Elements of Cost-Benefit Analysis for Forestry Investments

Harry F. Campbell

EFI Technical Report 96, 2014

Elements of Cost-Benefit Analysis for Forestry Investments
Harry F. Campbell

Publisher: European Forest Institute
Email: publications@efi.int
http://www.efi.int

Editor-in-Chief: Marc Palahí

Contents

Acknowledgements

I would like to thank Associate Professor Richard Brown for comments on an earlier draft, and Dr. Patrice Harou and members of the Forestry Economics Group at EFI for helpful discussions. However I am solely responsible for the views expressed.

June 2013

Harry F. Campbell
Emeritus Professor
University of Queensland
h.campbell@uq.edu.au

1. Introduction

This introduction to cost-benefit analysis (CBA) is based on *Benefit-Cost Analysis: financial and economic appraisal using spread-sheets* by H.F. Campbell and R.P.C. Brown (Cambridge University Press, 2003; www.uq.edu.au/economics/bca) and should be read in conjunction with that text. The book presents a spread-sheet model for conducting cost-benefit analysis which accommodates, in a logical and easy to implement way, the complex social accounting interactions resulting from investment projects undertaken in economies which exhibit the usual range of market failures, distortions and imperfections.

Undertaking an investment project involves expenditures on inputs, such as land, labour, capital, and materials, to construct a facility which is expected to generate future returns in the form of output of goods and services. The type of facility involved can vary widely and includes, for example, industrial plant, roads, power stations, education and health programs, and forest plantations. The input expenditures involved in setting up the facility are termed the capital costs of the project; in the case of a forestry project these expenditures, which may occur over a number of years, may include outlays on land acquisition, infrastructure, equipment, materials and labour. In addition, annual input costs are usually incurred in operating the project to produce its output. The value of the project's output in a given year, less the operating cost, is termed the project's net benefit in that year. Investment appraisal is the process of determining whether a proposed investment project is worthwhile undertaking – are the expected net benefits in the future adequate compensation for the capital costs in the present?

A distinction is made between financial and economic analysis of a project: a financial analysis examines the project from the viewpoint of the project proponent, whereas an economic analysis looks at the project from the viewpoint of the economy as a whole. As discussed below, the project proponent may not bear all of the costs or receive all of the benefits of the project, and so the two analyses may reach different conclusions. The project proponent may be a private firm, a public-private partnership, a non-government organization, a government department or some other type of organization. Whatever the organization, it will require an analysis of the revenues and expenses associated with undertaking the project, and this is termed the financial analysis. Since the project funding and tax situation vary from one type of organization to another we need to be specific about the type of organization considering the project, and in this introduction the proponent will be assumed to be a private firm.

If the financial analysis presents all of the information the project proponent requires to make a decision, why is it necessary to perform an economic analysis as well? An economic analysis is conducted for projects in which there is a public as well as a private interest. As noted above, the project proponent will generally not receive all of the benefits nor bear all of the costs of the project. Where there are significant external (or indirect) costs or benefits the government generally takes an interest in the investment decision. This interest can take the form of an approval process which must be completed before the project is allowed to proceed. The economic analysis of the project is a major input into that process. The spreadsheet model discussed below incorporates both a financial and an economic analysis of the project, but before discussing the structure of the model we need to understand the way in which investment appraisal is conducted.

A comparison of costs in the present with net benefits in the future must take account of the time-value of money as measured by the rate of interest. This is a particularly important issue in the case of long-lived projects such as forestry plantations. The rate of interest is established by the interaction of lenders and borrowers in the capital market; it reflects the preference of lenders for present over future consumption and the productivity of the projects which the borrowers plan to undertake. The rate of interest may also reflect concerns about price inflation and risk but we will ignore these issues for the present. From the perspective of a lender, a sum of money deposited in the bank today, the Principal (*P*), will, through the operation of compound interest at a constant annual rate r, have grown to equal the Amount (*A*) after a period of *t* years: $A=P(1+r)^t$. In this formula *P* is the Present Value (*PV*) and *A* is the Future Value at time *t* (FV_t). The formula can be inverted to give an expression for the present value of a sum of money to be received *t* years in the future: $PV=FV_t[1/(1+r)]^t$. In this expression *r* is the *discount rate* and $[1/(1+r)]^t$ is the *discount factor*. Using discount factors we can express all future capital costs and net benefits associated with the project in terms of present values; this process, termed Discounted Cash Flow analysis, is discussed in more detail in Section 2. The present value of net benefits less the present value of capital costs is termed the net present value (NPV) of the project. A positive NPV indicates that the project benefits exceed the costs and that the project is worth undertaking, subject to the availability of funds.

To say that the project is worth undertaking is to say that it represents a better use of resources than the alternative use: in other words, to say that the *world with the project* is better in financial or economic terms than the *world without the project*, or, equivalently, that the sum of the present values (positive or negative) of the *changes* wrought by the project is positive. *With-and-without* is not the same as *before-and-after* as circumstances may change and the world *without* the project may be different from the world *before* the project. The *with-and-without* comparison lies at the heart of cost-benefit analysis. In the world *with* the project we get the project net benefits in the future, consisting of both timber and non-timber benefits, but in the world *without* the project we would have received the net benefits from the alternative use of the project inputs – the land, labour, capital and materials involved in establishing the project. In other words, the cost of the project must be thought of as an opportunity cost – the net benefits forgone as a result of not taking the opportunity of using the inputs in an alternative way.

Given that the comparison is between project net benefits and the forgone net benefits of alternative projects, why is the technique labelled *cost*-benefit analysis (and not *benefit*-benefit analysis)? The reason is that in the textbook example of a perfectly competitive economy the cost of the project inputs, at market prices, measures the benefits that these inputs would have generated in their alternative uses. The reason for this is too technical to discuss in detail here but an example may be helpful. The cost of a unit of labour to be employed in the project is the market wage, *w*. Assume that, in the absence of the proposed project, the unit of labour would have been hired by a competitive profit-maximizing firm. Such firms maximize profit by hiring additional units of labour as long as the resulting increase in value of output – the value of the marginal product (VMP) – is at least equal to the cost of the additional unit of labour, *w*, and competition amongst firms ensures that VMP = w. Thus *w* measures the value of the extra output the labour would have produced in the absence of the project – the opportunity cost of the labour.

The textbook case of the perfectly competitive economy is similar to the concept of absolute zero temperature employed in physics – a useful yardstick but unattainable in practice. In a perfectly competitive economy all commodities which affect the level of economic welfare are traded. Commodities can be traded only if the buyer can obtain secure title to the commodity from the seller. Property rights to a wide range of commodities which affect the level of economic welfare are lacking or imperfect (environmental services provided by forests, such as water catchment protection, conservation of biological diversity, soil erosion control, salinity reduction, and carbon sequestration are examples) and, in consequence, these commodities are generally not traded and have no market prices for the analyst to use. In addition to being subject to property rights, commodities must be traded in markets which are free from monopoly control and from distorting taxes and regulations, otherwise market prices may give a misleading view as to marginal benefit or opportunity cost.

As suggested above, real-world economies are evidently not perfectly competitive. This is not a problem for financial analysis of a project because market prices measure benefits and costs to those undertaking the project. However market prices cannot be relied on, in all cases, to measure accurately benefits and costs to the wider economy. As already noted, some commodities which affect economic welfare are not traded in the market and have no market price. For other commodities which are traded in monopoly or distorted markets the market price may not measure the benefit of an additional unit of the project's output (marginal benefit) or the opportunity cost of an additional unit of input to the project (marginal cost). In such cases *shadow-prices* are developed for use in the economic analysis. Shadow-prices (sometimes referred to as *accounting prices*) are not prices that are actually paid or received by any economic agent and their use is restricted to the internal workings of the cost-benefit analysis. It is important not to exaggerate the extent of the imperfections in real world markets. For the most part the analyst can assume that market prices more or less reflect competitive conditions and it is only in obvious cases of market imperfection, or of market failure (the absence of market prices altogether), that time and expense must be devoted to calculating shadow-prices, and then only for commodities that play a significant role in the project.

The reason for conducting both an economic and a financial analysis was discussed above but, in fact, the spread-sheet model proposed looks at the project from *four* different perspectives. The Market Analysis (referred to as the Project Analysis in the Text) evaluates the benefits and costs at market prices to determine whether, in the absence of income tax and debt financing, the project has a positive NPV. The NPV calculated by the Market Analysis is then disaggregated among the groups with an interest in the project – generally the financiers, the government and the holders of the equity in the proponent firm. The return to the latter group return is calculated in the Proponent Analysis (referred to as the Private Analysis in the Text), which, for the present discussion, is a standard financial analysis of a private investment project which calculates the return to the proponent after debt financing and taxation. As noted above, the Market Analysis generally does not account for all of the project benefits and costs to the economy as a whole: non-marketed commodities, such as air pollution, are not included because they are not-traded in the market and have no market price; and, because of market imperfections, some market prices do not reflect the marginal benefit of an output or the marginal cost of an input to the economy.

The Efficiency Analysis is similar to the Market Analysis, but with shadow-prices substituted for market prices where appropriate, and non-market valuations of non-marketed commodities included. The NPV calculated by the Efficiency Analysis summarises the net value of the project to the economy as a whole. It can be disaggregated to determine the gains or losses to various groups – private firms, various levels of government, local, regional and national residents, non-residents and so on. The decision-maker will generally not be concerned with the effects of the project on all groups but will have in mind a subset of the affected population, which we term the Referent Group. The Referent Group normally consists of the residents of a region, state or country, but sometimes other groups such as indigenous peoples, students, pensioners etc. can be specified, and sometimes the effects of the project on two or more groups, such as individual countries and the EU as a whole, are to be calculated. It is a matter for the decision-maker, who commissions the cost-benefit analysis, to specify the Referent Group and the results of the analysis are summarised by the Referent Group Analysis.

It might seem cumbersome to perform four separate analyses of an investment project, but, in the spread-sheet framework proposed, the analyses complement and contribute to one another, making the task of the analyst simpler. Furthermore, the decision-maker usually wishes to consider the project from various points of view. While the concern of the economist is mainly with economic efficiency, as measured by the Efficiency Analysis, the decision-maker may be more interested in the project's effects on his constituency, as measured by the Referent Group Analysis. The decision-maker will also be interested in the Proponent Analysis, irrespective of whether the proponent is a member of the Referent Group, as project proponents often ask government for various types of concessions, such as tax breaks or subsidised loans, to make the project viable. Sometimes these concessions are necessary if the project is to proceed, and sometimes not, and the decision-maker may want this information. Some projects that do not pass the test of the market are viable from a private point of view only because of concessions such as subsidised loans. Some projects may pass the test of the market because of subsidised inputs but may fail on efficiency grounds. A decision-maker will want to look carefully at these issues in weighing up the overall merit of the project.

This introduction to cost-benefit analysis inevitably focuses on situations in which reliable measures of the value of a project's output or the cost of its inputs cannot readily be obtained from market observations: either there are significant market distortions in the form of taxes, regulations and uncompetitive behaviour, or the market for the commodity in question is absent altogether. It can be costly, in terms of the analyst's time and resources, to gather the data required to produce accurate valuations in the presence of market distortion and failure. This is particularly true in the case of market failure where expensive non-market valuation techniques are available to estimate benefits or costs. The need for a cost-benefit analysis of the cost-benefit analysis has been suggested: the analyst needs to weigh up the cost of obtaining additional and more precise information against the benefit in terms of the improved quality of the information provided to the decision-maker and the influence of that information on the decision about the project. Relevant considerations are how significant a contribution a commodity is likely to make to the overall project benefit or cost, how large the discrepancy is likely to be between the market price (if it exists) and the shadow-price, and the cost, in terms of time and resources, of calculating the shadow-price.

Subsequent sections of this review deal with: discounted cash flow analysis; competitive pricing, market distortions and failure; financial analysis of a project from the viewpoint of the market and the proponent; economic analysis to assess the efficiency of resource allocation; the use of shadow-prices to value project outputs and inputs; assessing the project from the viewpoint of the Referent Group; the structure of the spread-sheet cost-benefit model; a simple case study application of the model; valuing non-marketed commodities in the analysis of economic efficiency; a range of special topics relating to economic efficiency; and brief discussions on dealing with risk and uncertainty, project selection, and the impact of a project on the level of economic activity. A further case study is introduced in Appendix 2.

2. The Discounted Cash Flow Model

The discounted cash flow (DCF) model is used to calculate a project's net present value (NPV) or internal rate of return (IRR). The model enters all receipts/payments at the time they are received/incurred. For convenience values are generally grouped by calendar year: receipts and payments occurring in the calendar year in which construction of the project commences are treated as occurring *now* – that is in Year 0; values occurring in the following calendar year are considered as occurring in Year 1 of the project, a year from now, and so on. In the case of a very short project life, or a very high discount rate, values could be grouped by shorter time periods – 6-monthly, say – and the discount rate adjusted accordingly, but this would be an unusual situation.

Receipts are entered as positive dollar values and payments as negative values. When receipts and payments for a particular year are summed the net value of the project for that year is obtained. The net values for all the years of the project's life constitute the time-stream of net benefits. Typically the net benefit time-stream shows negative values in the early stages of the project when the facility is being constructed, and mostly positive values thereafter. When the net benefit time-steam is discounted back to the present, using an appropriate rate of interest (termed the discount rate, and usually assumed not to vary over time), the NPV of the project is obtained. The IRR is calculated as the rate of discount that would make the NPV exactly zero: as discussed in Chapter 2 of the text, this calculation can produce misleading results when the net benefit time-stream contains more than one change of sign. The IRR, expressed as a proportion, can be thought of as the average annual net benefit per dollar of resources invested in the project over its life. These values are calculated in Excel using the financial functions NPV and IRR.

A net benefit stream, starting in Year 1, which is constant over time and has an infinite duration is termed a *perpetuity*. The present value of a perpetuity is calculated simply as B/r, where B is the annual net benefit and r is the discount rate. While such time streams do not literally occur in practice, they can resemble the finite net benefit stream of a long-lived project such as a forest plantation and provide a simple way of calculating an approximate present value by mental arithmetic.

The analyst has a choice as to whether to value commodities at *real* or *current* prices. The real price of a commodity is its price at time zero – the starting point of the time stream of net benefits. The current price is the price of the commodity at the time it is bought or sold. The difference between the real price and the current price of a commodity is the amount by which the price has changed (usually increased) in the intervening period. Much of this increase will be due to inflation, but some may be due to relative price changes – the commodity price rising or falling relative to the prices of other commodities.

Inflation can be dealt with in two ways in the DCF analysis: all commodities can be valued at their real prices and a real rate of discount, r, used to calculate NPV; or all commodities can be valued at their current prices and a money rate of interest, m, used to calculate NPV. Since the money rate of interest is determined by the formula: $m=r+i+ri$, where i is the rate of inflation, the two methods yield the same result; in other words, the discount factor $[1/(1+r)]^t$ is the same as $[(1+i)/(1+m)]^t$. Since the former method, using the real rate of discount, is computationally much simpler than the latter it is the preferred method of dealing with inflation. However when choosing the discount rate, or considering a project's IRR, it is important to remember that it is money rates of interest that are published in the financial press and the expected rate of inflation must be subtracted from the quoted rate, according to the above formula, to give a real rate of interest.

When a significant relative price change for a key commodity is anticipated over the life of a project, such as, for example, the price of timber to be used in the evaluation of a forestry project, the real relative price of the key commodity can be calculated by inflating at the expected rate of price inflation of the commodity, i_c, and deflating by the expected rate of general inflation. The appropriate price in year t is: $P_0[(1+i_c\ )/(1+i)]^t$, or equivalently $P_0(1+i_r)^t$, where P_0 is the price in Year 0 and $i_r = (i_c–m)/(1+m)$, the rate of relative price inflation. By means of this price adjustment the analysis can still be conducted in real terms even although the price of the key commodity is inflating at a rate different from the general rate of inflation. Outdoor recreation services provide an example of a commodity for which the shadow-price is rising at a rate faster than the general rate of inflation: the shadow-price reflects supply and demand conditions, with supply tending to be reduced as land development takes place and demand tending to increase as per capita income rises.

The Market and Proponent Analyses deal with market values and consequently the time streams of revenues and costs are actual cash flows. As well as flows of marketed inputs and outputs, the Efficiency and Referent Group Analyses deal with effects, such as the environmental effects of forest projects, which are not traded in the market. These non-traded effects are subject to non-market valuation techniques which estimate dollar values of their benefits or costs. The dollar values appear as cash flows in the spread-sheets although they do not represent sums that are actually paid or received by anybody. While they might be more accurately termed *value flows* they are treated the same as cash flows in the cost-benefit analysis.

It is important to understand that depreciation allowances and interest payments are not a cost item in DCF analysis. From an economic point of view depreciation is a flow of annual capital costs which, when discounted back to the present, equals the present value of the project's capital cost. Since the DCF model includes capital costs as annual entries in the initial years of the project's life these costs are brought to a present value as part of the calculation of NPV. If economic depreciation were also included as a cost item capital costs would have been included twice in the DCF analysis. For this reason depreciation must be ignored in DCF analysis. As with depreciation, interest costs are part of the cost of using capital and the capital costs are already measured directly in the initial years of the net benefit time-stream.

However depreciation and interest flows cannot be ignored in the Proponent Analysis because they represent tax deductions, and the return to equity is net of project taxes and loan financing. Taxable income is defined as revenues less operating costs less interest payments less depreciation. In this calculation depreciation deductions are calculated according to the rules established by the tax authorities and they seldom conform to economic depreciation. Interest payments depend on the conditions of the loan negotiated to fund the project. Once taxable income has been calculated and the business income tax due is established, the net return to the equity holders can be calculated as earnings less interest, capital repayment and tax payments. The present value of this cash flow, and the corresponding internal rate of return, summarizes the performance of the project from the viewpoint of the project proponent (the equity holders). Annual interest and capital repayments, which depend on the rate of interest and the repayment period for the loan, can be calculated using the Excel financial functions IPMT and PPMT.

In the Market and Proponent Analyses the interest rate to be used to calculate NPV or to be compared with the IRR is set by the market. Different industries are perceived to involve different risks and the financial press publishes required rates of return (RRR) for projects undertaken in these industries. The RRR is the after-tax rate of return required by the equity holders if they are to allocate capital to the project as compared with undertaking an alternative project. The RRR measures the opportunity cost of equity capital. It follows that the Market Analysis evaluates a project as if it were to be entirely financed through equity in a business income tax-free environment, whereas the Proponent Analysis takes account of taxation and the amount of financial gearing chosen. Gearing, together with business income tax liabilities, means that the Market and Proponent Analyses will generally produce different estimates of IRR, raising the possibility, noted earlier, that a project which fails the test of the market could appear attractive to the proponent because of the availability of a subsidised loan.

The Efficiency and Referent Group accounts in the spread-sheet investment analysis model take a different perspective to the Market and Proponent accounts. Here the emphasis is on returns to the economy as a whole or to a subset of the economy. The appropriate interest rate to use in DCF analysis of economy-wide benefit and cost streams is one that reflects the time preference of society as a whole. Volumes have been written on this question, which is particularly important in the case of long-lived forestry projects, and it is discussed briefly in Section 11.4. It is recommended that sensitivity analysis should be conducted using a range of discount rates, including those favoured by the jurisdiction in question. A range of discount rates specified by various jurisdictions at various times is reported in Table 4, Section 11.4, and these rates may be subject to revision.

The cash or value flows subjected to DCF Analysis are projections into the future and can be termed expected values. Each of these values is subject to risk, as measured by the variance of its probability distribution around the expected value, and the expected value itself may be subject to uncertainty. The effect of risk and uncertainty is considered briefly in Section 12.

3. The Market Analysis

In the Market Analysis the project inputs and outputs are valued at market prices and a net cash flow is calculated. Since prices are location-specific the relevant output or input prices are those for outputs sourced from, or inputs delivered to, the project location, which may be a remote forest site. The physical flows of project inputs and outputs, together with their prices, are generally available to the analyst from the project description, but it is important to recognise that a large amount of work goes into preparing this information. In the case of a forestry project many weeks of work by scientists, engineers, industry specialists and economists may be involved in designing the project and identifying the commodity flows and the input and output prices involved.

Cost-Benefit Analysis can contribute to project design - determining the appropriate scope, scale, technology, location and timing of the project. For example, a forestry project might be considered as a number of sub-projects producing different outputs, such as timber, pulp and soil conservation, and with some costs in common. Cost-Benefit Analysis can be undertaken to evaluate the *incremental* benefits and costs associated with adding the pulp sub-project to the timber sub-project, for example. If the incremental effects of the pulp sub-project have a positive NPV the combined timber-pulp project becomes the preferred project. Now the incremental effects of the soil conservation project can be analysed in a similar way and incorporated in the scope of the preferred project if their NPV is positive. Similar incremental analyses can be conducted to determine the best scale, technology (labour or capital intensive, for example), location and timing (rotation age, for example) of the proposed project.

Rotation age is an important feature of the design of a forest plantation project and marginal cost-benefit analysis can be used to determine it by implementing the Faustmann Rule. Suppose that at the start of each year the manager of the plantation has the choice of either continuing to grow the trees for another year in order to gain an increase in the stumpage value of the timber (the marginal benefit), or to cut the trees and sell them together with the vacant site and place the proceeds in the bank to earn interest over the year (the marginal opportunity cost). As long as marginal benefit exceeds marginal opportunity cost the optimal rotation age has not been reached, and *vice versa*. The optimal rotation age is that at which marginal benefit equals marginal cost. In practice this simplified decision-rule needs to be augmented to take account of factors such as non-marketed benefits, risk and changes in site productivity over time due to factors such as climate change.

