end{aligned}$$



$$\begin{aligned} A &= \$1617 \\ n &= 36 \\ i &= 1.5\% \\ PV &= ? \end{aligned}$$

Present value of an annuity factor (36, 1.5%)
27.6607

$$\begin{aligned} PV &= A \times \text{factor} \\ &= 1617 \times 27.6607 \\ &= \$44727 \end{aligned}$$

$$\begin{aligned} \text{Interest component} &= 1.5\% \text{ of } \$44727 \\ &= 0.015 \times 44727 \\ &= \$671 \end{aligned}$$

$$\begin{aligned} \text{Principal component} &= \text{Payment} \\ \text{- Interest} &= 1617 - 671 \\ &= \$946 \end{aligned}$$

14. Option A:

$$\begin{aligned} n &= 12 \\ i &= 1.3\% \end{aligned}$$

$$\begin{aligned} i \text{ eff p.a.} &= (1 + i)^n - 1 \\ &= (1.013)^{12} - 1 \\ &= 0.1723 \text{ or } 17.23\% \end{aligned}$$

p.a.

Option B:

$$\begin{aligned} p &= \$60000 \\ R &= \$1850 \\ T &= 48 \end{aligned}$$

$$\begin{aligned} FV &= R \times T \\ &= 1850 \times 48 \\ &= \$88800 \end{aligned}$$

$$\begin{aligned} Si &= FV - PV \\ &= 88800 - 60000 \\ &= \$28800 \end{aligned}$$

$$\begin{aligned} \text{Interest p. a.} &= 28800/4 \\ &= \$7200 \text{ p.a.} \end{aligned}$$

$$\begin{aligned} f &= \text{Interest p.a.}/PV \\ &= 7200/60000 \\ &= 12\% \text{ p.a.} \end{aligned}$$

$$\begin{aligned} i \text{ eff p.a.} &= (2 \times f \times T)/(T + 1) \\ &= (2 \times 0.12 \times 48)/49 \\ &= 0.235 \text{ or } 23.5\% \text{ p.a.} \end{aligned}$$

Option C:

$$f = 10\%$$

$$T = 48$$

$$i \text{ eff p.a.} = (2 \times f \times T) / (T + 1)$$

$$= (2 \times 0.1 \times 48) / 49$$

$$= 0.1959 \text{ or } 19.59\% \text{ p.a.}$$

Option D:

$$i = 4.1\% \text{ (16.4\% p.a./4 payments p.a.)}$$

$$n = 4 \text{ (4 payments p.a.)}$$

$$\text{eff } i \text{ p.a.} = (1 + i)^n - 1$$

$$= (1.041)^4 - 1$$

$$= 0.174 \text{ or } 17.4\% \text{ p.a.}$$

Question 15. If you can only choose one project, choose the one with the highest NPV, i.e. Project A

Question 16.

Project A: Payback period = 4 years

Year	Net cash flow nominal \$	Discounting factor - 10%	Present value cash flow
0	(2000)	1	(2000)
1	400	0.9091	364
2	700	0.8264	578
3	700	0.7513	526
4	850	0.6830	581
			NPV = \$49

$$\text{IRR} = 0.1 + [0.02 (49/95)]$$

$$= 0.1 + 0.0103$$

$$= 0.1103 \text{ or } 11.03\%$$

Project B: Payback period = 8 years

Year	Net cash flow nominal \$	Discounting factor - 10%	Present value cash flow
0	(1000)	1	(1000)
1	(1000)	0.9091	(909)
2	200	0.8264	165

3 - 10 350 Present value of an annuity factor (8, 10%)
= 5.3349 x 0.8264

$$1543$$

$$\text{NPV} = (\$201)$$

$$\text{IRR} = 0.07 + [0.03 (65/266)]$$

$$= 0.07 + 0.0073$$

$$= 0.0773 \text{ or } 7.73\%$$

Question 17.

Project A:

Year	Net cash flow nominal \$	Discounting factor - 10%	Present value cash flow
0	(4000)	1	(4000)
1	350	0.9091	318
2	500	0.8264	413
3	600	0.7513	451
4 - 20	650	8.0216 x 0.7513	3917
			NPV = \$1099

$$\text{IRR} = 0.13 + [0.02 (149/488)]$$

$$= 0.13 + 0.0061$$

$$= 0.1361 \text{ or } 13.61\%$$

Project B:

Year	Net cash flow nominal \$	Discounting factor - 10%	Present value cash flow
0	(6000)	1	(6000)
1	(200)	0.9091	(182)
2	300	0.8264	247
3	450	0.7513	338
4 - 20	850	8.0216 x 0.7513	5123
			NPV = (\$473)

$$\text{IRR} = 0.08 + [0.02 (584/1057)]$$

$$= 0.08 + 0.0111$$

$$= 0.0911 \text{ or } 9.11\%$$

Choose Project A.