Project costs include capital expenditures, investment in working capital, and operating costs, while benefits take the form of sales revenues and residual or salvage values. Capital costs are costs of construction, equipment and installation incurred in the initial years of the project's life, Years 0, 1 and 2 for example, while operating costs of labour and materials are incurred thereafter. Capital costs are expected to be recouped gradually over the life of the project, whereas operating costs are normally met out of sales revenue (otherwise the profit-maximising firm would cease to operate). Investment in replacing worn out equipment may also be required at intermediate stages of the project's life. Because it important to have an uninterrupted flow of materials a project will usually maintain a stock of *working capital* that can be drawn on in the event of any interruption to input supply. The investment in working capital takes place in the initial year of the operation of the project and the capital is drawn down in the terminal year. The working capital stock can be visualised as a shed which is stocked with quantities of various inputs at the start of operations: over the life of the project these quantities are drawn down from time to time to smooth out fluctuations in deliveries, and restocked from the regular flow of input purchases; at the end of the project's life the contents of the shed will be allowed to run down. The implications of this way of viewing working capital are that an investment of, say, 6 months' supply of materials is made in the first year of the project's operation, and that a credit of the value of 6 months' materials supply is applied against the operating costs in the last year. At the end of the last year the project is discontinued and residual or salvage values of buildings and equipment may accrue as benefits. Some costs of dismantling the project, such as land regeneration expenses, may also be incurred. Revenues may be received annually over the project life, or intermittently as in the case of a timber harvesting operation.

The existence of various kinds of indirect taxes or subsidies can generate two prices for a commodity traded in the market – the before-tax and the after-tax price. An indirect tax drives a wedge between the price the seller receives, P_S, and the price the buyer pays, P_B: $P_B = P_S (1+t)$, where t is the proportional rate of *ad valorem* tax (see Figure 1). In the case of a subsidy, the price the buyer pays is less than the price received by the seller: $P_B = P_S (1-s)$, where s is the *ad valorem* subsidy. *Ad valorem* taxes are the most common type of indirect tax, but some commodities are subject to a specific tax – a fixed charge per unit of the commodity sold. In the case of a specific tax: $P_B = P_S + T$, where T is the dollar per unit charge. When we refer to market prices in the Market Analysis we mean the price the buyer pays for a commodity. For example: in the Market Analysis outputs and inputs are priced inclusive of indirect tax; labour is priced at the wage plus payroll tax; where fuel is subject to excise tax it is priced inclusive of tax, where it is subsidised it is priced net of the subsidy; and output of timber is valued at the price inclusive of tax or royalty.

The project's net revenue time stream, at market prices, is subjected to discounted cash flow analysis, using a range of discount rates including the market rate of interest (the rate of interest on government bonds of equivalent maturity to the project life) and the required rate of return for the type of project in question. A positive NPV at the market rate of interest, or an IRR in excess of the interest rate, suggests that the project is viable from the viewpoint of the market. This analysis of the project is necessarily incomplete because the project may not be viable from the viewpoint of the proponent, and, as will be discussed in detail in the Efficiency Analysis, some market prices may not accurately measure benefits or costs from an economy-wide point of view and some project inputs or outputs may not be traded in the market and are consequently omitted from the Market Analysis.

The advantage of the Market Analysis is that it gives an estimate of the viability of the project without any of the distortions which can be introduced by financial gearing, capital depreciation conventions and business income taxation. It is also a convenient way of assembling the information required for the subsequent stages of the cost-benefit analysis.

4. The Proponent Analysis

While the discussion here is based on the assumption that the project proponent is a private firm, the proponent could be a government department, public corporation or a combination of government and private entities, as in the case of a public private partnership (PPP). The same principles of analysis apply as in the case of a private firm, but the nature of the debt, tax or other cash flows will differ from case to case. It is not possible to generalise about this but the appropriate procedure can readily be ascertained through discussion with the proponent.

In the case of a private firm the result of the Proponent Analysis is an estimate of the after-tax IRR on equity capital. This value can be compared with the firm's required rate of return on equity to determine whether the firm considers the project to be viable or not. The result of this analysis can be used by the decision-maker to change the terms under which the project is approved, either to make it more or less profitable depending on the circumstances.

Since the whole is the sum of its parts we can divide the net cash flow calculated in the Market Analysis between the private firm and others, usually consisting of the debt holders and the government. The debt holders receive interest and capital repayments and the government receives direct tax payments in the form of business income tax, and indirect taxes levied on project output. Indirect taxes levied on project inputs are not included in the net cash flow calculated in the Market Analysis because inputs are costed at prices including tax. In practice the first line of the Proponent Analysis is the net revenue flow copied from the Market Analysis. From this flow indirect taxes on output are subtracted to derive the EBITDA (Earnings Before Interest Tax Depreciation and Amortisation) net cash flow. The return to equity holders is then calculated as the residual once the debt and direct tax flows have been netted out from EBITDA.

The effect of borrowing is to reduce the initial capital contribution of the equity holders in return for the interest and capital repayments once the project is producing a net revenue flow. If the amount and term of the loan and the rate of interest are known it is a simple matter to use Excel to calculate the annual interest and capital repayments. These are subtracted from the EBITDA, and the initial loan is subtracted from capital cost, to calculate net earnings after interest and amortisation. Business income tax is calculated as the tax rate multiplied by the tax base which is generally specified as net earnings less interest payments and depreciation allowances. Once the tax due has been calculated it is subtracted from earnings after interest and amortisation to give the time-stream of the net earnings accruing to equity holders. The net earnings are brought to a present value, using a range of discount rates, and an internal rate of return is also calculated, again using Excel financial functions. It should be stressed that depreciation is not subtracted from net earnings in this discounted cash flow analysis; the only reason for considering depreciation allowances was to calculate the business income tax liability of the firm.

Full consideration of indirect tax/subsidy flows is deferred until the Referent Group Analysis. Since the Proponent Analysis values outputs net of indirect tax and inputs inclusive of indirect tax, the calculation of return to equity holders counts such tax payments as costs of the project, and subsidies as benefits. However from a government viewpoint indirect tax flows are a benefit and subsidies are a cost. To anticipate, indirect tax or subsidy revenue flows may be considered as a benefit or cost of the project from the viewpoint of the community and will appear in one form or another in the Referent Group Analysis which summarises the overall net benefit of the project to the economy. The exact nature of the benefit or cost represented by the indirect tax or subsidy flows depends on whether the taxes or subsidies are distorting or corrective in nature.

An indirect tax generally reduces the annual quantity traded of the commodity to which it is applied. In most cases the effect on quantity traded is an unintended consequence of the government's need for tax revenue. Economists would argue that in general the reduction in quantity demanded and supplied caused by the imposition of an indirect tax lowers the level of economic welfare since, at the market equilibrium, consumers are willing to pay more for an extra unit of the good, P_B, than it costs to produce, P_S (see Figure 1). We refer to such a tax as *distorting*.

However some indirect taxes are intended to discourage consumption of a commodity – the tax on diesel fuel, for example. The argument is that while the marginal cost of producing a litre of fuel is offset by the benefit the purchaser receives, there are additional costs to the community of fuel consumption in the form of health effects and depletion of a non-renewable resource. The decision to use fuel, it is argued, should be based on the full marginal cost of consumption – the cost of fuel production plus the *external cost* of the community health and depletion effects – to ensure that the willingness to pay for the product is at least equal to its full marginal cost to the economy. An indirect tax, which represents the marginal cost of the external effects, is imposed as a premium to the supply price of diesel so that the consumer bears the full marginal cost of consumption of the product; such taxes, which have the intended effect of reducing quantity demanded, are termed *corrective*. Since subsidies reduce government net revenue it may seem reasonable to assume that their only purpose must be corrective, although, to put it mildly, not all subsidies are designed with economic efficiency in mind. The treatment of indirect taxes or subsidies in cost-benefit analysis is discussed more fully in the section on valuing non-marketed commodities in the Efficiency Analysis.

5. The Efficiency Analysis I: Valuing Marketed Commodities

The Efficiency Analysis conducts what most economists would regard as a standard cost-benefit analysis of the project. As argued elsewhere, there are various advantages to examining the project from four different viewpoints in a spread-sheet framework, but this approach incorporates, rather than substitutes for, the traditional analysis. The traditional approach is the *with-and-without* analysis discussed in the Introduction: it compares the net benefits of the project with the net benefits which would have accrued had the resources devoted to the project – the land, labour, capital and materials – been used in an alternative way. To make this comparison it is necessary to specify, in general terms, the nature of the world without the project – what kinds of alternative uses for the project inputs are likely – as well as considering the value of the output of the project.

The Efficiency Analysis is similar to the Market Analysis in that all project outputs and inputs are valued and expressed in the form of cash flows. The Market Analysis takes into account only those inputs or outputs which have market prices – in effect it prices non-marketed commodities at zero. The non-marketed commodities generated by the project are termed *external* or *indirect* effects, and, as noted earlier, these are particularly important in the case of forestry projects. Examples are positive externalities, such as carbon sequestration, flood control and salinity reduction, or negative externalities such as loss of wildlife habitat or stream sedimentation, and such effects need to be identified and taken into account. This is accomplished by subjecting them to non-market valuation techniques with the resulting values being included as benefit or cost flows in the Efficiency Analysis. Where market prices *are* available to value commodities associated with the project they may fail to measure marginal benefit or cost to the economy because of market distortions, and alternative measures, termed shadow-prices, need to be constructed and used to calculate values. While the result of the Efficiency Analysis can be summarised in the form of a net cash flow it actually represents a net value flow constructed from the values of the various marketed and non-marketed effects of the project. A project with a positive NPV in the Efficiency Analysis represents an efficient allocation of resources provided that there is no lower cost way of obtaining the project benefits.

By *efficient* in this context we mean that, in theory, the net benefits could be distributed in such a way that no member of society would be worse off as a result of undertaking the project, and some people would be better off. While some redistribution of net benefits is sometimes built into the design of a project – by charging road tolls, for example – the cost-benefit analysis does not evaluate the income distribution effects of the project. However the Referent Group Analysis can provide a detailed break-down of the distribution of benefits and costs and a summary of the net effect of the project on each sub-group in society. The decision-maker can take this distribution into account, either formally through a set of explicit weights, or informally through subjective assessment, in evaluating the project.

We will discuss first the valuation of outputs and inputs which are already traded in a market and defer discussion of non-marketed effects until Section 10. As noted earlier, markets can generally be assumed to be perfectly competitive unless information is available to the contrary. When the market for a commodity is approximately competitive and undistorted the market price, determined by the intersection of the demand and supply curves is used for valuation purposes; the price measures both the consumer's willingness to pay for an extra unit of the commodity (its marginal benefit) and the producer's cost of producing that unit (its marginal cost). Under imperfect competition or market distortions, however, there are two different price signals provided by the market – one reflecting demand conditions and one supply conditions. The analyst needs to be able to decide which price is appropriate for valuation purposes.

The effect of a market distortion is to drive a wedge between the price the buyer pays for a commodity and its marginal cost. Unlike the perfectly competitive market in which each commodity has a single price, in the distorted market there are, in effect, two prices for each commodity – one representing a point on the demand curve and the other representing a point on the supply, or marginal cost, curve. The demand curve measures the benefit of an extra unit of output (marginal benefit) and the supply curve measures the cost of an extra unit of output (marginal cost). The analyst needs to decide which price is the appropriate measure of marginal benefit or marginal cost to the economy.

Before considering this issue in detail, some examples of the effects of distortions may be helpful. In each case there is a difference between marginal benefit and marginal cost, but the reasons for the gap differ:

- An indirect tax drives a wedge between the price the buyer pays and the price the seller receives for a commodity (see Figure 1);
- A regulated monopoly is permitted to charge a price which covers average cost, but because of scale economies, the marginal cost is less than average cost, and hence less than price (see Figure 2);
- An unregulated monopoly maximizes profit by hiring labour up to the point at which the marginal revenue product of labour equals the wage, and, since price exceeds marginal revenue, the value of the marginal product of labour exceed the wage (see Figure 3);
- A minimum wage is set at a level above that which would clear the market, thereby resulting in unemployment and a gap between the wage the unemployed would be willing to accept and the wage the employer must legally pay (see Figure 4);
- A tariff drives a wedge between the world and domestic prices of a commodity (see Figure 5).

With this analytical framework in mind, we now consider which of the two pieces of information provided by the uncompetitive or distorted market –the demand price or the supply price – is appropriate for valuing project outputs and inputs. Much of our attention is directed to indirect taxes or subsidies because they are easy to identify and shadow-prices can readily be calculated. In Sections 5.1 and 5.2 it is assumed that indirect taxes or subsidies are *distorting*, and the special case of *corrective* taxes or subsidies is left to Section 5.3. We start by considering project outputs.

5.1. Calculating the Value of the Project Benefits

If the project output is traded in a competitive and undistorted market there is a single price for the commodity – determined by the intersection of supply and demand - that can be used to calculate the annual value of the flow of output. If, on the other hand, the market for the output is imperfect or distorted, then, as noted above, there are, in effect, two prices for the commodity – the price the buyer pays and a seller's price measuring the marginal cost of production.

Which of these two prices is appropriate for valuation purposes depends on whether the project output satisfies additional demand for the commodity, or whether it is an alternative means of satisfying existing demand. Usually the former is the case and the appropriate price is the demand price. Each point on a demand curve measures the value to buyers of a small additional amount of the commodity. The output of a project which adds a marginal amount to current supply (satisfies additional demand) is valued at the price buyers are willing to pay for that additional amount – the demand price. For example, in the case of a distorting indirect tax the commodity would be valued at its price including tax, and additional indirect tax revenue would be credited to the government in the Referent Group Account. However it is in the nature of many projects subject to cost-benefit analysis that their output is not subject to tax.

Sometimes a project is intended as an alternative source of supply to meet current demand. In that case the value of the project output to the economy is the avoided cost of the previous source of supply, which, under competitive conditions, is measured by the supply price of the commodity. Since the overall quantity of the commodity traded in the market has not changed no additional tax revenues accrue to government. Indeed, as shown by the following example, indirect tax revenues will decline if project output which is not subject to tax replaces taxed output, as may be the case for a project replacing imports subject to a tariff.

In the case of an import-replacing project (see Figure 5) buyers are unaffected –they continue to pay the market price for the good, which is the world price plus the tariff, and they continue to consume the same quantity. The likely effect of the project is to substitute, to the extent determined by the scale of the project, more costly domestic output for cheaper imported product. In this case the value to the economy of the project output is the savings in the cost of imports – the quantity of output of the import replacing project multiplied by the world price of the good. Looking at the effect of the project in a disaggregated way, consumers are unaffected (assuming no quality differences) – neither the price they pay nor the quantity they consume has changed – the proponent breaks even, assuming competitive conditions, and the government loses tariff revenue as a result of reduced imports. The project revenue less the loss in tariff revenue is the value of project output at the world price – the benefit of the project.

To summarise: when valuing project output use the demand price when the output satisfies additional demand for the good, and use the supply price when the project output replaces existing sources of supply. In the former case the government receives additional indirect tax revenue, while in the latter there is no additional indirect tax revenue, or even a loss as in the case of the forgone tariff on imports.

5.2. Calculating the Opportunity Cost of Project Inputs

Project inputs can be grouped under the headings of materials, labour, capital and land. The opportunity cost of each of these inputs is the value of the output it would have produced in its alternative use – the world *without* the project. In a competitive and undistorted market the market price of the input measures the value of its marginal product to the user; in the case of labour, for example, the wage set in a competitive undistorted market measures the value of the output of an extra unit of labour input. As noted above, however, the uncompetitive or distorted market generates two prices for a commodity and the analyst has to decide which of the two is the appropriate price for valuation purposes.

Which price is appropriate depends on whether the input used in the project is in addition to current supply or is diverted from an alternative use elsewhere in the economy. This in turn depends on the economic environment and the particular circumstances of the project. As discussed in Section 5.5 projects in developing economies typically involve inputs in addition to those in current supply to the economy, such as otherwise unemployed labour or imported capital equipment. In developed economies project inputs are often diverted from alternative employment: skilled labour may be diverted from other jobs, or power may be redirected from an electricity grid already operating at capacity. In the following discussion, the implications of both assumptions about the source of the inputs are discussed.

Materials

In the case of materials subject to indirect taxes the price per unit the buyer pays exceeds the price the seller receives by the amount of the tax. If the materials used in the project are in addition to current supply, which is the usual case, then their opportunity cost is their marginal cost of production which is measured by the supply price before tax. If, on the other hand, because of a supply constraint, the materials are diverted from another use elsewhere in the economy their opportunity cost is the value of the output they would have produced. In the absence of an indirect tax on that output, this value is measured by the price the buyer was willing to pay for the materials – their demand price inclusive of tax. In the former case, the Referent Group Account credits the government with additional indirect tax revenue, whereas in the latter there is no change in overall purchases of the input and hence no change in tax revenues.

For an example that is not tax related, consider a regulated utility which supplies electricity at a price which is regulated to equal average cost of production (see Figure 2). Because of scale economies the average cost exceeds the marginal cost of production. If additional units of electricity are generated to supply the project the opportunity cost of those units is measured by the marginal cost of production, which is lower than the price of electricity. Suppose, on the other hand, that the electricity grid is operating at capacity and additional power cannot be generated to supply the project. In that case units of electricity are diverted from existing users to satisfy the demand of the project. Since these alternative users were willing to pay the regulated price for electricity the demand price measures the opportunity cost. To summarise: if the input is in addition to current supply the supply price measures its opportunity cost, but if it is diverted from an alternative use the demand price is the appropriate measure.

Labour

As noted earlier, market regulations, such as rent control or minimum wages, cause distortions which need to be taken into account in the Efficiency Analysis. Perhaps the most pervasive example of regulation in the economy is a minimum wage which causes a divergence between the wage paid to the employee and the marginal cost of the employee's time, and a corresponding divergence between the quantity of labour workers would like to supply and the quantity demanded by firms – *unemployment* to give it its familiar name (see Figure 4). The marginal opportunity cost of a unit of labour used in the project is measured by the market wage if the labour is diverted from employment elsewhere in the economy, but by the supply price of labour if the labour is drawn from the ranks of the unemployed. The wage measures the value of the marginal product of employed labour in a competitive market and hence measures its marginal opportunity cost to the economy; the supply price of labour is the remuneration required to induce labour to forgo an additional unit of leisure and hence is the marginal value of leisure to the economy. As will be seen later, following these procedures for pricing labour ensures that the benefit of a job to an otherwise unemployed worker is included in the Efficiency Analysis and that employment benefits can be reported in the Referent Group Analysis. To summarise: project labour hired from an alternative use should be priced at the market wage in the Efficiency Analysis, and labour hired from the ranks of the unemployed should be priced at the marginal value of its alternative use –leisure.

If competitive firms are subject to payroll tax on the labour they employ they will hire labour up to the point at which its value of the marginal product (VMP) falls to the level of the wage plus tax. The shadow-price of labour diverted to the project from alternative employment is given by the wage plus tax, whereas the shadow-price of otherwise unemployed labour is its supply price (the marginal value of leisure) not including tax. In the former case the project does not yield any increase in payroll tax revenue whereas in the latter case additional payroll tax revenue would be credited to government in the Referent Group Account.

At this point a digression on the value of leisure may be helpful. Since unemployment is involuntary we know that the unemployed worker prefers work to leisure. In other words, the value of an additional unit of leisure is less than the market wage. Some analysts take the extreme view that the unemployed place no value on their time and correspondingly adopt a edzero shadow-price to cost otherwise unemployed labour used in the project. It has even been argued that the provision of work for the unemployed reduces the level of crime and other anti-social behaviour and that the reduction in social cost should be reflected in a lower (even negative) shadow-price of labour. Most analysts agree that the activities of the unemployed, such as hobbies, sports, voluntary work, subsistence farming, hunting and gathering, generally have a value which should be recognised as an opportunity cost of employment on the project. One study of the activities of the unemployed in a developing economy indicated that the shadow-wage was around 50% of the market wage (Campbell (2008)), but analysts have used a wide range of values for the opportunity cost of time and it is a matter for informed judgement.

Most projects use both skilled and unskilled labour. It is reasonable to assume, under normal circumstances, that skilled labour would find employment elsewhere in the absence of the proposed project. This assumption may also be valid for unskilled labour in areas of low unemployment; in such areas the rate of unemployment may simply reflect friction in the working of the labour market – inevitable gaps between quitting one job and starting another. In areas of high unemployment, however, a project may provide work for labour which would otherwise remain unemployed: it may hire directly from the ranks of the unemployed, or, by hiring people from other jobs, it may create vacancies which can be filled by the unemployed. In either case, to the extent that the wage exceeds the value the worker places on his time, an employment benefit is generated. The employment benefit, which is measured as the difference between the wage and shadow-price of leisure, will appear in the calculation of Referent Group benefits.

We argued that the individual prefers work over leisure if the market wage exceeds the marginal value he places on leisure. However this argument needs to be modified when the unemployed receive payments from the government – often referred to as *unemployment insurance*. Now the wage has to be higher than the value of leisure plus the unemployment insurance payment for the unemployed to accept a job. The opportunity cost to the economy (the *social opportunity cost*) of the otherwise unemployed worker's time is the value of the forgone leisure as before, but the opportunity cost to the individual (the *private opportunity cost*) is higher by the amount of the unemployment insurance benefit. By costing labour at the marginal value of leisure the Efficiency Analysis recognises the nature of the payment to the unemployed as a *transfer* – a benefit to the worker but a cost to the tax-payer – and that it nets out of the calculation of aggregate project cost. To anticipate, in the Referent Group Analysis the employment benefit is divided between the worker and the government: the worker's share of the benefit is the difference between the wage and the combined value of leisure and the forgone unemployment insurance payment; the government's share is the reduction in the unemployment insurance payment.

The opportunity cost of otherwise employed labour is measured by the value of its marginal product (VMP) – the value of the additional output resulting from using one additional unit of labour input. As described in Figure 3, however, a profit-maximising monopoly in the output market operates where the marginal revenue product (MRP) of labour equals the wage. Since

MRP is lower than VMP (because the downward sloping product demand curve means that marginal revenue is lower than product price) the wage understates the opportunity cost of labour and a shadow-price of labour, taking account of the gap between MRP and VMP (w = MRP < VMP), should be used. Just as a monopoly restricts the supply of output in order to drive up price, so a monopsony restricts its demand for an input, such as labour, in order to drive down its price. A profit-maximising monopsony hires labour up to the point at which marginal factor cost (MFC) equals the value of labour's marginal product (VMP). Since marginal factor cost exceeds the wage (because of the upward sloping supply curve of labour), the wage is lower than the opportunity cost of labour (w < MFC = VMP) and a shadow-price of labour is required. It should be stressed that, in the absence of compelling evidence to the contrary, market structure is assumed to be competitive, with an absence of monopoly or monopsony influences.

Working on the construction or operation of a project may contribute to the development of labour skills which can be put to use elsewhere once the worker's association with the project is terminated. The annual value of additional skills is measured by the difference between the wage subsequently earned and the wage which would have been earned by the unskilled person, if he would have been employed, or the marginal value of his leisure if he would have been unemployed, had he not participated in the project. Bearing in mind that the value of a skill depreciates over time, the value of the human capital formed can be entered as a capital sum, akin to a salvage or residual value, in the last year of the project's net benefit stream.

Capital

The equity capital used in the construction of the project may represent additional supply to the economy – sourced, for example, from domestic savings or foreign investors – or it may be diverted from alternative use elsewhere in the economy. In the former case, capital is costed at its supply price, measured by the market cost of borrowing, while in the latter it is, in principle, costed at the before-tax rate of return it would have earned elsewhere in the economy. The logic underlying the latter procedure is that if the Efficiency Analysis includes as a project benefit the share of the project's return that accrues to government in the form of business income tax, it must also include as an opportunity cost business income taxes that would have been paid on an alternative displaced project. This means that it is the tax-inclusive rate of return that is appropriate for measuring the opportunity cost of equity capital when it is diverted from another use.

It should be stressed that the issue is not the forgone business income taxes *per se* from a displaced project, which, after all, are simply a transfer from business to government, but rather the fact that these taxes represent government's share in the real returns to investment. Treating private investment projects as perpetuities, to reflect the reinvestment of project returns, and ignoring debt financing, the annual after-tax rate of return on equity capital, net of the cost of risk, is given by $r = r^*(1-t)$, where r is the rate of return which can be earned from an alternative investment, r^* is the before-tax rate of return on the project and t is the business income tax rate. This means that \$1 of equity capital diverted from elsewhere in the economy would have produced an annual stream of output valued at \$r*; the annual value of this output would have been shared between the firm and government in the amounts \$r and \$r*t respectively. The annual opportunity cost of the diverted capital is the full value of the forgone output, *r** per annum.

When the capital contributed to the project is in addition to current supply it is costed at its nominal value in the Efficiency Analysis: \$1 of capital would have yielded an annual return of r to its suppliers, with a present value of \$1. When the capital is diverted from an alternative use in the economy there is an additional opportunity cost measured by the forgone business income taxes, and this can be represented as a premium on the cost of domestic equity capital. Thus the opportunity cost of equity capital diverted from an alternative use is measured by its nominal value plus an annual *capital cost premium*.

Comparing the two treatments of the cost of equity capital in terms of the relationship between the Efficiency and Referent Group Analysis, it can be seen that, in the case of capital which is in addition to current supply, the efficiency net benefit is higher by the amount of the business income tax paid by the project proponent as compared with the case in which capital is diverted from an alternative use. The reason for this difference is the fact that in the former case the business income tax is included whereas in the latter it is netted out of the efficiency net benefit through application of the capital cost premium. In the former case the Referent Group account is correspondingly higher than the latter by the amount of additional business income tax accruing to government.

The capital costs of a project are generally shared in some proportion between bond and equity holders. If additional loan funds are supplied by domestic or foreign bondholders to the project they are assumed to be diverted from consumption expenditures with an opportunity cost measured by their nominal value. If the funds are diverted from an alternative loan at the market rate of interest, r, the present value of the interest and capital repayments would have equalled the amount of the loan; in other words, the opportunity cost of the loan is again measured by its nominal value.

To summarise: if project capital is in addition to current supply it is costed in the Efficiency Analysis at its nominal value, and the business income taxes levied on the investment are included as a benefit in the Referent Group Analysis; if a portion of project capital is diverted from an alternative investment in the economy that portion is costed at its nominal value plus a capital cost premium. Capital supplied by foreign equity or bondholders, or by domestic lenders, can generally be regarded as in addition to current supply. In a relatively open economy it would be expected that additional foreign capital would normally be available to supplement domestic lending and that the proportion of equity capital diverted from alternative uses would be small. For this reason the capital cost premium is usually ignored in practice.

Land

The opportunity cost of land used in a forestry project is the net value of the output which the land would have produced in its alternative use. Land use may be subject to subsidies and regulations: in the former case the value of forgone output is calculated according to the procedures discussed in Section 5.1 above; if, in the latter case, the regulations would continue to apply in the absence of the proposed project, the value of output in its constrained use measures the opportunity cost of the land. Often the alternative use of land is in agriculture, in which case its opportunity cost is the time-stream of net returns – value of output less cost of inputs other than land – that would have been generated. Sometimes the net returns from marginal areas of land decline over time as soil degrades as a result of cropping and erosion. In that event the shadow-price representing the annual opportunity cost of the land also declines over time. Sometimes it is argued that the activities which would have occurred on the area of land selected for the project will be undertaken on some other, currently vacant, area of land, in which case the opportunity cost is the net value that would have been generated by that currently vacant area of land.

It might seem, at first sight, strange to attribute net value to an otherwise vacant area of land, but when land is described as vacant it simply means that it is currently not traded in the market because it is unable to generate goods or services with a net market value. However goods or services which are valued by the community are often generated on vacant land. Ecosystems in so-called wilderness areas help to prevent soil erosion, stream sedimentation and salinity, act as a carbon sink, provide a refuge for wildlife, supply fodder, firewood and food for hunter-gatherer societies, and recreational opportunities for members of the community, to name but a few types of ecosystem goods and services produced. On the other hand, vacant areas of land sometimes impose costs in the form of a refuge for agricultural pests, a source of weeds, risk of fire and so on which offset to some extent their beneficial effects. While such externalities, whether goods or bads, are not priced in the market they have a value or cost which must be reflected in the Efficiency Analysis through non-market valuation techniques. Instead of it seeming strange that a positive opportunity cost is attributed to otherwise vacant land the analyst should question the use of a zero shadow-price.

The opportunity cost of land is best entered as a series of annual values over the life of the project. In cases where the capital value of land is used to measure cost the residual value of the land must be entered as a benefit at the end of the project's life.

5.3. The Treatment of Corrective Taxes and Subsidies

We have seen that, in the case of distorting indirect taxes, the Efficiency Analysis prices outputs which satisfy additional demand at their tax-inclusive price, because that is the value the buyers attach to them, and inputs in addition to current supply at their before-tax price, because that is their marginal cost of production. In the case of distorting subsidies, outputs are valued at their subsidised price (the value buyers attach to them), and inputs at their unsubsidised prices (their marginal cost of production).

In the discussion in Sections 5.1 and 5.2 we were careful to label the indirect taxes and subsidies "distorting" because in some cases a different treatment is required for corrective taxes or subsidies in the CBA. A corrective tax (subsidy) is used to deter (encourage) use of an output or input which is believed to have harmful (beneficial) effects on the general public. While the output or input commodities themselves are traded in the market, and can be taxed (subsidised), their associated harmful (beneficial) effects are not traded. Such effects are termed external (or indirect) costs or benefits. Two examples will suffice to illustrate the treatment of indirect taxes and subsidies in the Efficiency Analysis in these cases – the valuation of project output which meets additional demand, or the costing of project inputs which are in addition to current supply.

Production of biofuel from forest residue may be encouraged through a subsidy on the output of a cellulosic-ethanol plant. The marginal benefit to the buyer of a litre of biofuel is measured by the subsidised price, while the value of the additional benefit to the community as a whole, in the form of the avoided external costs of conventional fuel use, is measured by the subsidy. In this case the output of the ethanol plant would be valued in the Efficiency Analysis at the before-subsidy price of ethanol, the government account in the Referent Group Analysis would be debited by the additional subsidy payment, and the economy as a whole would be credited with health and resource conservation benefits equivalent in value to the subsidy.

Diesel fuel is used in various operations associated with establishing and running a forest plantation. As we have seen, an indirect tax is levied on diesel fuel because of the health costs associated with air pollution and the non-renewability of the resource. In principle the tax is set at a rate that measures the marginal external cost to the economy of using an extra unit of fuel so that the price paid by the buyer measures the sum of the marginal production cost plus the marginal external cost. If fuel use was being costed in the Efficiency Analysis the relevant price of the input (unlike in the case of a distorting tax) would be the tax-inclusive price which measures the marginal cost of production plus the marginal cost of the external effects. In the Referent Group Account government would be credited with additional indirect tax revenue but, unlike the case of a distorting tax, the economy would be debited an equivalent amount in additional health and resource depletion costs. Where the tax on fuel has the objective of raising revenue in addition to reducing fuel use the full tax is credited to government in the Referent Group Account and only the proportion of the tax which measures additional external cost is debited.

In summary, in the case of distorting taxes/subsidies the tax/subsidy flows included in the Efficiency Analysis represent the portion of project benefit/cost to the economy accruing to or borne by the government in the form of additional tax receipts or subsidy payments. In the case of corrective taxes/subsidies these receipts/ payments are offset by additional real costs/benefits such as those resulting from higher/lower levels of air pollution and resource extraction associated with the changes in diesel fuel consumption/biofuel production discussed above. In consequence, the tax/subsidy flows which will appear as benefit/cost flows in the Referent Group Analysis will be offset by, in these examples, higher/lower health and non-renewable resource costs.

We turn now to the treatment of corrective taxes/subsidies on project outputs which satisfy existing demand or inputs which are diverted from uses elsewhere in the economy. In such cases the level of the external cost or benefit to the economy and the amount of tax revenue collected by the government remain unchanged; there is no change in the level of tax/subsidy collections/payments and there is no offsetting additional external cost/benefit as a result of the project. Here the treatment of corrective taxes/subsidies is the same as in the case of distorting taxes/subsidies discussed above.

5.4. The Efficiency Pricing Rule

Much of the discussion of pricing outputs and inputs in the Efficiency Analysis has centred on the existence of two prices generated by a distorted market for a commodity, and the question of which price measures marginal benefit or cost – the price represented by a point on the demand curve, P_B, or the price represented by a point on the supply curve, P_S, of the commodity. Table 1 summarises the conclusions which were reached:

Table 1. The Efficiency Cost-Benefit Analysis Pricing Rule.

ITEM TO BE VALUED	VALUED AT THE EQUILIBRIUM POINT ON:	
	THE DEMAND CURVE (P_B)	THE SUPPLY CURVE (P_S)
OUTPUT	SATISFIES ADDITIONAL DEMAND	SATISFIES EXISTING DEMAND FROM ALTERNATIVE SOURCE
INPUT	SOURCED FROM AN ALTERNATIVE MARKET USE	SOURCED FROM ADDITIONAL SUPPLY

As noted earlier, there are two exceptions to this rule: when a corrective tax or subsidy is in place output which satisfies additional demand is priced at the equilibrium point on the supply curve (P_S), and an input which is sourced from additional supply is priced at the equilibrium point on the demand curve (P_B).

As discussed in the next section the demand curve for an output or an input is generally the correct measure when the project is undertaken in a developed economy, and the supply curve of output or input is often the correct measure in a developing economy. However detailed information about the operations of output and input markets, such as skill shortages or capacity constraints, or about the nature of the project, import-replacing for example, or about the external effects of project outputs or inputs, may indicate that alternative assumptions should be adopted.

5.5. Application of the Pricing Rule in Developed and Developing Economies

Developed economies share the following characteristics to a greater or lesser degree: competitive markets open to foreign goods and capital, low unemployment in normal times, a broad based set of indirect taxes such as a Value Added Tax (VAT) or a general sales tax, and excise duties on a small range of commodities. This description fits most of the OECD member countries.

To conduct a cost-benefit analysis of a project in such an economy the following assumptions can be made: project output satisfies additional demand, materials and labour used in the project are diverted from uses elsewhere in the economy, and capital is provided from domestic savings or overseas sources. In such circumstances it is reasonable to use observed market prices to value all marketed commodities in the Efficiency Analysis. Non-marketed commodities, such as environmental effects, would need to be valued as described in Section 10. In effect the Efficiency Analysis would consist of the Market Analysis supplemented by a section dealing with non-marketed effects. In the Referent Group Analysis tax effects and external effects measured by corrective tax or subsidy flows could reasonably be ignored as the project involves simply reallocating existing resources, and external costs or benefits, identified by non-market valuation analysis, would continue to be transferred from the Efficiency Analysis into the Referent Group Account as usual. In circumstances of high regional or cyclical unemployment labour would be shadow-priced in the Efficiency Analysis and the employment benefits registered in the Referent Group Account.

In developing economies, in contrast, markets are less sophisticated and competitive, tariff barriers restrict the entry of foreign goods, there tends to be a high level of unemployment, and the tax system is rudimentary with heavy reliance on import duties and excise taxes. For some marketed commodities market prices will not be appropriate for calculating benefits or costs in the Efficiency Analysis: in the presence of tariff barriers both the import-replacing output of a project, and those inputs which are imported, should be valued at world rather than domestic market prices. In the Referent Group Analysis changes in tariff revenues, excise tax revenues and business income taxes are likely to be important effects of the project. Projects are likely to use otherwise unemployed labour with consequent employment benefits: labour input will routinely be shadow-priced in the Efficiency Analysis and the employment benefits transferred to the Referent Group Account. Non-marketed effects are included in both the Efficiency and Referent Group Analyses as before.

In summary, the application of the cost-benefit model to assess project efficiency in a developed economy, where the project simply involves a reallocation of existing employed resources, can be relatively straightforward with the emphasis on the Market Analysis augmented by an evaluation of the non-marketed effects as discussed in Section 10. In a developing economy, on the other hand, where project inputs tend to be in addition to current supply and output may satisfy existing demand from a domestic rather than a foreign supplier, shadow-prices may be required for a range of commodities, including labour, in the Efficiency Analysis to ensure that the tax and employment effects of the project are correctly measured and registered in the Referent Group Account. Employment benefits and changes in tax revenues may be important components of Referent Group benefits or costs. As before, the non-marketed effects of the developing country project continue to be measured in the Efficiency Analysis and included in the Referent Group Account.

6. Review of the Framework of Analysis

Before discussing the Referent Group Analysis, which summarises the information of most relevance to the decision-maker, it may be helpful to review what has been accomplished so far, and to anticipate the next stage in the discussion. The Efficiency Analysis has established the Net Present Value of the project, including all costs and benefits to all groups affected. The NPV can be partitioned into two parts: one part, represented by Areas A and B in Table 2, contains all of the benefits and costs which were measured by the Market Analysis; the other part, represented by Areas C and D, contains the values which were not measured by market prices because of market distortions and failure. For example, the returns to the proponent and the bondholders, the business income tax and the indirect tax on output are included in A+B; indirect taxes on inputs, employment benefits and non-market values are included in C+D.

Table 2. Classification of Net Benefits.

	Net Benefits Accruing to:	
	Referent Group	Non-Referent Group
Net Benefits Measured by the Market Analysis	**A**	**B**
Net Benefits not Measured by the Market Analysis	**C**	**D**

In addition to the horizontal division of NPV in Table 2 there is a vertical division – into net benefits accruing to the referent group (Area A+C) and net benefits which accrue to others. For example, government revenues, employment benefits and local non-marketed effects are included in A+C, whereas, if the project was undertaken by a foreign firm with financing from foreign banks, the Proponent NPV and the debt flows would be allocated to Area B. Area D includes project effects which neither materially affect the welfare of the Referent Group nor are measured by market prices – pollution of the High Seas might be an example.

Since the results of the Efficiency Analysis form the basis for the identification of Referent Group net benefits – the main focus of the decision-maker and the cost-benefit analysis – it is obvious that errors in the Efficiency Analysis may flow through to the Referent Group Analysis. For example, failure to shadow-price otherwise unemployed labour in the Efficiency Analysis lowers the project net benefits by the amount of the employment benefits generated by the project. If these are not included in area C in the Efficiency Analysis they will not be included in the Referent Group Analysis.

The shadow-prices used in the Efficiency Analysis provide clues as to the kinds of benefits and costs to be accounted for in the Referent Group Analysis. Shadow-prices accounting for distorting indirect taxes or subsidies suggest that the project may have indirect tax/subsidy revenue/cost implications for government. In addition, shadow-prices reflecting corrective taxes or subsidies may indicate that there are real external costs or benefits to be recorded. Shadow-pricing labour indicates that there are employment benefits to be considered. Shadow-pricing land suggests that the project leads to changed levels of land rent, and so on.

The structure of the spread-sheet model offers a test for internal consistency of the analysis: since the whole is the sum of the parts, the sum of referent and non-referent group net benefits, in each year of the project, must equal the net benefit identified by the Efficiency Analysis for that year. If this check is carried out the decision-maker can generally be confident that the analyst has correctly appraised the project given the data that were used. Since the data are prominently displayed in the opening spread-sheet of the model the decision-maker can also readily asses the quality of the cost-benefit model.

7. The Referent Group Analysis

In Table 2 the project net benefits (positive or negative) identified by the Efficiency Analysis were sliced horizontally into those measured by the Market Analysis (A+B) and those which were not (C+D). The Referent Group Analysis slices the efficiency net benefits vertically into those accruing to the Referent Group (A+C) and those accruing to outsiders (B+D). The composition of the Referent Group will depend on the circumstances of the project in question. In this discussion we will assume that the project is proposed by a foreign firm and financed by foreign banks, so that the proponent and the banks, represented by Area B in Table 2, are not included in the Referent Group. Also we will ignore the possibility of the existence of non-referent group non-marketed net benefits (Area D). All other net benefits accruing to all levels of government, to labour, landowners and the general public are, in this discussion, assumed to accrue to the Referent Group. It is important to remember that we are concerned with *changes* in levels of benefits and costs as a result of the project.

The Referent Group net benefit estimates are obtained from the Proponent and Efficiency Analysis spreadsheets. The Proponent Analysis provides the estimate of business income taxes paid by the project and indirect tax revenues on project output collected by government. Since the project is funded from abroad the former tax revenue flow can be assumed to be a net benefit to government. Whether the latter flow represents additional revenue depends on whether the project satisfies additional demand or meets existing demand from an alternative source. If the project satisfies additional demand its output was valued at the tax inclusive price in the Efficiency Analysis, whereas if it is an alternative means of meeting existing demand the before-tax price was used. In other words, in the former case the Efficiency Analysis provides for an additional benefit to government, which can be entered in the Referent Group Analysis, whereas in the latter case it does not.

Additional indirect input tax revenue flows can also be inferred from the shadow-pricing procedures adopted in the Efficiency Analysis. Where an input is in addition to current supply it is costed at its before-tax price, ensuring that the indirect tax is included as an efficiency net benefit to be transferred to the Referent Group Analysis. Where an input is diverted from an existing use it is costed at its tax-inclusive price and no additional indirect tax revenue is included as an efficiency net benefit, or in the Referent Group account.

The shadow-pricing procedures also provide a guide to the benefits or costs of external effects which are matched by corrective taxes or subsidies. In the case of a corrective tax on output which satisfies additional demand, additional indirect tax revenue, matched by additional costs to the general public, is transferred to the Referent Group Analysis. Where the project satisfies existing demand there are no such flows to be accounted for. Similarly, in the case of an input sourced from increased supply, the increased indirect tax revenues are matched by increased costs to the general public in the Referent Group Analysis, but, again, in the case of an input diverted from an alternative market use there are no corresponding revenues or costs. The treatment of corrective subsidies is analogous – increased subsidy payments are matched by benefits to the general public in the case of output which satisfies additional demand, and no change is recorded in the case in which the project is an alternative means of satisfying existing demand.

In the case of Value Added Taxes a complicating factor is the crediting of tax paid on inputs against tax due on the value of output. The Efficiency Pricing rule continues to operate but care must be taken in crediting government with tax revenues in the Referent Group Analysis. Suppose that the project being analysed is a sawmilling operation which will purchase logs, mill them and sell the sawn timber to meet the additional demand of the building industry. To make the example concrete, suppose that the VAT is levied at 10%, that the sawmill buys $110 worth of logs, including VAT, and sells them for $220, including VAT. The net benefit to the proponent of the project is $220 less $110 less the net VAT payment of $10. If the logs are in addition to current supply the Efficiency Pricing rule tells us to value the log input at $100 to give a net project value of $120. In the Referent Group Analysis the government's share of net value is the $20 VAT levied on output, plus the $10 VAT levied on input of logs minus the $10 VAT refund. If the logs are diverted from an alternative use they are costed at the VAT-inclusive value of $110 in the Efficiency Analysis, giving a net project value of $110. The sawmill's share remains at $100 and the government share is $20 VAT levied on output less the $10 refund of VAT levied on inputs. In this case there is no additional VAT collected by the industry supplying the logs to offset the refund of $10 VAT claimed by the sawmill because the logs are diverted from an alternative use where VAT would also have been levied on their sale.

If the equity capital involved in the project is sourced from increased supply, as in the case of a foreign investor, it is costed at its nominal value in the Efficiency Analysis and the business income taxes paid by the proponent are credited as additional government tax revenues in the Referent Group analysis. If, on the other hand, the equity capital is diverted from elsewhere in the economy a capital cost premium is applied in the Efficiency Analysis and this cost is netted out of any additional business income tax revenue recorded in the Referent Group account. As noted earlier, this adjustment is generally ignored in practice on the grounds that the share of project capital diverted from investment elsewhere in the domestic economy will normally be small.

Shadow-pricing labour reduces the wages cost recorded in the Efficiency Analysis and increases the efficiency net benefit by an equivalent amount. This amount measures the size of the employment benefit (or labour rent) which is transferred to the Referent Group account. Similarly, with land a shadow-price lower than the price paid by the project indicates additional rent being generated equal to the difference between the price and the opportunity cost. This difference is transferred to the Referent Group account as a benefit to landowners.

We have already seen that non-marketed effects associated with commodities subject to corrective taxes or subsidies are entered as dollar flows in the Referent Group account, with costs or benefits offsetting the revenues collected or subsidies paid. The benefits or costs of other non-marketed effects which affect the Referent Group are also transferred from the Efficiency Analysis to the Referent Group account. These take the form of time-streams of dollar values obtained from non-market valuation studies, as described in Section 10, and entered in rows in the Efficiency Analysis. The relevant rows are copied over to the Referent Group account.

We can now identify in more detail the categories of benefits and costs (defined as *changes* in levels relative to the *without-the-project* case) contained in the various sections of Table 2 which describes the allocation of the efficiency net benefits of the kind of project we have been considering - undertaken by a foreign firm and involving no non-marketed effects inflicted on the non-Referent Group, implying that Area D is empty:

Area A: business income tax revenues and indirect taxes on project output;

Area B: returns to foreign equity and bondholders;

Area C: loss of business income taxes elsewhere (if applicable); loss of indirect taxes on output elsewhere (if applicable); indirect taxes on inputs (unless inputs are diverted from uses elsewhere in the economy); employment benefits; increased rents to landowners; values or costs of non-marketed effects.

8. The Structure of the Spread-Sheet CBA Model

The spread-sheet cost-benefit analysis model consists of at least five inter-related spread-sheets: a sheet containing the data to be used in the analysis, and one sheet each for the Market, Proponent, Efficiency and Referent Group analyses. In some cases data will be obtained from several sources, for example bio-physical data from foresters, prices from industry specialists or the project proponent, and tax information from a government department. In such cases it may be convenient to have several data sheets. For a large and complicated project, such as a pulp mill, it may be convenient to treat the logging and manufacturing operations as separate but related projects and to construct Market, Proponent, Efficiency and Referent Group analyses for each sub-project, and to summarise the outcome in a Results sheet.

Whatever the arrangement of the spread-sheets, it is critical that each piece of information to be used in the analysis should be *entered only once* in the Data sheet or sheets. In all subsequent uses that piece of information is accessed as a cell reference to the Data sheet directly, or from a cell in another sheet or table which references the Data sheet. Following this principle ensures *transparency* – it can readily be seen what data are used in the analysis. It also facilitates: *data revision* – often data are refined in the course of the analysis; *threshold analysis* – critical values can be obtained by varying a single cell entry; and *sensitivity* and *risk analysis*.

Once the data have been assembled, some perhaps as preliminary values, the analyst sometimes finds it convenient to undertake some processing of the data in a Working Table section of the Data sheet, taking care to ensure that entries to the Working Table are cell references to the Data Table. This procedure reduces the complexity of the formulae to be entered in subsequent sheets.

Once any preliminary processing of the data is completed the Market Analysis is undertaken in the Market Analysis sheet. It will be recalled that this is simply a matter of valuing each output and input at its market price, calculating a net benefit stream and calculating a net present value. By convention a column is devoted to each calendar year of the project, and the values of the various inputs and outputs are recorded in rows. Benefits are recorded as positive values and costs as negative values so that the sum of benefits and costs, for a given year, is the net benefit for that year. All values occurring in the initial year of construction are regarded as occurring now (the present), all values in the subsequent year (Year 1) are regarded as occurring one year from the present and are discounted accordingly, and so on for Years 2,3 etc. It must be stressed again that all values entered in the Market Analysis and subsequent spread-sheets are in the form of cell references, either directly or indirectly *via* a working table or other sheet, to the Data sheet.

The results of the Market Analysis form the basis for the Proponent Analysis. The first step is to copy the net benefit stream calculated in the Market Analysis sheet into the top row of the Proponent Analysis sheet. Indirect taxes, if any, levied on output are calculated and subtracted from revenue to give the project net earnings flow, known as EBITDA. Interest and capital repayment flows are calculated using the IPMT and PPMT financial functions in Excel. The flow of taxable income is calculated by subtracting interest and depreciation allowances from earnings, and the tax rate is used to calculate the business income tax payable. The net benefit to the project proponent is given by net earnings less interest, capital repayments and tax. This net benefit stream can be discounted at the relevant market rate of interest to produce a net present value (using the NPV function) and an internal rate of return is calculated (using the IRR function). If the IRR is in excess of the firm's risk-adjusted cost of capital then the project is regarded as viable.

The Efficiency Analysis draws heavily on the Market Analysis – indeed sometimes the first step is to copy the Market Analysis into the Efficiency Analysis spread-sheet and to make minor revisions as appropriate. However, as we have seen, some market prices may have to be adjusted to deal with indirect taxes or subsidies or other market distortions. In addition, some benefits and costs of the project may not feature in the Market Analysis at all. Commodities not traded in the market, and hence lacking a market price, are subjected to non-market valuation techniques and the resulting benefit or cost flows are entered as rows in the Efficiency Analysis. As discussed in Section 10, a non-market valuation study can be quite elaborate, costly and time-consuming, and the analyst might prefer to enter a provisional value in the Data sheet to allow the analysis to proceed pending the availability of more precise information. If it turns out that a non-market value is too difficult to obtain the provisional value can serve as the basis of a threshold analysis once the spread-sheet analysis is complete. The spread-sheet rows are summed to give the project net benefit stream in dollar terms. The net present value is calculated using a range of interest rates, including the market rate. As will be discussed in Section 11.4, this range should also include the rate of *social time preference*.

In the case in which the project proponent and financiers are not members of the referent group, a foreign firm backed by foreign bondholders for example, the first step in the Referent Group Analysis is to enter a row consisting of the efficiency net benefit less the proponent and bondholder net benefit (Area B), and less any non-referent group net benefits not measured by market prices (Area D); in terms of Table 2, the efficiency net benefit (A+B+C+D) less (B+D) yields the Referent Group net benefit. We now know that we have to identify Referent Group net benefits that sum to the value of this row in each and every year. This provides a check on the *internal consistency* of the cost-benefit model. If all parties affected by the project were members of the referent group, then the sum of each year's referent group net benefits must equal the value of the efficiency net benefit in that year.

The detailed information required for the Referent Group Analysis is contained in the previous three sheets. Direct tax flows and indirect output tax flows are copied from the Proponent Analysis sheet. The shadow-pricing procedures adopted in the Efficiency Analysis identify the relevant indirect tax flows on inputs. Corrective taxes or subsidies indicate where real cost or benefit streams correspond to tax flows. Shadow-prices on inputs such as labour or land indicate the creation of rents which accrue as employment benefits or to landowners. Often a simple way of measuring a Referent Group net benefit, such as tax revenue, is to subtract the Efficiency cost row from the corresponding Market cost row. The results of non-market valuation studies, such as the costs of stream pollution or the benefits of soil salinity reduction, are transferred from the Efficiency Analysis and entered in rows. The Referent Group Analysis rows are summed to give the project net benefit stream in dollar terms and the net present value is calculated using a range of interest rates.

The values entered in the Referent Group analysis can be grouped according to various categories: tax revenue effects experienced by local, regional and central governments; net benefits to the local labour force or landowners; environmental effects experienced by the local community and so on. This kind of summary provides some of the information needed to assess the distributional effects of the project.

9. A Simple Illustration of the Spread-Sheet CBA Model

The Walnuts International Group (WIG) proposal to establish a plantation in Tasmania has been developed to illustrate the application of the spread-sheet cost-benefit model. While this example is wholly fictional, and its biophysical details unrealistic, it has been constructed to include many of the valuation issues discussed above. In particular the project has many of the characteristics associated with developing economies: it is import-replacing, utilises imported capital goods which are subject to tariffs, relies on a subsidised loan from government, and uses a range of subsidised inputs.

The analyst is fortunate to have been provided with all the information required to perform the cost-benefit analysis: the proponent has supplied a project summary and various government agencies have provided information about the tax regime and the markets for key inputs. Since the information was provided in spread-sheet format, the first step is to copy it into the Data Sheet to be used in the analysis. This is the only occasion in which raw data are entered; all subsequent steps in the analysis are performed using cell references to the Data Table.

Walnuts International Group: Tasmanian Walnut Plantation Project

Walnuts International Group (WIG) has applied to the Australian government for a subsidised loan, under the Rural Reconstruction Program, to establish a walnut plantation in the eastern region of Tasmania in 2014, to operate over the period 2015-29. In support of its application the company argues that the project will reduce Australia's dependence on imported walnuts, generate jobs in an area of high unemployment, and help to reduce soil salinity in the local area. WIG has revenue from other operations in Australia against which it can deduct any losses for tax purposes, and says that it would be more likely to undertake the project if it were given relief from import duties on the initial investment in equipment and vehicles. Industry sources suggest that WIG requires a real rate of return of 8% on its equity capital. The Tasmanian government is broadly supportive but has expressed concern about the use of fertilisers and insecticides causing stream pollution which will adversely affect coastal oyster farms. The Australian government has commissioned a cost-benefit analysis of the project and the Tasmanian government has asked for a separate analysis of the effects on Tasmania. As part of its application WIG has supplied the following information about the project:

Walnuts International Group - Tasmanian Walnut Plantation Project (2014 - 2029)

Investment Costs		Number	Price ($/unit)	**Operating Costs**		Units pa	Price/Unit
(i) Fixed Investment (2014)				Rent on land (Ha)		100	30
Farm Equipment (units)		4	100000	Fuel (litres)		2500	0.7
Vehicles (units)		3	30000	Seeds (Kg)		250	20
Buildings (m2)		250	1000	Fertilizers (tonnes)		3	500
(ii) Working Capital (2015)				Insecticides (litres)		3000	30
Fertilizer Stocks (tons)		2	500	Water (ML)		900	20
Insecticide stocks (Litres)		2500	30	Spare Parts (units)		12	1000
Spare Parts (units)		10	1000	Casual labour (days)		100	60
Fuel stocks (Litres)		500	0.7	Administration (units)		12	1000
(iii) Salvage Value (% of fixed investment)			10%	Insurance (units		1	8265
(iv) Land Rehabilitation Cost (2029)			50000	Management (units)		12	3000
(v) Depreciation		Life(yrs)*		Miscellaneous (units)		1	7700
Equipment		10		**Revenues**			
Vehicles		5		Walnuts (tons)		100	3000
Buildings		15		Timber (m3 in 2034)		100	1000
(vi) Financing	Term (yrs)	Amount	Interest Rate	*Capacity Output*			
Loan (Government)	10	700000	4%	2015	2016	2017	2018+
Overdraft (Aus. Bank)	4	40000	8%	25%	50%	75%	100%

*These are book lives for tax purposes and none of the capital will need to be replaced during the life of the project.

Various government agencies have provided further information about the project:

Australian Treasury		**Bureau of Land Management**	
Taxes, Subsidies, Duties & Rates		Cost of stream pollution ($ pa)	10000
Taxes		Benefit of reduced salinity ($ pa)	5000
Fuel tax*	10%	Opportunity cost of land (% of market rent)	30%
Business Income Tax	30%	**Department of Employment**	
Subsidies		Opportunity cost of labour (% of wage)	50%
Seed subsidy	25%		
Fertilizer subsidy	30%		
Insecticide subsidy	20%		
Water subsidy	40%		
Import duties			
Spare Parts	10%		
Equipment	10%		
Vehicles	25%		
Walnuts	10%		
Market Rate of Interest	5%		
Expected Rate of Inflation	2.5%		

*to discourage use because of health effects

1	**DATA SHEET**													
2	**Walnuts International Group - Tasmanian Walnut Plantation Project (2014 - 2029)**									**Australian Treasury**		**Bureau of Land Management**		
3	**Investment Costs**		Number	Price ($)	**Operating Costs**			Units pa	Price/Unit	**Taxes, Subsidies & Rates**		Cost of stream pollution ($ pa)		10000
4	*(i) Fixed Investment (Yr 0)*				Rent on land (Ha)			100	30	*Taxes*		Benefit of reduced salinity ($ pa)		5000
5	Farm Equipment (units)		4	100000	Fuel (litres)			2500	0.7	Fuel tax*	10%	Opportunity cost of land (% of rent)		30%
6	Vehicles (units)		3	30000	Seeds (Kg)			250	20	Business Income Tax	30%	**Department of Employment**		
7	Buildings (m2)		250	1000	Fertilizers (mt)			3	500	*Subsidies*		Opp cost of labour (% of wage)		50%
8	*(ii) Working Capital (Yr 1)*				Insecticides (L)			3000	30	Seed subsidy	25%			
9	Fertilizer Stocks (tons)		2	500	Water (ML)			900	20	Fertilizer subsidy	30%			
10	Insecticide stocks (Litres)		2500	30	Spare Parts (no.)			12	1000	Insecticide subsidy	20%			
11	Spare Parts (units)		10	1000	Casual labour (days)			100	60	Water subsidy	40%			
12	Fuel stocks (Litres)		500	0.7	Administration (units)			12	1000	*Import duties*				
13	*(iii) Salvage Value (% of fixed investment)*			10%	Insurance (units)			1	8265	Spare Parts	10%			
14	*(iv) Land Rehabilitation Cost (2029)*			50000	Management			12	3000	Equipment	10%			
15	*(v) Depreciation*		Life(yrs)		Miscellaneous (units)			1	7700	Vehicles	25%			
16	Equipment		10		**Revenues**					Walnuts	10%			
17	Vehicles		5		Walnuts (tons)			100	3000	*Market Rate of Interest*	5%			
18	Buildings		15		Timber (m3 in 2034)			100	1000	*Expected Rate of Inflation*	2.5%			
19	*(vi) Financing*	Term	Amount	Interest	*Capacity Output*					*to discourage use because of health effects				
20	Loan	10	700000	4%		2015	2016	2017	2018+					
21	Overdraft	4	40000	8%		25%	50%	75%	100%					
22	**Working Table**													
23	**Investment Costs**		*Efficiency*	*Market*	**Operating Costs**			*Efficiency*	*Market*	**Revenues**	*Efficiency*	*Market*	**Financing**	
24	*(i) Fixed Investment*		*Price ($)*	*Price ($)*				*Price($)*	*Price($)*		*Price ($)*	*Price ($)*	**Real Interest Rates**	
25	Farm Equipment		90909	100000	Rent on land (Ha)			9	30	Walnuts	2727	3000	Loan (Aus. Govt.)	1.5%
26	Vehicles		24000	30000	Fuel (litres)			0.6	0.7	Timber	1000	1000	Overdraft (Bank)	5.5%
27	*(ii) Working Capital*				Seeds (Kg)			26.7	20.0		*Efficiency*	*Market*	Market Rate	2.5%
28	Fertilizer Stocks		714	500	Fertilizers (mt)			714.3	500.0	**Capital Costs**	*Prices*	*Prices*	**Discount Rates**	2%
29	Insecticide Stocks		37.5	30	Insecticides (L)			37.5	30.0	Fixed Investment Cost	685636	740000		4%
30	Spare Parts Stocks		909	1000	Water (ML)			33.3	20.0	Working Capital Cost	104619	86350		6%
31	Fuel Stocks		0.6	0.7	Spare Parts (no.)			909	1000	**Annual Costs & Revenues**				
32					Casual labour (days)			30	60	Operating Cost	231834	201215		
33										Revenues	272727	300000	**Conversion Factor**	1000

In discussion with the client (the Australian Government) the analyst has established that, as a fully foreign owned firm, WIG is not to be included in the Referent Group, but that the Australian bank providing the overdraft is to be included. In assessing the information provided, the analyst needs to make some judgements about the sources of the various project inputs. Given the developing country context, and in the absence of information to the contrary, it can be assumed that they are all in addition to current supply. The fuel tax is explicitly described as a corrective tax but all other indirect taxes and subsidies can be assumed to be distorting in nature. In addition to the subsidies on project inputs WIG is hoping to receive a subsidised loan from government. Since the project is described as import-replacing in nature its output can be assumed to be an alternative to imports as a means of satisfying existing demand.

In order to simplify the process of undertaking the various stages in the analysis a Working Table is completed, as cell references to the Data Table, prior to entering values in the Market, Proponent, Efficiency and Referent Group sheets. This Table calculates costs and benefits at market and efficiency prices before copying them into the relevant sheets. Since the information supplied to the analyst is mostly at market prices, efficiency prices have to be calculated using the information supplied by the various government departments. In the case of subsidies, for example, the efficiency price, P_S, is determined by the following relationship: $P_B = P_S(1-s)$,where P_B is the market price. Since a change in the subsidy rate would change the market price, not the efficiency price, we first calculate the efficiency price, P_S, from the market price, P_B, using the above formula, and then fix it as a value in the Working Table. We then enter the market price as a formula based on the efficiency price. This procedure ensures that if we are asked to assess the effect of changing a subsidy or tax rate, as, for example, if WIG were allowed to import their equipment and vehicles free of import duty, it would be the market price that would be affected by setting the tariff equal to zero, not the efficiency price (the world price in this example).

The analyst has been asked to provide a break-down of the Referent Group net benefits between the Australian Government and Tasmania. The Australian government receives the benefit of any taxes and bears the cost of any subsidies (apart from the water subsidy which is provided by the Tasmanian government), while the employment benefits and changes in land rent, health costs (caused by increased fuel use), stream pollution and soil salinity are assumed to affect Tasmania.

Once the Market, Proponent, Efficiency and Referent Group spread-sheets are completed a check is carried out on the internal consistency of the analysis. The aggregate Referent Group net benefit is entered as the first row in the Referent Group sheet; this row is obtained, for this project, by subtracting the proponent net benefit row from the efficiency net benefit row. The disaggregated Referent Group net benefits are then entered and their sum should equal the aggregate net benefit in each and every year. The model can then be tested for robustness by varying the values of the taxes, subsidies and shadow-prices in the Data Sheet to ensure that the check remains valid.

The remaining spread-sheets (included in Appendix 1 to this chapter) are not discussed in detail but a few comments may be helpful. It will be seen that project calendar years are represented by numbers, with the year of the initial investment (2014) set at Year 0. These numbers are used in the IPMT and PPMT financial functions to calculate annual interest and loan repayments. Real rates of interest, calculated on the basis of Treasury's inflation forecast, are used in all financial function operations: the real rate is calculated as the nominal rate (5%) less the expected rate of inflation (2.5%), and, as discussed earlier, all values are at real prices (not adjusted for inflation). When values are transferred from the Working Table to the other spread-sheets they are converted, in this case, to thousands of dollars by means of a conversion factor. Investment in working capital appears as a cost in Year 1 and a benefit in Year 15, the latter reflecting cost savings as withdrawals from stocks replace input purchases. In this case there are implications for tariff revenue in both these years. While it takes four years for output to reach capacity, it is assumed that the full operating cost is experienced in each of years 1-3. It is assumed that the government takes out a loan, at the market rate of interest and for the term of the loan, to provide the subsidised loan to WIG; the amount of the subsidy, reported in the Efficiency and Referent Group accounts, is the difference between the annual cost (interest and repayments) of the two loans. In this example it is assumed that WIG can deduct losses in early years against income earned from other projects in Australia.

The results of the cost-benefit analysis of the WIG proposal are reported in Appendix 1 as NPVs calculated for a range of real rates of discount. Since the Excel NPV function calculates the present value of a series of payments starting one year from the present, the cells containing the project net benefits from Year 1 onwards should be entered in the function, and the Year 0 capital cost (expressed as a negative number) added separately. As discussed below, there are various opinions about the appropriate discount rate to be used in the Efficiency and Referent Group Analyses and the intention here is to provide information about the sensitivity of the results to a range of rates including the market rate of interest.

Table 3 reports the results of the analysis of the WIG project in terms of the classification illustrated in Table 2. Slicing the Table horizontally the NPV (at a 4% discount rate) obtained by the Market Analysis (Area A+B) is -$29.6 thousand; slicing it vertically the Referent Group NPV (Area A+C) is -$862.6 thousand. The overall net benefit according to the Efficiency Analysis (Area A+B+C+D) is -$679.7 thousand.

Table 3: Net Benefits of the WIG Project ($000's NPV @ 4%)

Area A:	**-$212.5**	**Area B**:	
Federal Direct Taxes:	-$130.2	Proponent NPV:	**+$182.9**
Government Loan:	-$84.4		
Bank Loan:	+$2.1		
Area C:	**-$650.1**	**Area D**:	
Indirect Taxes & Subsidies	-$516.0	$0	
Water Subsidy:	-$133.4		
Labour & Land Rents:	+$56.7		
External Effects:	-$57.4		

From WIG's point of view the Tasmanian plantation is a viable project, yielding a 9.1% internal rate of return (IRR), which is above the cost of equity capital, and if import duties on equipment and vehicles were waived, as requested, the rate of return would rise to 10.6%. According to the Market Analysis the project is barely viable, with an IRR of 3.7%, just above the real market rate of interest. However its market viability stems from the subsidies on inputs and the high domestic price of walnuts resulting from the tariff. According to the Efficiency Analysis the IRR is negative 5%: the net benefit stream is strongly negative in the first few years of the project's life with positive values subsequently. If the net benefit stream were considered as a loan and the associated repayments, it would not be recouped even at a zero rate of interest. This explains why in the Efficiency Analysis the project NPV becomes *larger* in absolute value as the discount rate is increased. Since the present values of the net benefits of the project to the Referent Group are strongly negative the project would not be recommended.

10. The Efficiency Analysis II: Valuing Non-Marketed Inputs or Outputs

Many forestry projects have effects which are not traded in the market, and consequently are not accounted for in the Market Analysis, but nonetheless are valued by individuals or firms, affect the level of economic welfare, and must be included in the Efficiency Analysis. Analysts distinguish between *use* and *non-use* values. For example, access to the forest for recreational purposes generates a *direct* use value, while soil salinity reduction generates an *indirect* use value. An individual who regards conservation of ancient trees as important derives a non-use value from preservation of the forest without necessarily having any direct or indirect physical contact with it. It is necessary to include in the Efficiency Analysis these kinds of benefits or costs in terms commensurate with the measures of the other benefits and costs of the project – dollars – if the cost-benefit analysis of the project is to be complete.

It may be instructive to consider why there is no private market for these kinds of project effects. Markets exist to trade ownership of commodities, and for exchange to take place there must be a reasonably well-defined set of property rights that specify what is being traded and who owns it. In particular the good or service must be *excludable* - the buyer cannot obtain it from the seller without paying for it. It may not be possible, at reasonable cost, to restrict the benefits of forest recreation to those who pay for it, in which case no-one has an incentive to pay for it, the provider would be unable to collect revenue sufficient to cover the cost of supply, and the service will not be supplied by the market system. There are other characteristics of private property rights which are important, such as *transferability*, *duration*, *comprehensiveness* and *share of benefit* and a full treatment of the topic can be found in Scott (1985, 2008).

Some effects are a by-product of undertaking a project: these may be “goods”, such as salinity reduction, or “bads”, such as stream pollution. In the former case a private firm has an incentive to charge for the service but is unable to supply mitigation to one sufferer without supplying it to all and, hence, cannot obtain any revenue. In the latter case sufferers as a whole may have an incentive to purchase relief but there is no incentive for an individual to contribute because the benefit is *non-excludable*. Such non-marketed by-products of projects are often referred to an *external effects*, or *externalities*.

Where private markets are reasonably complete and undistorted, projects which meet the test of the market, as carried out in the Market Analysis, are likely to contribute to general economic welfare. However this conclusion does not extend to projects involving significant inputs or outputs which are non-marketed because of lack of property rights. While the government can be confident that a private firm seeking to undertake a project will find it profitable, it cannot be confident that the project is in the public interest. It is for this reason that a cost-benefit analysis may be undertaken to determine the overall merits of the project. The fact that the CBA has been commissioned suggests that the analyst is likely to encounter outputs and inputs which are not valued or costed by the market. In other words, non-market valuation is likely to be a core issue in economic analysis of projects.

The non-marketed commodities produced by a project may be intended or unintended consequences, may primarily affect consumers or producers, and may be considered as goods or “bads”. There is a demand for goods, such as improved recreational facilities, carbon sequestration or soil salinity reduction, and a demand for abatement of bads, such as air or stream pollution. The demand for abatement of bads is measured by the marginal cost they impose: the higher the marginal cost of air or stream pollution the more the consumer or producer is willing to pay for a unit of abatement. The efficiency pricing rule (Table 1) tells us that if a commodity satisfies additional demand it should be valued at the price recorded on the demand curve. Similarly if supply of a commodity, such as pollution abatement, is reduced the cost to the affected individual or firm is the *willingness to pay* for an extra unit of abatement as measured by the demand curve. As noted above, the willingness to pay for an extra unit of abatement is determined by the marginal cost of the pollution, a supply-side measure. If a commodity meets existing demand, such as a forest’s contribution to an overall carbon emission target, the sequestered carbon is valued at the cost of the alternative method of making that contribution to the target.

There are two main ways of determining the demand for a non-marketed commodity. One is to *observe* individual behaviour and infer willingness-to-pay from the observations – this is termed the *Revealed Preference* approach. The other is to *ask* individuals what they are willing to pay – this is termed the *Stated Preference* approach. The Revealed Preference approach can be applied to measure use values of currently available commodities only, whereas the Stated Preference approach applies to non-use values and new products as well.

The most frequently used Revealed Preference approach is known as the Travel Cost Method (TCM) which, in the case of valuing recreational resources, relies on the fact that different individuals face different levels of cost of travelling to the site. Travel costs include the costs of fuel, car wear and tear, risk of accident, and time. These costs are aggregated to provide an estimate of the implicit price of a visit to the site. Since different individuals face different prices, a cross-sectional analysis, taking account of other relevant factors such as income, prices of other goods, and tastes, can be used to estimate the demand curve, assumed to be continuous, of a representative individual for visits to the site. This demand curve can be used to estimate the value to the representative consumer of the reduction in travel cost due to improved accessibility, and this value multiplied by the number of individuals likely to use the site can be used to generate an estimate of the annual value of the improvement.

There are problems with the TCM, such as dealing with travel that has multiple destinations and identifying the values of individual attributes of a site, such as quality of walking tracks or availability of barbecue facilities. The Random Utility Model (RUM) was developed to deal with a situation in which each visit to a site is the result of a discrete choice among available sites. The actual choice depends on travel cost and personal characteristics, as in the TCM, but also on the characteristics of the available sites. Cross-sectional analysis, in which each individual’s choice of site is assumed to be the outcome of a utility maximisation process, can be used to determine the value of a site attribute, such as provision of life-guard services on a beach.

Another technique based on observed behaviour is the Hedonic Pricing Method (HPM). This method assumes that the purchase price of a good reflects the value the consumer places on all its characteristics, including any non-marketed characteristics associated with it. For example, variation in the market price of houses will reflect house and lot characteristics, but also other factors, such as proximity of a park or an airport. Cross-sectional analysis of all significant factors influencing price can be used to establish the value placed on characteristics which are not directly traded, such as access to a park or an absence of aircraft noise. Similarly, cross-sectional farmland values can be used to infer values or costs of effects such as reduction in salinity or increase in stream pollution.

The main advantage of the Revealed Preference approach is that it is based on observations of individuals making actual choices in the economy – spending real money – but a drawback is that it is limited to measuring use values. The Stated Preference method, on the other hand, deals with hypothetical spending choices and can be used to measure both use and non-use values. The most commonly used approach is the Contingent Valuation Method (CVM) in which individuals are asked what they would be willing to pay for services such as access to a specific recreational site, or for higher recreational fishing catches, or for increased protection of wildlife habitat. To get sensible answers, such questions have to be posed in a context that reflects the kind of choice made in a market: the consumer needs to understand the nature of the commodity to be supplied, the availability and prices of substitute commodities, and the budgetary impact of the choice made. Even if the questionnaire is suitably designed to provide the appropriate context for choice there remains the possibility of strategic bias - that the individual will understate or overstate his willingness-to-pay so as to influence the outcome of the survey. As in the TCM, cross-sectional analysis of responses is used to generate a demand function for the service in question.

Discrete Choice Modelling (DCM) is another example of the Stated Preference approach. A panel is asked to identify a set of key services which could be generated by an area of land, such as bird habitat, forestry, and power generation. It is then offered a series of options consisting of combinations of various levels of these services, and asked to select the best option or to rank them in order of preference. The choices made can be used to establish relative values of services that could be supplied by the site – for example, the value of a given level of preservation of bird habitat in terms of reduction in output of a marketed good, such as electricity. If the panel is representative of those affected by the project the DCM approach may provide useful estimates of the value of the land’s non-marketed benefits.

The Revealed and Stated Preference approaches represent attempts to estimate the demand curve for a non-marketed good or service. However there are occasions in which a supply curve, incorporating information about costs, may provide useful information. As noted earlier the marginal cost incurred by a firm because of pollution of its water source provides an estimate of its demand for abatement. The Efficiency Pricing Rule suggests that the cost of an alternative method of reducing carbon emissions can be used as a measure of the value of a forest’s contribution, through carbon sequestration, to satisfying existing demand for abatement. The same principle has been used to measure the cost (negative price) of a “bad”: suppose that a by-product of a mining project is the destruction of a forest park, but that an identical substitute park can be created at a cost of *$X*. Since *$X* is the cost of maintaining the level of consumer welfare it is sometimes proposed as a measure of the external cost of the project. Because the park is a non-marketed service, however, we cannot tell whether consumers were willing to pay *$X* for the original park, and so *$X* represents the upper bound of the cost of destroying the park.

It will be obvious from the above discussion that estimating non-market values can be a very costly affair. Collecting data from cross-sectional analysis is time-consuming and expensive and significant expertise is required to process and interpret the data. Recalling a point made in the Introduction to this chapter, it is prudent to weigh the cost of additional and more precise information against the benefit of the resulting improvement in the quality of the decision which will be made. If elaborate non-market analysis of the effects of a project cannot be justified on cost-benefit grounds an alternative valuation method, known as *Benefit Transfer*, can be used. Benefit Transfer simply means adopting a non-market value from a study which has already been conducted elsewhere. To use this method, the analyst reviews the literature to look for estimates of the non-market value of the effect in question: air or water pollution, soil salinity reduction, carbon sequestration, traffic accidents and so on. Care must be taken that the context of the study selected for comparison is similar to that of the project in question: a country at a similar level of development and with a similar natural resource endowment, and a project with similar characteristics.

Some on-line sites are available that list references to non-market valuation studies by country and by type and these can be used to search for an appropriate comparison. In Australia the government of New South Wales operates *ENVALUE:*

http://www.environment.nsw.gov.au/envalueapp/

which offers studies of air and water quality, noise, radiation, land quality, natural areas, non-urban amenity and risk of fatality. For example, the user can choose air quality (101 studies) and then search sub-categories, such as odour (one study). Canada operates the Environmental Valuation Reference Inventory (*EVRI*):

https://www.evri.ca/Global/HomeAnonymous.aspx

which contains around 1700 studies grouped by geographic area, environmental focus asset, and valuation technique. Focus asset has four sub-categories – air, land, infrastructure and water – and valuation technique has three – revealed preference, stated preference and simulated market price.

A simple technique which can be used on its own or in partnership with Benefit Transfer is *Threshold Analysis* (sometimes termed *Break-Even Analysis*). Here the analyst uses the spread-sheet model to determine what level the benefit (cost) of the non-marketed effect would have to attain to result in the project being approved (rejected); the level can be established by trial and error or by using the *Solver* function in Excel. If this level is sufficiently low then it may be reasonable to recommend approval (rejection). If values obtained through Benefit Transfer are available for comparison confidence in interpreting the result of the Threshold Analysis is increased.

11. The Efficiency Analysis III: Special Topics

11.1. Price Changes and Producer and Consumer Surplus

In the discussion so far it has been assumed that market prices of outputs or inputs remain unchanged as a result of undertaking the project. This will be the case for project output which satisfies existing demand. It will also be the case for traded commodities, in which case prices are determined in international markets. Furthermore, even if an output or input is in addition to current supply, market prices will not be affected if the project is small relative to the economy – local, regional or national – in which it is undertaken.

Where a project is large, as in the case, for example, of a national oil pipeline, undertaking it may drive up the prices of some inputs, such as the wage paid to owners of scarce skills, welders for example. In this event the higher wage required to procure an additional supply of welders for the project is paid to all welders. The higher wage will contribute to raising the costs of all firms employing welders and the higher unit cost of output will raise price and reduce quantity of output demanded in these industries. As well as relinquishing some welders (for use in the project) these firms may reduce their demand for other factors of production, but it can generally be assumed that these will find employment elsewhere. The benefit of the higher wage paid to existing welders is offset by the higher cost to employers, which will be passed on to consumers, and nets out in the Efficiency Analysis.

The wage increase required to procure additional supply of welders reflects the fact that each successive unit of labour comes with a higher opportunity cost; thus the first additional welder comes with an opportunity cost of w_0, the initial wage level, and the last with an opportunity cost of w_1, the new wage level. The Efficiency Analysis measures opportunity cost by pricing the welders used in the project at an average of these two wage levels. With the exception of this adjustment, market price changes, if any, caused by a project can be ignored in the Efficiency Analysis: they represent *pecuniary externalities* and are simply part of the normal functioning of the market in reallocating resources. However since some gain and some lose as a result of these price changes there may be consequences for the Referent Group analysis.

While changes, if any, in market prices, can mostly be ignored in the Efficiency Analysis, changes in the shadow-prices of non-marketed goods need to be taken into account in the cost-benefit analysis. For example, when construction of a forest road provides improved access to a recreation site, thereby lowering the cost (or shadow-price) of a visit, the consumer receives a benefit without there being any offsetting cost to a producer. The lower cost must be counted as a benefit of the road, with any project costs being treated separately in the cost-benefit analysis. Dealing with this type of price change will now be discussed.

It was argued above that many projects are too small to have any effect on input or output prices, and that, where changes in market price do occur as a result of the project, they can be ignored in the Efficiency Analysis because they represent transfers of purchasing power from one group to another (pecuniary externalities) rather than real benefits or costs. Exceptions to this argument are cases in which a project lowers the cost of supplying output, thereby lowering its price and generating an increase in *consumer surplus*.

Improving the access road to a forest recreation site will have the effect of lowering the cost, in terms of travel time, fuel, car wear and tear, and risk of accident, of a day's recreation, which is a non-marketed commodity. Prior to undertaking the project, one point on the demand curve for recreation is known, as illustrated by point A in Figure 6. If the cost of a day's recreation is to be lowered from P_0 to P_1, as a result of the proposed road project, there will be an increase in quantity of recreation demanded, from Q_0 to Q_1. The extent of this increase can be determined by the value of the elasticity of the demand curve at the initial equilibrium point A.

Considering Figure 6, it can be seen that the cost of each of the original trips (Q_0) to the recreation site has fallen by ($P_0 - P_1$). This fall represents an annual cost-saving of $(P_0 - P_1)*Q_0$ to existing users of the site. In addition, the lower access cost encourages a number of additional trips ($Q_1 - Q_0$), which can be estimated using a demand curve obtained by application of a method such the travel cost method (TCM) or Contingent Valuation Method (CVM). Since trips beyond Q_0 were not undertaken at price P_0, and trips beyond Q_1 are not undertaken at price P_1, we know that P_0 and P_1 are upper and lower bounds on the gross value of each additional trip. Valuing them at an average of the two bounds gives the estimate $[(P_0 + P_1)/2]* (Q_1 - Q_0)$ of their gross value. Net value is obtained by subtracting the travel cost associated with the generated trips, given by area BCQ_1Q_0 in Figure 6. Assuming that the demand curve is a straight line the net value of the generated trips is measured by area ABC.

In summary, the estimate of the net annual benefit to recreationists of the proposed road improvement project is represented by area P_0ABP_1 +ABC = P_0ACP_1 in Figure 6.This benefit takes the form of an increase in consumer surplus – the value of an extra benefit accruing to consumers as a result of a fall in price. Without the project total consumer surplus is measured by area EAP_0, with the project it is measured by ECP_1, and the difference measures the project benefit. Since this extra benefit to consumers is a result of a cost reduction, and is not matched by corresponding losses to producers, it is included in the Efficiency Analysis, along with the capital and operating costs of the road project, and in the Referent Group account.

11.2. The Shadow-Price of Public Funds

It can be seen from the Referent Group account that the WIG project has, like most projects, implications for the flow of public funds. Because of import replacement, the input subsidies involved and the ability of WIG to recoup a portion of its losses in early years from its tax liability on other operations, the net effect of the project is an outflow of public funds. This result, of course, depends on the nature of the project: if it were satisfying existing demand by replacing domestic production instead of imports; if the inputs were diverted from alternative uses elsewhere in the economy; if the government loan were not subsidised; and if the equity capital were diverted from another domestic project, there would be few, if any, implications of the WIG project for the flow of public funds.

The government has three main methods of funding its operations: it can raise taxes; it can borrow by issuing bonds; or it can print money. Each of these methods imposes a cost in excess of the nominal cost of the funds raised. Higher tax rates impose further distortions on private markets, thereby creating additional costly inefficiencies in the allocation of resources; bond issues may displace private investment projects with a before-tax rate of return in excess of the market rate of interest; and an increased level of inflation resulting from money creation contributes to further distorting the decisions of economic agents. If public funds were being raised at least cost, the marginal costs of these three methods would be the same and the marginal cost of public funds would be measured by the marginal cost of tax funds, for instance. Since borrowing also involves eventual repayment from tax funds, most studies focus on taxes as a source of funds.

There is a substantial literature on the marginal cost of public funds. Different methods of analysis applied to different countries have established values in the range 1-2: this means that every dollar of public funds raised imposes an additional cost of between one and two dollars on the economy; the cost of a dollar of public funds consists of the dollar of revenue itself plus a cost premium of between one and two dollars which measures the cost of resource misallocation due to the additional distortions created by the funding method chosen. Dahlby (2008) reports estimates of the marginal cost of public funds as follows: Denmark and Sweden >2; Belgium, Netherlands, Luxembourg, Germany, Japan, and Austria 2-1.5; France, Finland, Czech Republic, Canada, Switzerland, Spain, NZ, Portugal, UK, Australia, Poland, and USA 1.5-1. As in other cases discussed below, the analyst can adopt an official view in his treatment of public funds.

The question that mainly concerns us here is not the value of the shadow-price but rather how it is incorporated in the spread-sheets of the cost-benefit analysis. Suppose, for example, in the analysis of the WIG project we had been told that the shadow-price of public funds was 1.2. We would prepare a Working Table at the bottom of the Referent Group account summarising the flows of public funds. These would include the import duties on equipment, vehicles and spare parts, the loss of import duties on walnuts, the fuel tax, the subsidies on inputs of seeds, fertilizers, insecticides and irrigation water, the flow of business income tax refunds and payments, and the flow of funds associated with the subsidised loan – the initial cost of the loan and the interest and capital repayments from the proponent. Shadow-pricing studies generally do not distinguish between federal and state funds, but where they do the two sources of funds would need to be treated separately.

The aggregate flow of public funds reported in the Working Table has been costed at its nominal value in our analysis of the WIG project, but a shadow-price of 1.2 would indicate that the actual benefit (cost) to the economy of a one dollar inflow (outflow) of public funds is $1.20. A public funds cost premium of 20% of the flow of public funds would be added to the Referent Group and Efficiency Analyses. This is done by adding 20% of the public funds flow, as a cost in the case of a net outflow and a benefit in the case of a net inflow, to the Referent Group net benefit account, and adding a similar amount to the Efficiency net benefit account. In performing this operation as an exercise, the reader will find that the Efficiency and Referent Group Net Present Values of the WIG project are reduced by $179.3, $172.9, and $167.8 thousands at 2%, 4% and 6% rates of discount respectively, and, of course, that the revised accuracy check continues to confirm the internal consistency of the cost-benefit model.

11.3. The Shadow-Price of Foreign Exchange

The market for foreign exchange can be distorted by regulation, or by import tariffs or export taxes or subsidies, which alter a country's demand for, or supply of, foreign exchange, thereby affecting the exchange rate for its currency. In today's world of more open economies this issue is of lesser importance for cost-benefit analysis than it once was and it can generally be ignored in the appraisal of projects in developed economies, but for some projects, particularly those in developing economies, it may still be relevant. There is insufficient space to deal with this issue in detail here, but the reader is referred to Chapter 8 in the Text and the references listed there for a more formal treatment. Here we will consider an intuitive explanation of the need to shadow-price foreign exchange in the cost-benefit model.

Suppose that the local currency is the Kina, and that imports are subject to an average 20% import duty, and there are no taxes or subsidies on exports. The effect of the duty is to discourage imports, thereby reducing the demand for foreign exchange and lowering its price in Kina/dollar terms. Suppose that this price – the official exchange rate (OER) - is 0.8 Kina, meaning that 0.8 Kina buys one dollar in the foreign exchange market (or $1.25 buys one Kina). However by spending $1.25 in overseas markets goods worth 1.2 Kina in the domestic market (the import price plus the tariff) can be obtained. This means that $1.25 is actually worth 1.2 Kina in the domestic economy, giving a shadow-exchange rate (SER) of $1.04 per Kina (or 0.96 Kina per dollar). In practice the SER is not a value to be calculated by the analyst but is determined by a central authority.

Two main approaches have been proposed for incorporating the SER into the Efficiency Analysis. One approach, suggested by the OECD (1968), is to continue to use the OER to value traded goods, but to re-price non-traded goods at their prices relative to those of traded goods; this is done by multiplying domestic values of non-traded goods by the ratio of SER/OER: 1.04/1.25 in our example. The other approach, favoured by the UN (1970), is to use the SER to convert values of traded goods denominated in foreign currency to domestic currency, and to continue to use domestic valuations of non-traded goods in the Efficiency Analysis. Of these two methods, the UN approach is to be preferred in the spread-sheet model since it expresses Referent Group net benefits at domestic prices; for example, employment benefits are recorded as the difference between the domestic wage and supply price of labour as opposed to being some multiple (usually less than unity) of that value – and hence not an intuitively appealing measure - under the OECD approach.

The adjustment to the Efficiency Analysis to deal with the shadow-price of foreign exchange will have implications for the Referent Group Analysis. In our example, in which the SER is lower than the OER in dollars/Kina terms, applying the SER, as opposed to the OER, to a project which has a net demand for foreign exchange will increase the project's cost and lower its net value in Kina terms in the Efficiency Analysis. The lower value in the Efficiency Analysis reflects a reduction in the measure of net benefits to the economy. If the extra foreign exchange is obtained by reducing imports the opportunity cost per dollar is the tariff–inclusive value of imported goods of 0.96 rather than 0.8 Kina, and a foreign exchange premium of 0.16 Kina per dollar is entered as a cost to the Referent Group. If extra foreign exchange is obtained by increasing exports the resources diverted to production of export goods valued at 0.8 Kina (to exchange for $1 on the foreign exchange market) could have produced goods for domestic consumption valued at the tariff-inclusive price of 0.96 Kina; again a foreign exchange premium of 0.16 Kina per dollar is entered as a cost to the Referent Group.

11.4. Social Time Preference

In the application of the cost-benefit model we used a range of interest rates, including the market rate of interest, to calculate the net present value of the Efficiency and Referent Group net benefits. It has been argued, however, that the market rate of interest may not represent society’s preference for present, as compared with future, consumption goods, particularly in the case of long-lived investment projects, such as timber plantations, which may span the generations. This argument is based on the view that the capital market, in which borrowing and lending takes place, is subject to a form of market failure. Specifically, the problem is that, while future generations are affected by the investment decisions of the present, they are unable to influence the market outcome through participation in the capital market. In consequence, the market fails to take account of the economic welfare of future generations.

Another way of looking at the issue is to recognise that, in theory, the market rate of interest – the rate of discount we use to trade present for future consumption goods – consists of two components. One component – the utility discount factor – measures the extent to which individuals prefer utility from consumption now over utility from consumption in the future. This form of utility time preference is thought to be innate in human nature. The other component – the utility growth factor – reflects the fact that we expect to be better off in the future and that an additional quantity of consumption goods in the future will be worth less to us than the same additional quantity now. The size of the utility growth factor is the product of how much richer we expect to be in the future (the economic growth rate) and the extent to which the marginal utility of consumption falls as we get richer. For example, a growth rate of 2% combined with an elasticity of marginal utility of consumption of 1.5 produces a utility growth factor of 3%. If the market rate of interest is 4%, the utility discount factor, on these figures, must be 1%. It is argued that, in making investment decisions which affect future generations we should not be discounting their utility, and that the appropriate discount rate, in the case of the above example is 3%, rather than the market rate of 4%.

There is a voluminous literature concerning the social time preference rate of discount and, as illustrated above, it can be quite technical. Fortunately for the cost-benefit analyst many countries and international organisations specify the interest rate they want to be used in calculating the present value of Efficiency and Referent Group net benefits. Table 4 reports some of these interest rates and the analyst is advised to include the recommended rate within the band of rates chosen to calculate net present value.

Table 4. International real discount rates for cost-benefit analysis
Country/ Agency Discount Rate (per cent)

Philippines 15% [a]
India 12% [a]
Pakistan 12% [a]
New Zealand Treasury and Finance Ministry 8% **g**. (From 1982 to 2008 used 10% [abf])
Canada Treasury Board 8% **c**.(From 1976-2007 used 10% (and test 8%–12%) [ab])
China (People's Republic) 8% [a]
South Africa 8% (and test 3% and 12%) [d]
United States Office of Management and Budget 7% (and test 3%).(Used 10% until 1992.[a])
European Union European Commission 5% (From 2001–2006 used 6% [a])
Italy Central Guidance to Regional Authorities 5% [a]
The Netherlands Ministry of Finance 4% (risk free rate) **.e**
France Commissariat General du Plan 4% (From 1985-2005 used 8% [ab])
United Kingdom HM Treasury 3.5% from 2003 **a** (1% for values occurring >300 years in the future) (1969–78 used 10% [a])
Norway 3.5% (From 1978–98 used 7% **ab**)
Germany Federal Finance Ministry 3% (From 1999–2004 used 4% [ab])
United States Environmental Protection Agency 2–3% (and test 7%) [a]
International Multi-lateral Development Banks:
World Bank 10–12% [a]**;** Asia Development Bank 10–12% [a]**;** Inter-American Development Bank12% [a]**;**
European Bank for Reconstruction and Development 10% [a]; African Development Bank 10–12% [a]

Footnotes (for references see Source):
[a] Zhuang et al. (2007, table 4, pp. 17-18, 20). [b] Spackman (2006, table A.1, p. 31). [c] Treasury Board of Canada (2007, p. 37, 1998, p. 45). [d] South African Department of Environmental Affairs and Tourism (2004, p. 8). [e] van Ewijk and Tang (2003, p. 1). [f] Use of the 10% rate by New Zealand government departments is confirmed by Young (2002, p. 12); Abusah and de Bruyn (2007, p. 4). [g] New Zealand Treasury (2008) recommends a default rate of 8% (after adjusting the market risk premium of 7% for gearing). **Source**: Australian Government Productivity Commission, Valuing the Future: the social discount rate in cost-benefit analysis", Mark Harrison, 22/4/2010, Table 2-1

12. Risk and Uncertainty

The comparison of the world *with* the project and the world *without* the project is conducted using *estimates* of future values of the relevant variables. An estimate is a measure of central tendency with a range of possible values on either side - for example, the mean value of a probability distribution of outcomes. The variance of the probability distribution can be used as a measure of the degree of *risk* surrounding the estimate. *Uncertainty* refers to lack of precise information about the value of the mean of the probability distribution of outcomes. The degree of uncertainty about the mean value of a variable can be reduced by acquiring additional information; we have already noted that this may be a costly process which should be evaluated in terms of the likely resulting improvement in the quality of the decision made about the project. Additional information may also reduce the risk attached to an estimate, but the cost-benefit analysis will always contain some residual risk with which the decision-maker must cope.

In the private sector risk is taken into account in investment analysis by means of the *Capital Asset Pricing Model* (CAPM). The amount of risk associated with an investment is measured by its *Beta Factor*, which is an industry-specific measure of the extent to which the asset contributes to the overall risk of a widely diversified portfolio, taking account of the variance of its return and its covariance with the returns of other assets. The unit cost of risk is measured by the *market risk premium*, which is the additional rate of return required to compensate an investor for each additional unit of risk. The risk premium assigned to the project is a rate of return, measured by the quantity of risk (the Beta Factor), times the market risk premium rate. The required rate of return on a project is the risk-free rate plus its risk premium rate.

Some governments attempt to mimic the private sector investment appraisal process by specifying a required rate of return for public projects; for example, the State of Victoria, Australia, sets the market risk premium at 6% and uses Beta Factors of 0.3, 0.5 and 0.9 for very low, low and medium risk projects respectively. The risk-free rate of interest can be approximated by the rate of return on top quality government bonds – say around 3% - so that, on the basis of this information, Victoria would require a 6% rate of return from a project judged to be low risk. A proposed project would need to have a positive net present value, using the required rate of return as the discount rate, to be accepted. A problem with this approach is that adding a risk premium, p, to the risk free discount rate, r, has the effect of calculating the *expected* NPV of a project which has a chance, p, of permanent failure in each and every year: $(1-p)^t B_t$ is the expected value of the net benefit in year t, and $[(1-p)/(1+r)]^t B_t$ is its present value, which can also be expressed approximately as $[1/(1+r+p)]^t B_t$-. While this approach might fit some situations, such as the annual risk of catastrophic fire in a forest plantation, decision-makers might argue that this approach fails to deal with the annual fluctuations in net benefits which are a more common feature of projects than permanent failure.

Alternative approaches to dealing with risk and uncertainty favoured in the cost-benefit model are *Sensitivity* and *Risk Analysis*. Since the Referent Group account is the main concern of the decision-maker, these methods are normally applied to the Referent Group NPV. Sensitivity analysis involves calculating how sensitive the NPV is to changes in the values of key variables – variables with significant impacts on the outcome of the analysis. It will be recalled that the value of each variable enters the model only once in a single cell in the Data Sheet. The values of a selected variable or group of variables in their respective cells can be changed to determine the impact on NPV. Clearly the more uncertainty there is about the value of a variable, such as the cost of environmental damage associated with logging, and the more significant its value will be in determining the overall NPV of the project, the more important it is to include it in the sensitivity analysis. The output of the sensitivity analysis is a range of values within which the NPV can reasonably be expected to lie.

In Risk Analysis key variables are entered in the form of probability distributions and a program such as *@Risk* or *Crystal Ball* is used to calculate a probability distribution for the Referent Group NPV. For example, a variable might be represented by entering the mean and variance of a normal distribution in its cell in the Data Sheet. Since some variables are obviously not independently distributed, such as rainfall and tree-growth for example, covariances can also be specified in the cell entry. Furthermore, time-trends, such as random walks for example, can also be entered. Some jurisdictions offer the analyst advice about the appropriate form of distribution to be used: in the State of South Australia, for example, analysts are advised to use the Poisson or Binomial Distribution for a discrete variable, a Normal Distribution for a symmetric and continuous variable, a Triangular Distribution for an asymmetric and bounded variable, and a Uniform Distribution if no information about the value of the variable, apart from its likely bounds, is available. The Triangular Distribution is particularly useful because often information about the distribution of the variable has to be obtained from experts in areas relevant to the project: industry experts can supply information about likely prices and exchange rates, foresters can supply information about likely tree-growth rates, and so forth. The parameters of the Triangular Distribution can often be elicited by a series of simple questions: What do you regard as the most likely value this variable will take? What is the lowest value the variable could take? What is the highest value this variable could take?

The program *@Risk* is an add-on to the Excel spread-sheet model. With variables defined by probability distributions, as described above, it operates by randomly selecting a value of each variable from its probability distribution, and then running the spread-sheet model, incorporating the selected values of all variables, to determine a corresponding value for the output variable of interest, such as Referent Group NPV. This procedure can be repeated 5000 times, say, with the result of each iteration saved and assembled as a probability distribution of NPV, and estimates of mean, median or mode value, variance, confidence intervals, and probability of project failure, defined as a negative NPV, can be obtained. It is then up to the decision-maker to assess the level and cost of risk associated with the project and to incorporate that information into the decision-making process.

13. Choosing Among Projects

In this section we consider three situations in which the question is not *whether* an individual project should be undertaken but rather *which* among two or more projects should be chosen. Capital rationing refers to a limit to the total capital expenditure which can be made because of a fixed budget and projects have to be selected to meet this constraint. Sometimes a choice has to be made between projects with different lengths of life and care has to be taken to ensure that like is compared with like. Sometimes choice among alternative projects can be made by comparing their effectiveness per dollar of cost, such as the reduction of the incidence of disease resulting from various medical interventions.

13.1. Capital Rationing

A budget may be allocated to a department or firm for its capital expenditures and it may have more projects with NPV>0 than it can finance from the budget. The exact nature of the budget may vary but here we will assume that the present value of the combined construction costs of the projects undertaken must not exceed the budget allocation. By undertaking a cost-benefit analysis of each project, the analyst can calculate its Net Benefit Investment Ratio (NBIR), which is the ratio of the present value of net benefits, benefits less operating costs, to the present value of its capital cost, which is the critical value for budgetary purposes (note that the NBIR is not the same as the Benefit-Cost Ratio (BCR) in which the present value of benefits is the numerator and the present value of *all* costs is the denominator). Projects are then ranked in terms of their NBIRs and selected in order until the budget is exhausted. The effect of this procedure is to maximise the present value of the net benefits which can be obtained by spending the budget.

If projects are indivisible (because, for example, half of a bridge is of no value) it will not be possible to complete the project selection process by undertaking a fraction of the lowest ranked project selected. The analyst must then allocate a value to any residual unspent funds, which is usually the nominal value but could be represented by a shadow-price. The value of any combination of projects is then the sum of the present values of the project net benefits plus the value of the residual. This value may not be maximised by selecting projects in order of their NBIRs because there is now a trade-off between two project attributes to be considered – the NBIR and the extent to which the project contributes to exhausting the budget. For example, a larger project with a lower NBIR might be selected over a smaller project with a higher NBIR because of the smaller amount of unspent funds: suppose the budget is $100 and one of two indivisible projects costing $80 and $50 with NBIRs of 1.5 and 1.6 respectively must be chosen, with any residual funds allocated their nominal value.

13.2. Projects with Different Lives

An example of a pair of projects with different lives is provided by alternative ways of constructing a road: Project A might have a low capital cost, high annual maintenance costs and a life of 4 years; Project B might have a high capital cost, low annual costs, and a life of 8 years. Clearly the choice between projects should not be made on the basis of the present value of cost because this does not compare like with like – Project B provides twice as many years of service. One solution, known as the *Replacement Chain* or *Common Life* method, is to compare the cost of Project B with the cost of an alternative program which provides the same number of years of service - undertaking Project A initially and then again at the end of year 4. While the comparison might be practicable in this case, the method would be more difficult to apply if the project lives were, say, 7 and 9 years: predicting the relative costs of the two projects over a 63 year period might be beyond our ability and, in any case, conditions would likely change significantly over this period.

An alternative method of choosing between such projects is the *Equivalent Annual Cost* method (EAC). The present value of the capital and operating costs of each project over its life is calculated and then converted to a constant annual cost over the life of the project. The project with the lower annual cost of providing the service is then selected. The Equivalent Annual Cost can be calculated using the PMT function in Excel: the present value of the capital and annual operating costs of the project is treated as a loan which must be repaid in equal annual amounts over the life of the project.

In the above example it was assumed that Projects A and B provide the same level of annual benefit over their respective lives. If the annual benefits were different, because Project A was a two-lane and Project B a three-lane road for example, a comparison of Equivalent Annual Costs would no longer be sufficient. The Equivalent Annual Annuity (EAA) method converts the NPV of each project to an annuity, an annual net benefit measured as an equal annual payment over its life. The project with the higher annual payment is preferred.

13.3. Cost-Effectiveness Analysis

As discussed earlier the non-marketed benefits of some types of project can be difficult (costly) to value. For example, various kinds of road improvements are designed to save lives, and a full cost-benefit analysis of such a project would require placing a value on a life saved. In fact, the value of life has been calculated in various ways in numerous jurisdictions, but decision-makers are sometimes uncomfortable with the idea of trading off dollars against lives. An alternative is to measure the project benefits in physical terms and to compare the number of lives saved by each project per dollar of cost – effectiveness per unit cost. These ratios are, in effect, benefit/cost ratios, with physical quantities substituted for dollar values of benefits and their use in project selection is similar to the selection process under capital rationing. Other examples of benefits which sometimes may be more conveniently measured in physical terms include quality adjusted additional years of life, savings in commuter time, reduced soil salinity, and lower sulphur dioxide emissions.

14. Impact Analysis

When the proponent of a private project commissions a cost-benefit analysis he sometimes has in mind an *Impact Analysis*: he wishes to demonstrate to the public sector decision-maker the advantages of the project in stimulating economic activity. However impact and value are very different concepts and must not be confused: digging a hole in the ground and building a hospital might have a similar impact, in terms of generating jobs, income and expenditures, but very different net benefits. Since the spread-sheet cost-benefit model assembles much of the data required for an impact analysis, it may be relatively easy for the analyst to include an impact analysis in the form of a separate sheet in the model. However, as noted above, the results of the two forms of analysis should not be confused and must be regarded very differently by the decision-maker.

In simple terms, the impact analysis recognises that, in hiring labour and purchasing other inputs, the project generates income for workers and the owners of other factors of production. Expenditures out of those incomes create further demand for commodities which, in turn, generates additional incomes, which generate further expenditures and so on. In macroeconomic analysis the result of the income-expenditure flows is summarised by a national or regional income multiplier: the multiplier predicts the eventual increase in income resulting from an initial increase in expenditure. However, as discussed below, the predicted increase in income should not be regarded as a benefit of the project, even although the project proponent might cite it as such.

There are several reasons for not including the results of an impact analysis in project appraisal. First, if the project under consideration displaces other projects, either public or private, no net increase in income may result – the multiplier effects of the displaced project would have been similar to those of the project under consideration. Second, if the economy is close to full-employment, increases in demand will simply drive up prices and the increase in nominal income predicted by the multiplier may represent inflation rather than any real benefits. Third, the size of the multiplier is often exaggerated in calculating the impact of a project: in each round of income and expenditure, leakages, in the form of imports, taxes or savings, from regional or national expenditures occur. Extra income which is devoted to purchasing imported goods, paying taxes, or increasing savings or paying off debt generates no additional jobs in the economy. The calculated multiplier can be quite low when realistic assumptions are made about leakages, particularly in the case of a regional economy with substantial imports. Fourth, since the bulk of project expenditure may occur in the construction phase any significant multiplier effects may be of limited duration. Finally, while the multiplier might draw otherwise unemployed labour into production, the other inputs used in conjunction with the labour may have to be reallocated from uses elsewhere. In calculating the value of the net benefit of the multiplier effect the opportunity cost of such diverted inputs must be netted out of the value of any increased production.

The multiplier analysis is based on a simple model of national income determination. More complicated models are available which provide more detailed information, and these are discussed in Chapter 13 of the Text. For example, *Inter-Industry Analysis*, in the form of an input-output model, can be used to predict the final effect of the construction of the project on the demand for the output of individual industries. A multiplier analysis can also be incorporated in this kind of model, and an employment multiplier, giving extra jobs per dollar of project expenditure, can be calculated. More detailed still is the output of a *General Equilibrium Model* which uses the equations of the input-output model, the assumption of competitive markets, and equations determining household demand for goods and supply of factors of production, to generate a system of equations which can be solved for the equilibrium prices and quantities of all goods and factors, with one good chosen as the *numeraire* by arbitrarily setting its price equal to unity. The increase in demand for commodities resulting from undertaking a project is then used to shock the model and a new equilibrium solution is obtained. The change in equilibrium prices and quantities from the original equilibrium can then be attributed as the impact of the project.

Figures

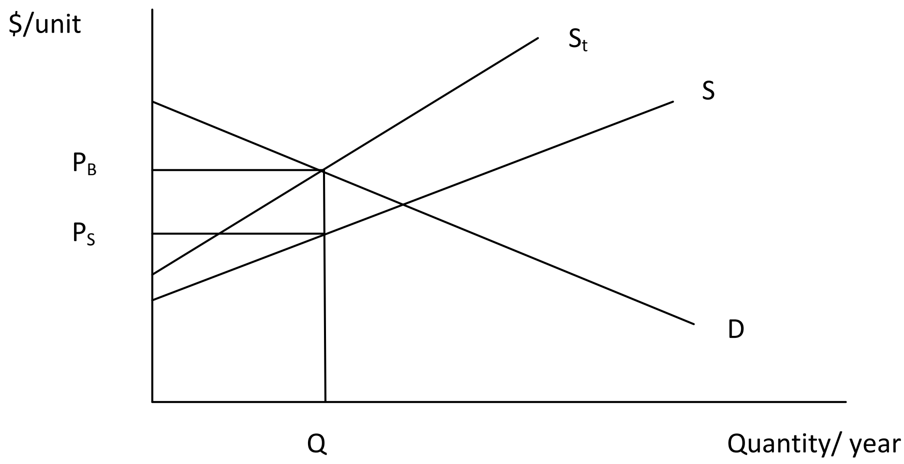

Figure 1. Equilibrium Prices in a Market Distorted by a Tax.

Discussion: Because of the imposition of an *ad valorem* tax there are two supply curves of the commodity: the supply curve *S* denotes the price the producer receives at various levels of output, while the curve S_t denotes the price the consumer pays. The effect of the tax is to raise the price the consumer pays by a percentage of the price received by the supplier, so that the gap between the two supply curves widens as supply price rises. In the absence of the tax, market equilibrium would occur where the Demand (*D*) and Supply (*S*) curves intersect. Because of the tax, however, the market equilibrium is at the quantity demanded and supplied, *Q*, determined by the intersection of *D* and S_t. At this equilibrium there are, in effect, two market prices – the price received by the supplier, P_S, and the price paid by the buyer P_B, where $P_B = P_S(1+t)$ and *t* is the rate of tax. The analyst needs to decide which of these two prices is to be used to value the commodity in the cost-benefit model. If the commodity is an output satisfying additional demand an extra unit is worth P_B to the buyer, whereas if it is an alternative means of satisfying existing demand the value of an extra unit is the saving in the cost of supply from an alternative source, measured, under competitive conditions, as P_S. If the commodity is an input which is diverted from use elsewhere in the economy its opportunity cost is its value of marginal product in that use, measured by P_B. If the input is in addition to current supply its opportunity cost is the marginal cost of supply, measured by P_S.

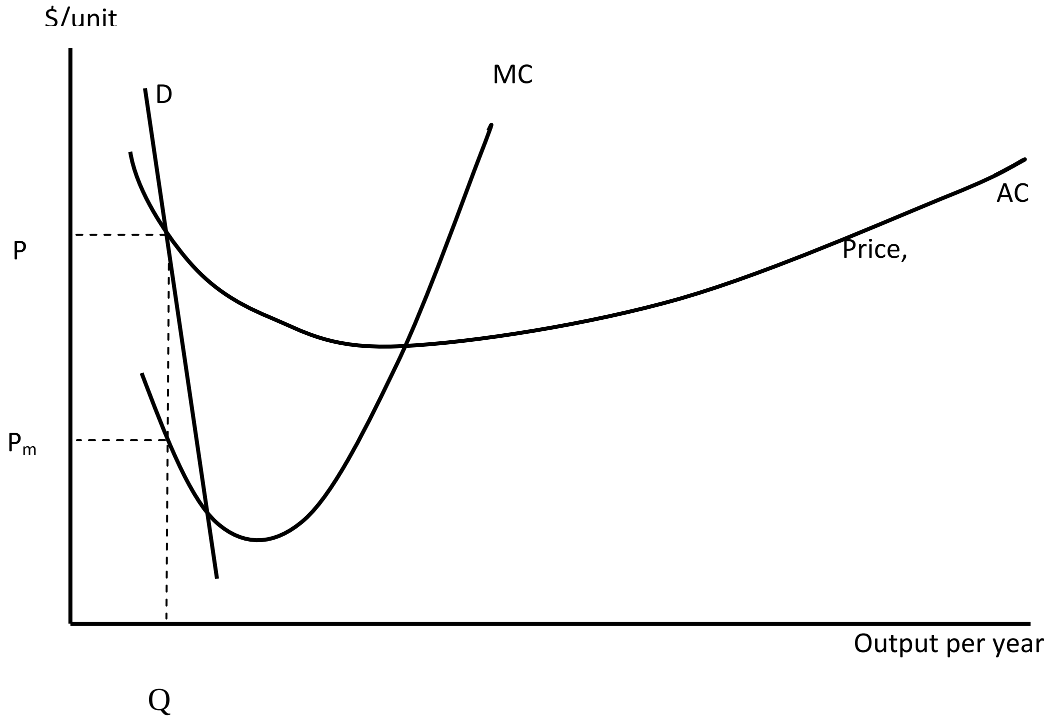

Figure 2. Pricing the Output of a Regulated Monopoly.

Discussion: Production of electricity is subject to increasing returns to scale, which means that the average cost of production (*AC*) falls over a substantial range of output. As long as average cost is falling marginal cost (*MC*) lies below average cost. The demand curve for electricity (D) cuts the average cost curve at the quantity of output, *Q*. The regulatory authority mandates *P* as the price which the monopoly may charge customers in order to cover its costs. However at output level *Q* the marginal cost of production is P_m. If additional units of electricity are produced to meet the increased demand resulting from the project, the cost per unit is P_m. If, on the other hand, the electricity network is operating at full capacity, power will have to be diverted from existing users to meet the demand of the project. The willingness to pay by existing users is measured by *P*. In the former case, electricity is shadow-priced at P_m per unit in the Efficiency Analysis, and in the latter is it priced at the market price *P*.

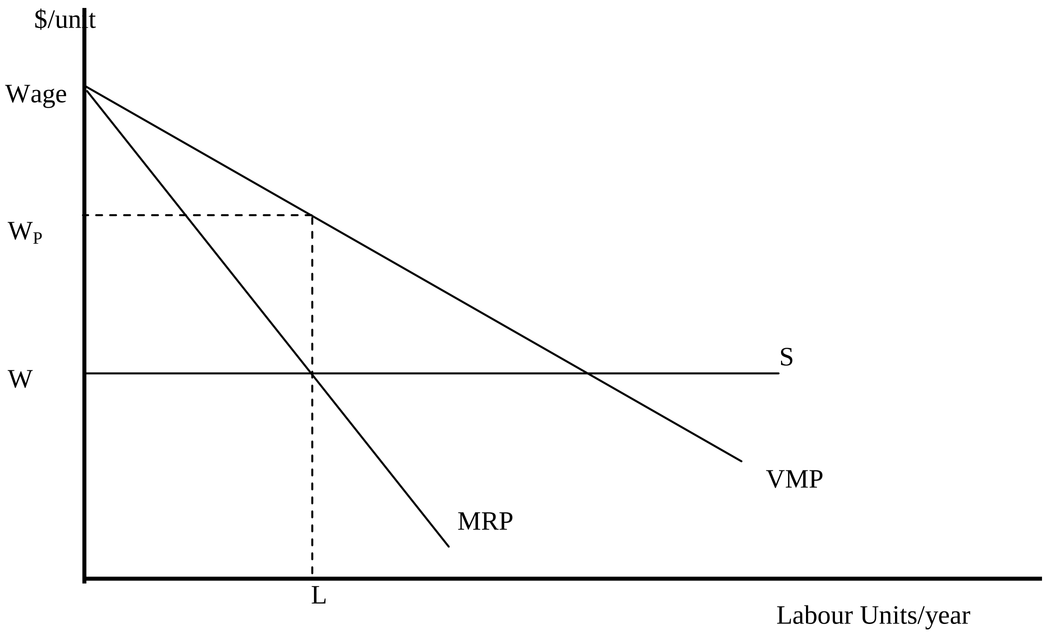

Figure 3. The Value of the Marginal Product of Labour Employed by an Unregulated Monopoly.

Discussion: The competitive firm's demand curve for labour is the value of the marginal product of labour curve (*VMP*). Value of the marginal product is defined as the additional contribution to the value of output (sales revenue) of an extra unit of labour input. *VMP* is measured by the market price of output multiplied by the marginal physical product of labour (*MPP*), which is the quantity of additional output produced by an additional unit of labour input. Additional output supplied by a monopoly has the effect of driving down the product price because of the downward sloping demand curve for output: not only does an extra unit of output receive a price lower than the current market price, but the price of all existing units of output supplied is lowered as well. This means that the extra revenue to a monopoly from supplying an additional unit of output, termed the Marginal Revenue (*MR*), is less than the current output price. Employing an extra unit of labour adds an amount of monopoly revenue equal to the *MPP* of labour multiplied by *MR*; this value is termed the Marginal Revenue Product (*MRP*). The profit maximising monopolist will hire an additional unit of labour as long as its contribution to revenue (*MRP*) is at least as large as its contribution to cost, measured by the wage (*w*). The profit maximising point is at labour input L, where $MRP = w$. At this level of input the opportunity cost of labour, *VMP*, is higher than the market wage, *w*. Labour reallocated from the monopoly to a project would be shadow-priced at *VMP* in the cost-benefit analysis of the project. It can be shown that $VMP = MRP/(1 - 1/e)$ where *e* is the elasticity of the product demand curve, expressed as a positive number. The shadow-price of labour would be:

$w/(1 - 1/e)$.

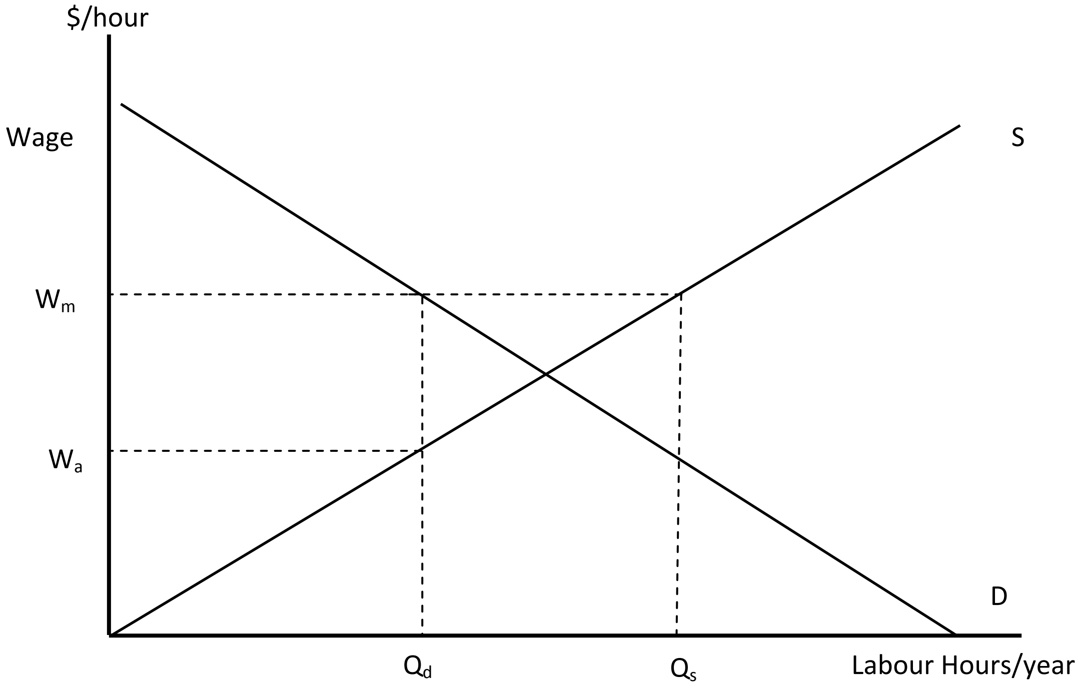

Figure 4. The Effect of a Minimum Wage.

Discussion: If the labour market were unregulated the market wage would be set by the intersection of the Demand (*D*) and Supply (*S*) curves. At this wage level the market would *clear* – meaning that the quantity of labour demanded would equal the quantity supplied. When a minimum wage, W_m, is set, by government or by a union, at a level above the market-clearing price – in a bid to make workers better-off – the quantity of labour supplied at that wage, Q_s, exceeds the quantity demanded, Q_d. The difference between quantity supplied and quantity demanded, measured by the length Q_dQ_s, represents involuntary unemployment – hours that people would like to work at the minimum wage but that are not taken up by employers. From the viewpoint of employers, hiring labour beyond the level Q_d would reduce profits because the value of the marginal product of labour (*VMP*), represented by the demand curve, *D*, is lower than the wage which has to be paid, W_m. At the distorted market equilibrium level of employment, Q_d, there are, in effect, two market prices of labour, W_m and W_a. If a project diverted labour from another market use, the opportunity cost would be its *VMP*, measured by W_m, unless the vacated jobs could be readily filled by the unemployed, in which case the labour would be priced at W_a. If the labour was drawn directly from the ranks of the unemployed its opportunity cost is W_a – the value labour places on an extra unit of leisure. In summary, in the cost-benefit analysis, labour diverted from another market use is priced at the market wage, W_m, and labour which is in addition to current supply is shadow-priced at its marginal opportunity cost, W_a.

If, on the other hand, the wage paid to skilled labour were subject to a *maximum* level, at W_a for instance, there would be excess *demand* for labour rather than excess supply. Labour hired for the project would be diverted from other jobs and would be shadow-priced at *Wm*.

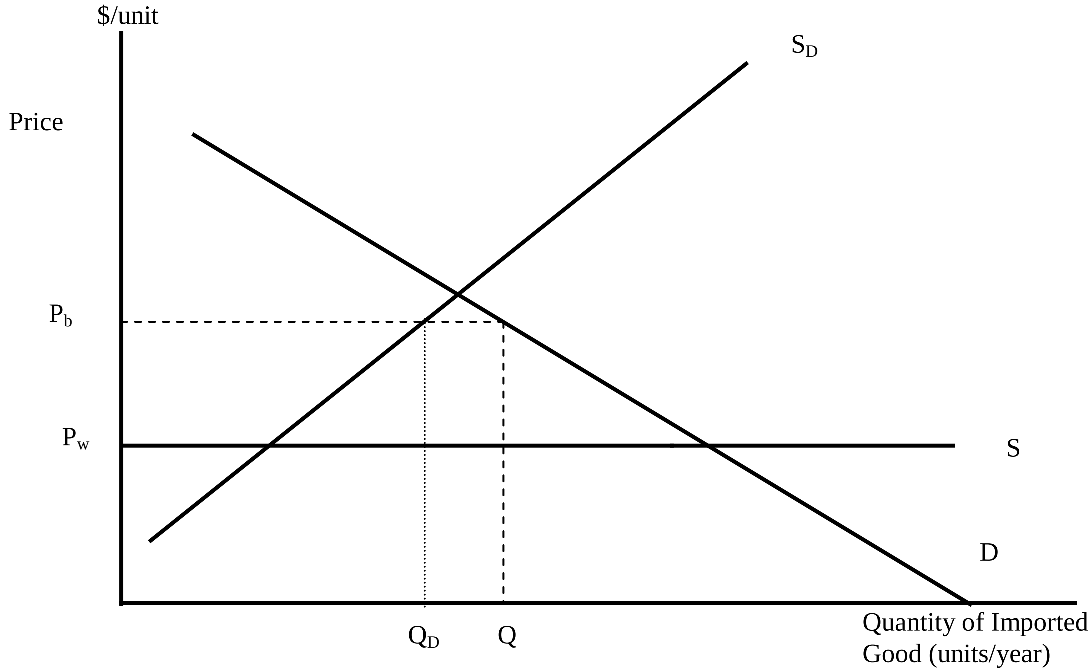

Figure 5. The Effect of an Import Tariff.

Discussion: The supply curve, *S*, of the imported good is drawn as perfectly elastic, reflecting the fact that the level of the country's imports will not affect the world price of the good, P_w. Production from domestic sources is represented by the supply curve, S_D, which slopes upward because as quantity supplied increases the cost of supplying an extra unit, the *marginal cost of production*, increases as ever higher prices have to be offered to attract additional resources into the industry. The effect of the import tariff is to increase the price paid by domestic consumers for imports to P_b, and quantity demanded at this price is *Q*. At the price P_b domestic producers find it profitable to supply Q_D units of the good, with the remaining demand, represented by the distance QQ_D, being satisfied by imports. An import replacing project, which supplied an additional quantity of domestic production, would produce goods at a cost of P_b per unit, thereby saving the economy P_w per unit. In the Efficiency Analysis the output of the import-replacing project would be priced at P_w per unit – the value of the cost-saving to the economy. Consumers are unaffected (assuming they are indifferent between imported and domestically produced output), the proponents of the import-replacing project can be assumed to cover their costs, and the economy suffers a loss measured by ($P_b - P_w$) per unit. This loss will be experienced by some member of the Referent Group, and in this case it appears as a loss of government tariff revenue. However it must be emphasised that the loss in tariff revenue is merely the measure of a real loss to the economy.

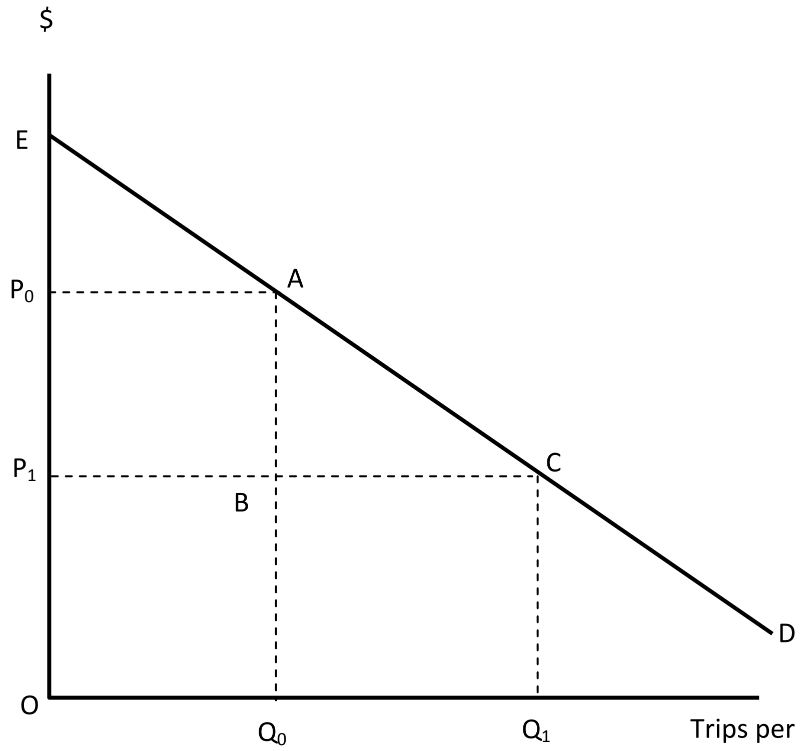

Figure 6. Consumer Surplus Generated by Improved Access to a Recreation Site.

Discussion: The line *ED* represents the demand curve (assumed to be linear) of a representative individual for trips to the recreation site each year. It has been estimated by cross-sectional analysis of data obtained by the Travel Cost or Contingent Valuation Method, for example, and scaled to average values of the variables associated with the individuals in the sample, other than the price variable. The price P_0 is the average cost of a trip for the sampled individuals and at that price Q_0 visits are undertaken each year. A forest road improvement will lower the average cost of a trip because of savings in time, fuel, vehicle wear and tear and reduced probability of accident. Once the road project is completed the average cost of a trip is estimated to fall to P_1, and the demand curve tells us that the representative individual will increase his annual number of visits to Q_1. The benefit to this individual is measured by the cost savings on the original number of trips, P_0ABP_1, plus the net value of the additional trips undertaken. The gross value of each additional trip beyond Q_0 is measured by the corresponding point on the demand curve, while the cost is P_1. The net benefit derived from the additional trips is measured by area *ABC*, which represents the additional trips valued at an average of *with* and *without* project values, P_1 and P_0. The total annual benefit to the representative individual generated by the project is measured by area P_0ACP_1. It can be seen that this is the increase in consumer surplus from the original level EAP_0 to the new level ECP_1. An estimate of the total annual benefit of the project is obtained by multiplying the annual benefit of the representative individual by the estimate of the number of visitors to the park.

References

Campbell, H.F. and Brown, R.P.C. (2003), Benefit-Cost Analysis: financial and economic appraisal using spreadsheets, Cambridge University Press, Melbourne (Reviewed in Development and Change 35(2): 399-400, April 2004; The Economic Record 80(251): 468-469, December 2004; Australian Journal of Agricultural and Resource Economics Vol. 49, No 3, pp. 351-352, September 2005)

Campbell, H.F. (2008), The Shadow-Price of Labour and Employment Benefits in a Developing Economy. Australian Economic Papers Vol. 47, No. 4, December, pp. 311-319.

Dahlby, B. (2008), The Marginal Cost of Public Funds: Theory and Applications, MIT Press.

Dasgupta, P., Sen, A. and Marglin, S. (1970), Guidelines for Project Evaluation (United Nations).

Little, I.M.D. and Mirrlees, J.A. (1968), Manual of Industrial Project Analysis in Developing Countries (OECD)

Scott, A.D. (1985), Property Rights: Developing the Characteristics of Interests in Natural Resources. In: Scott, A.D. (ed.), Progress in Natural Resource Economics, Clarendon Press, Oxford, Chapter 13.

Scott, A.D. (2008), The Evolution of Resource Property Rights, Oxford University Press.

Appendix 1: Analysis Sheets for the Walnuts International Group Project

1	**Market Analysis**																
2	**WIG ($ 000's)**																
3	**Year**	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
4	**Investment Cost**																
5	**Fixed Investment**	-740															74
6	**Working Capital**		-86.4														86.4
7	**Land Rehabilitation**																-50
8	**Capital Cost**	-740	-86.4														110.3
9																	
10	**Operating Cost**		-201.2	-201.2	-201.2	-201.2	-201.2	-201.2	-201.2	-201.2	-201.2	-201.2	-201.2	-201.2	-201.2	-201.2	-201.2
11	**Revenues**																
12	**Walnuts**		75.0	150.0	225.0	300.0	300.0	300.0	300.0	300.0	300.0	300.0	300.0	300.0	300.0	300.0	300.0
13	**Timber**																100
14	**Net Cash Flow**	-740	-212.6	-51.2	23.8	98.8	98.8	98.8	98.8	98.8	98.8	98.8	98.8	98.8	98.8	98.8	309.1
15																	
16	**Net Present Value**	2%	4%	6%													
17		165.5	-29.6	-183.0													
18	**IRR**	3.7%															

1	**Proponent Analysis (WIG)**																
2	Year	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
3																	
4	**EBITDA**	-740	-212.6	-51.2	23.8	98.8	98.8	98.8	98.8	98.8	98.8	98.8	98.8	98.8	98.8	98.8	309.1
5																	
6	**Financing**																
7	*Principal*																
8	Loan	700	-65.4	-66.4	-67.4	-68.4	-69.4	-70.5	-71.5	-72.6	-73.7	-74.8					
9	Overdraft		40				-40										
10	*Interest*																
11	Loan		-10.50	-9.52	-8.52	-7.51	-6.49	-5.45	-4.39	-3.32	-2.23	-1.12					
12	Overdraft			-2.2	-2.2	-2.2	-2.2										
13	Net Financing	700.0	-35.9	-78.1	-78.1	-78.1	-118.1	-75.9	-75.9	-75.9	-75.9	-75.9					
14	NCF (Equity, Pre-Tax)	-40	-248.5	-129.3	-54.3	20.7	-19.3	22.9	22.9	22.9	22.9	22.9	98.8	98.8	98.8	98.8	309.1
15																	
16	**Tax Calculation**																
17	Revenues		75.0	150	225	300	300	300	300	300	300	300	300	300	300	300	400
18	Operating Cost		-201.2	-201.2	-201.2	-201.2	-201.2	-201.2	-201.2	-201.2	-201.2	-201.2	-201.2	-201.2	-201.2	-201.2	-201.2
19	Interest		-10.50	-11.72	-10.72	-9.71	-8.69	-5.45	-4.39	-3.32	-2.23	-1.12					
20	**Depreciation**																
21	Equipment		-40	-40	-40	-40	-40	-40	-40	-40	-40	-40					
22	Vehicles		-18	-18	-18	-18	-18										
23	Buildings		-16.7	-16.7	-16.7	-16.7	-16.7	-16.7	-16.7	-16.7	-16.7	-16.7	-16.7	-16.7	-16.7	-16.7	-16.7
24	**Total Depreciation**		-74.7	-74.7	-74.7	-74.7	-74.7	-56.7	-56.7	-56.7	-56.7	-56.7	-16.7	-16.7	-16.7	-16.7	-16.7
25	**Taxable Income**		-211.4	-212.3	-136.3	-60.3	-59.2	-20.0	-18.9	-17.9	-16.8	-15.7	65.5	65.5	65.5	65.5	165.5
26	**Business Income Tax**		-63.4	-63.7	-40.9	-18.1	-17.8	-6.0	-5.7	-5.4	-5.0	-4.7	19.6	19.6	19.6	19.6	49.6
27																	
28	**Proponent NCF**	-40	-185.1	-65.6	-13.4	38.8	-1.5	28.9	28.6	28.2	27.9	27.6	79.1	79.1	79.1	79.1	259.5
29																	
30	**Net Present Value**	2%	4%	6%													
31		$297.9	$182.9	$95.7													
32	**IRR**	9.1%															

1	**Efficiency Analysis**																
2	**WIG ($ 000's)**																
3	Year	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
4	**Investment Cost**																
5	Fixed Investment	-685.6															68.6
6	Working Capital		-104.6														104.6
7	Land Rehabilitation																-50
8	**Capital Cost**	-685.6	-104.6	0	0	0	0	0	0	0	0	0	0	0	0	0	123.2
9																	
10	**Operating Cost**		-231.8	-231.8	-231.8	-231.8	-231.8	-231.8	-231.8	-231.8	-231.8	-231.8	-231.8	-231.8	-231.8	-231.8	-231.8
11	**Revenues**																
12	Walnuts		68.2	136.4	204.5	272.7	272.7	272.7	272.7	272.7	272.7	272.7	272.7	272.7	272.7	272.7	272.7
13	Timber																100
14																	
15	**Loan Subsidy**		-4.08	-4.08	-4.08	-4.08	-4.08	-4.08	-4.08	-4.08	-4.08	-4.08					
16	**Stream Pollution**		-10	-10	-10	-10	-10	-10	-10	-10	-10	-10	-10	-10	-10	-10	-10
17	**Reduced Salinity**		5	5	5	5	5	5	5	5	5	5	5	5	5	5	5
18																	
19	**Net Benefit**	-685.6	-277.3	-104.5	-36.4	31.8	31.8	31.8	31.8	31.8	31.8	31.8	35.9	35.9	35.9	35.9	259.1
20																	
21	**Net Present Value**	2%	4%	6%													
22		-593.65	-679.66	-744.19													
23	**IRR**	-5%															

1	**Referent Group Analysis**																
2	**WIG ($000's)**																
3	Year	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
4	**RG Net Benefits**	-645.6	-92.3	-38.9	-22.9	-6.9	33.4	2.9	3.3	3.6	3.9	4.2	-43.3	-43.3	-43.3	-43.3	-0.4
5	**Disaggregated Net Benefits**																
6	**Australian Government**																
7	**Indirect Taxes**																
8	Fuel Tax		0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.1
9	*Tariff Revenue*																
10	Walnuts		-6.8	-13.6	-20.5	-27.3	-27.3	-27.3	-27.3	-27.3	-27.3	-27.3	-27.3	-27.3	-27.3	-27.3	-27.3
11	Spare Parts		2	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	0.2
12	Equipment	36.4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	-3.6
13	Vehicles	18	0	0	0	0	0	0	0	0	0	0	0	0	0	0	-1.8
14	*Input subsidies*																
15	Seeds		-1.7	-1.7	-1.7	-1.7	-1.7	-1.7	-1.7	-1.7	-1.7	-1.7	-1.7	-1.7	-1.7	-1.7	-1.7
16	Fertilizer		-1.1	-0.6	-0.6	-0.6	-0.6	-0.6	-0.6	-0.6	-0.6	-0.6	-0.6	-0.6	-0.6	-0.6	-0.2
17	Insecticides		-41.3	-22.5	-22.5	-22.5	-22.5	-22.5	-22.5	-22.5	-22.5	-22.5	-22.5	-22.5	-22.5	-22.5	-3.8
18	Government Loan Subsidy		-4.1	-4.1	-4.1	-4.1	-4.1	-4.1	-4.1	-4.1	-4.1	-4.1	0.0	0.0	0.0	0.0	0.0
19	**Direct Taxes**																
20	Business Income Tax		-63.4	-63.7	-40.9	-18.1	-17.8	-6.0	-5.7	-5.4	-5.0	-4.7	19.6	19.6	19.6	19.6	49.6
21	Government Loan	-700	75.9	75.9	75.9	75.9	75.9	75.9	75.9	75.9	75.9	75.9					
22	**Total Australian Govt.**	-645.6	-40.2	-29.0	-13.1	2.9	3.2	15.0	15.3	15.6	16.0	16.3	-31.2	-31.2	-31.2	-31.2	11.6
23	**Tasmanian Government**																
24	Water Subsidy		-12	-12	-12	-12	-12	-12	-12	-12	-12	-12	-12	-12	-12	-12	-12
25	**Tasmanian Community**																
26	Employment Benefits		3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
27	Land Rents		2.1	2.1	2.1	2.1	2.1	2.1	2.1	2.1	2.1	2.1	2.1	2.1	2.1	2.1	2.1
28	External Health Costs		-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.1
29	Stream Pollution		-10	-10	-10	-10	-10	-10	-10	-10	-10	-10	-10	-10	-10	-10	-10
30	Reduced Soil Salinity		5	5	5	5	5	5	5	5	5	5	5	5	5	5	5
31	**Total Tasmania**		-12.1	-12.1	-12.1	-12.1	-12.1	-12.1	-12.1	-12.1	-12.1	-12.1	-12.1	-12.1	-12.1	-12.1	-12.0
32	**Australian Bank**		-40.0	2.2	2.2	2.2	42.2										
33	**Total RG Net Benefits**	-645.6	-92.3	-38.9	-22.9	-6.9	33.4	2.9	3.3	3.6	3.9	4.2	-43.3	-43.3	-43.3	-43.3	-0.4
34	**Check**	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
35	**Net Present Values**	2%	4%	6%													
36	**Australian Government**	-741.8	-730.5	-722.1													
37	**Tasmania**	-155.0	-134.1	-117.1													
38	**Australian Bank**	5.2	2.1	-0.7													
39	**Total**	-891.5	-862.5	-839.9													

Appendix 2: The Tasmanian Pulp Mill Project Proposal

A Pulp Mill for Tasmania?

A Scandinavian company, Nordic Forest Products Ltd (NFP), is proposing to build and operate a pulp mill at Devil River on the north coast of Tasmania. Construction will start in 2011 and the mill will take two years to build (Years 0 and 1). In its first year of operation (2013, Year 2 of the project) it will convert 3.2 million tonnes of fibre obtained from eucalypt logs into pulp for the export market. The quantity of fibre processed is scheduled to rise by 80,000 tonnes per annum until a throughput of 4 million tonnes of fibre per annum is achieved in Year 12 of the project. The Year 12 level of throughput will be maintained until Year 31 of the project, after which the mill will cease to operate.

In the long-run the primary source of fibre will be privately owned eucalypt plantations, with 30% of private plantation fibre coming from plantations established under Managed Investment Schemes (MIS). However these plantations will not be fully mature at the start of operations and the shortfall in the initial years of the project will be made up of logs from the State's native forests operated by Forestry Services Tasmania (FST).

Table 1: Sources of Eucalypt Fibre (tonnes)

	Project Year 2	Annual Change Years 3-12
FST Native Forest	2560000	-171000
FST Plantations	150000	0
Private Plantations	490000	+251000

The mill will cost $2 billion to construct and a further $100 million will be required to construct pipelines for water supply and effluent disposal. In addition Highways Tasmania (70%) and the Federal Government (30%) are proposing to spend $100 million on road up-grades to cope with the transport of logs. No scrap value or decommissioning cost of the mill has been assessed.

Table 2: Capital Costs (millions)

	Project Year 0	Project Year 1
Plant and Equipment	1000	1000
Pipelines	100	100
Road Upgrades	100	100

The ratio of fibre input to pulp output is 4.1 for native forest logs and 3.6 for plantation logs. Pulp is expected to sell for US$560 in the initial year of the mill's operation. However over Project Years 3-11 the world pulp price is expected to fall by 1.4% per annum and then remain constant in real terms. The exchange rate is expected to be $US0.85 = $AUS1. The project expects to earn $20 per tonne of pulp produced from sales of surplus energy, and it expects to receive a further $20 per tonne of pulp from sale of renewable energy certificates (RECs) earned under the Federal Government's renewable energy subsidy program.

NFP will pay stumpage fees to the suppliers of logs, a road levy to Forest Services Tasmania to pay for the maintenance of logging roads, and the harvesting and transport costs required to deliver the logs to the mill. The stumpage rate on logs supplied from native forests is set at 2% of the world pulp price. Stumpage rates on plantation timber are negotiated with suppliers.

Table 3: Cost of Fibre ($/tonne fibre)

	FST Native Forest	FST Plantations	Private Plantations
Stumpage	13.18*	27.00	33.00
FST Road Costs	7	7	4
Harvesting Cost	20	20	15
Transport Cost	24	15	10

*Calculated as 2% of the pulp price reported above converted to $AUS at the exchange rate reported above.

Operating costs include costs of labour, maintenance, chemicals and energy, and ocean freight.

Table 4: Operating Costs ($/tonne of pulp)

Labour (including 6.1% State payroll tax)	$AUS 42
Maintenance	$AUS 38
Chemicals and Energy	$US 50
Ocean Freight	$US 70

The project will also use 2600 megalitres (ML) of water per annum, which will be supplied by Tasmania's Hydro Electric Commission (HEC) at a price of $35 per ML.

Shares in 20% of the proposed project will be owned by Tasmanian shareholders with the remaining shares held by Scandinavian interests. NFP will borrow 70% of the capital cost it incurs to undertake the project through an export credit facility provided by a consortium of Scandinavian banks at a real interest rate of 3.5% over a 20 year term, with interest and capital repayments starting in Year 2. The balance of the initial capital costs will be borne by the Tasmanian and Scandinavian shareholders. The capital cost of the mill and the pipelines can be depreciated at 7% per annum for tax purposes and the business income tax rate is 30%. NFP requires a 10% real rate of return on the project. NFP has income from other ventures in Australia against which any losses from this project can be offset. Aside from dividends paid to Tasmanian shareholders, after-tax profits will be repatriated.

Independent analysis of world pulpwood markets suggest that the stumpage value of native forest timber supplied to the mill is actually 4% of the world pulp price. In addition logs constituting 5% of the volume of timber supplied from native forests are thought to come from high conservation value areas where the non-timber value of stands exceeds the stumpage value by 10%. It has been calculated that the prices of logs supplied from private plantations under the MIS are subsidized by 30% through federal government business income tax concessions.

While the mill will generate employment in its construction and operation phases, it is estimated that construction workers will be diverted from other projects and that only a small proportion of the mill's labour force would otherwise have been unemployed. It is estimated that 5.6% of the gross operations wage bill constitutes employment benefits which are divided in the following proportions: workers 1.21%; State 0.39% in the form of payroll tax; and Commonwealth 4% in the form of personal income tax, GST and reduced social security payments.

While the water supplied to the mill by Hydro Tasmania will not involve any reduction in the volume of power generated, it will be diverted from irrigation. Irrigators in the region are currently paying $46 per megalitre.

It has been estimated that supplying the mill with fibre will involve an additional 4.2 million kilometres of log-truck travel per annum. Currently Tasmanian roads serve an estimated 2900 million vehicle kilometres per annum, and the annual cost of traffic accidents, including injury and loss of life, is estimated by the Bureau of Transport Economics to be $310 million.

It has been estimated that operation of the mill will increase the ambient concentration of ultra fine particles in the northern Tasmanian airshed, resulting in a 0.75% increase in the incidence of respiratory disease in the region. This will result in 3 additional deaths, 300 hospital admissions and 300 working days will be lost per annum. A study has suggested that the cost of each death is $1.026 million, hospital admissions cost $3870 each, and days of work lost cost $150 per day.

The mill will dispose of 64,000 tonnes of effluent per day through a pipeline into Bass Strait. While the limits set for dioxins and furans per litre of waste discharged equal or improve on levels set by the US EPA, Environment Canada and the EC, as well as meeting various best practice guidelines, there is concern for the long-run effect of the effluent on Bass Strait seal colonies and fisheries, but no estimate of the cost is available.

The plantations supplying the mill will reduce stream run-off by absorbing rainfall and releasing it into the atmosphere through evapo-transpiration. The reduction in stream-flow may affect the availability of irrigation water in northern Tasmania, but there is no estimate of the impact.

Proponents of the mill argue that sustainable forestry is carbon neutral and that exporting pulp, as opposed to wood-chips, will reduce greenhouse gas emissions associated with ocean transport. Opponents of the mill argue that cutting mature forests reduces the amount of carbon stored in the trees and the soil.

Tasmanian farmers, fishermen, winegrowers and tourism operators have expressed concern that the pulp mill will affect Tasmania's "clean green" image. Mill supporters point to the example of New Zealand, which has several pulp mills, but enjoys a positive environmental image.

Discussion:

This example is a fictional project that resembles, in a simplified way, the project proposed for Bell Bay on the Tamar River in northern Tasmania. To date the Bell Bay project has not proceeded for several reasons, including: the recent appreciation in the value of the Australian dollar; lower pulp prices because of competition from overseas pulp suppliers; the reluctance of Japanese consumers to accept pulp sourced in part from native forest woodchips; and community concern about native forest logging and other environmental effects of the project. The fictional project has been constructed to illustrate the application of cost-benefit analysis in a developed economy context: there are no import duties, subsidies are limited to those on renewable energy production and private forest plantations, there are pricing issues associated with inputs, such as logs and water, supplied by government agencies, and there is an emphasis on health and environmental effects.

The NFP Variables Table summarizes the information provided in the project description above, and the Market, Proponent, Efficiency and Referent Group analyses are reported in subsequent tables. All values reported are in real terms and real rates of discount are used to calculate NPVs. The Market Analysis starts with a materials balance calculation which is the basis of the cost-benefit model and reports an IRR of 7.7% as compared with a cost of capital of 10%. However the Proponent Analysis shows that the equity holders earn an IRR of 10.6% because of the gearing provided by a low-interest loan.

Because of lack of information the Efficiency Analysis is incomplete. While the costs of additional road accidents, caused by additional log truck traffic, and the health costs of additional particulate matter in the air are included in the analysis, the cost of effluent discharge is costed at zero in the base case analysis, and other externalities such as stream flow reduction, carbon sequestration and changes in customer perceptions are not included. The project is, at best, marginal in efficiency terms, with an IRR of 6.4%. A threshold analysis indicates that an external cost of $4 per tonne of effluent is more than sufficient to make the Efficiency NPV negative at all three discount rates chosen.

The Referent Group Analysis indicates that the project does not benefit Tasmania as a whole: the government bears some of the infrastructure cost and subsidises native forest wood supply; the general community bears the external costs that have been measured, but these are offset by returns to the minority Tasmanian shareholders. Stream flow effects and reduced tourism numbers might further reduce the returns to Tasmania. The federal government is a beneficiary of the project because of the business income tax revenues. Full details can be found in the following spread-sheets.

1	**Variables Table**	**Units**	1000000	**Days/yr**	365			
2	**NFP Project**							
3	**Fibre Input**	*Year 2*	**Fibre Cost ($/tonne fibre)**	FST Native	FST Plantations	Private Plantations	Discount Rates	
4	FST Native Forest (tonnes pa)	2560000	Stumpage	13.18	27	33	0.03	
5	FST Plantation (tonnes pa)	150000	FT Road Costs	7	7	4	0.05	
6	Private Plantation (tonnes pa)	490000	Harvesting	20	15	15	0.08	
7	*Total Fibre Input*	3200000	Cartage	24	15	10		
8	*Change in Fibre Input Years 3-12 (tonnes pa)*		Total Excluding Stumpage	51	37	29		
9	FST Native Forest (tonnes pa)	-171000	**Other Costs ($/tonne pulp)**					
10	FST Plantation (tonnes pa)	0	Labour (incl.payroll tax)	42				
11	Private Plantation (tonnes pa)	251000	Maintenance	38				
12	*Total Annual Change Years 3-12 (tonnes pa)*	80000	Chemicals & Energy (US$/ADT)	50				
13	Native Fibre/Pulp Ratio	4.1	Ocean Freight (US$/ADT)	70				
14	Plantation Fibre/Pulp Ratio	3.6	Quantity of Water (MLs pa)	26000				
15	Price of Pulp US$/ADT	560	Price of Water ($/ML)	35				
16	Price of Pulp $AUS/ADT	658.82	**Capital Costs ($millions)**	Year 0	Year 1			
17	Fall in Pulp Price till Yr 11 (proportion pa)	0.014	Mill	1000	1000			
18	Fall in Pulp Price from Yr 12 on (proportion pa)	0	Pipelines	100	100			
19	Native Forest Royalty Rate (proportion of pulp price)	0.02	Transport Infrastructure	100	100			
20	Exchange Rate US$/$AUS	0.85	**Efficiency Analysis**					
21	Energy Sales ($/ADT)	20	Employment Benefits (prop'n labour cost)	0.056	**Health Costs**	Number pa	Cost ($/unit)	Total
22	RECs ($/ADT)	20			Deaths	3	1026000	3078000
23	**Private Analysis**				Hospital Admissions	300	3870	1161000
24	Debt Proportion	0.7			Lost work Days	300	150	45000
25	Tasmanian shareholding proportion	0.2			Total Health Costs			4284000
26	Interest Rate	3.5%			**Road Congestion**			
27	Term (yrs)	20			Current Usage (m kms pa)	2900		
28	Depreciation Rate (per annum)	0.07			Additional Use (m kms pa)	4.2		
29	Business Income Tax Rate	0.3	Nat. Forest Opp.Cost (prop'n of pulp price)	0.04	Cost of Accidents ($m pa)	310		
30	**Referent Group Analysis**		MIS Subsidy (prop'n of private fibre cost)	0.3				
31	Tas Govt share of road infrastructure cost	0.7	MIS Proportion of Private Plantation Fibre	0.3	**Effluent**			
32	Workers Employment Benefits (share of labour cost)	0.0121	Non-timber Value Proportion	0.05	Effluent Flow (tons/day)	64000		
33	Tas.State Payroll Tax Receipts(share of labour cost)	0.0039	Non-timber Value Premium	0.1	Cost/tonne ($)	0		
34	Commonwealth Taxes (share of labour cost)	0.04	Opportunity Cost of Water ($/ML)	46				

1	**Market Analysis**																
2	**NFP** ($AUS millions)																
3	Year	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
4	**Fibre/Pulp Balance (Tonnes)**																
5	FST Native Forest (tonnes pa)			2560000	2389000	2218000	2047000	1876000	1705000	1534000	1363000	1192000	1021000	850000	850000	850000	850000
6	FST Plantation (tonnes pa)			150000	150000	150000	150000	150000	150000	150000	150000	150000	150000	150000	150000	150000	150000
7	Private Plantation (tonnes pa)			490000	741000	992000	1243000	1494000	1745000	1996000	2247000	2498000	2749000	3000000	3000000	3000000	3000000
8	**Total Fibre**			3200000	3280000	3360000	3440000	3520000	3600000	3680000	3760000	3840000	3920000	4000000	4000000	4000000	4000000
9	**Total Pulp**			802168	830183	858198	886213	914228	942243	970257	998272	1026287	1054302	1082317	1082317	1082317	1082317
10	**Revenues**																
11	Pulp Sales			528.5	539.3	549.7	559.7	569.3	578.5	587.4	595.9	604.0	611.8	713.1	713.1	713.1	713.1
12	Energy Sales			16.0	16.6	17.2	17.7	18.3	18.8	19.4	20.0	20.5	21.1	21.6	21.6	21.6	21.6
13	RECs			16.0	16.6	17.2	17.7	18.3	18.8	19.4	20.0	20.5	21.1	21.6	21.6	21.6	21.6
14	**Total Revenue**			560.6	572.5	584.0	595.1	605.9	616.2	626.2	635.8	645.1	654.0	756.3	756.3	756.3	756.3
15	**Capital Costs**																
16	Mill	-1000	-1000														
17	Pipelines	-100	-100														
18	Transport	-100	-100														
19	**Total Capital Cost**	-1200	-1200														
20	**Operating Cost**																
21	**Fibre Cost**																
22	**Stumpage**																
23	FST Native			-33.7	-31.5	-29.2	-27.0	-24.7	-22.5	-20.2	-18.0	-15.7	-13.5	-11.2	-11.2	-11.2	-11.2
24	FST Plantation			-4.1	-4.1	-4.1	-4.1	-4.1	-4.1	-4.1	-4.1	-4.1	-4.1	-4.1	-4.1	-4.1	-4.1
25	Private Plantation			-16.2	-24.5	-32.7	-41.0	-49.3	-57.6	-65.9	-74.2	-82.4	-90.7	-99.0	-99.0	-99.0	-99.0
26	Total Stumpage			-54.0	-60.0	-66.0	-72.0	-78.1	-84.1	-90.1	-96.2	-102.2	-108.2	-114.3	-114.3	-114.3	-114.3
27	**Other Fibre Costs**																
28	FST Native			-130.6	-121.8	-113.1	-104.4	-95.7	-87.0	-78.2	-69.5	-60.8	-52.1	-43.4	-43.4	-43.4	-43.4
29	FST Plantation			-5.6	-5.6	-5.6	-5.6	-5.6	-5.6	-5.6	-5.6	-5.6	-5.6	-5.6	-5.6	-5.6	-5.6
30	Private Plantation			-14.2	-21.5	-28.8	-36.0	-43.3	-50.6	-57.9	-65.2	-72.4	-79.7	-87.0	-87.0	-87.0	-87.0
31	Total Other			-150.3	-148.9	-147.4	-146.0	-144.6	-143.1	-141.7	-140.2	-138.8	-137.3	-135.9	-135.9	-135.9	-135.9
32	**Total Fibre Cost**			-204.3	-208.9	-213.4	-218.0	-222.6	-227.2	-231.8	-236.4	-241.0	-245.6	-250.2	-250.2	-250.2	-250.2
33	**Fixed Costs**																
34	Labour			-33.7	-34.9	-36.0	-37.2	-38.4	-39.6	-40.8	-41.9	-43.1	-44.3	-45.5	-45.5	-45.5	-45.5
35	Maintenance			-30.5	-31.5	-32.6	-33.7	-34.7	-35.8	-36.9	-37.9	-39.0	-40.1	-41.1	-41.1	-41.1	-41.1
36	**Total Fixed Cost**			-64.2	-66.4	-68.7	-70.9	-73.1	-75.4	-77.6	-79.9	-82.1	-84.3	-86.6	-86.6	-86.6	-86.6
37	**Variable Costs**																
38	Chemicals & Energy			-47.2	-48.8	-50.5	-52.1	-53.8	-55.4	-57.1	-58.7	-60.4	-62.0	-63.7	-63.7	-63.7	-63.7
39	Ocean Freight			-66.1	-68.4	-70.7	-73.0	-75.3	-77.6	-79.9	-82.2	-84.5	-86.8	-89.1	-89.1	-89.1	-89.1
40	Water			-0.9	-0.9	-0.9	-0.9	-0.9	-0.9	-0.9	-0.9	-0.9	-0.9	-0.9	-0.9	-0.9	-0.9
41	**Total Variable Cost**			-114.2	-118.1	-122.1	-126.0	-130.0	-133.9	-137.9	-141.8	-145.8	-149.8	-153.7	-153.7	-153.7	-153.7
42	**Total Cost**	-1200	-1200	-382.6	-393.4	-404.2	-415.0	-425.7	-436.5	-447.3	-458.1	-468.9	-479.7	-490.4	-490.4	-490.4	-490.4
43	**Net Benefit**	-1200.0	-1200.0	178.0	179.1	179.8	180.2	180.1	179.7	178.9	177.7	176.2	174.3	265.9	265.9	265.9	265.9
44	**IRR**	7.7%															
45	**NPV**	3%	5%	8%													
46		1,971.1	907.7	-81.6													

Market Analysis (continued)																
NFP ($AUS millions)																
Year	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31
Fibre/Pulp Balance (Tonnes)																
FST Native Forest (tonnes pa)	850000	850000	850000	850000	850000	850000	850000	850000	850000	850000	850000	850000	850000	850000	850000	850000
FST Plantation (tonnes pa)	150000	150000	150000	150000	150000	150000	150000	150000	150000	150000	150000	150000	150000	150000	150000	150000
Private Plantation (tonnes pa)	3000000	3000000	3000000	3000000	3000000	3000000	3000000	3000000	3000000	3000000	3000000	3000000	3000000	3000000	3000000	3000000
Total Fibre	4000000	4000000	4000000	4000000	4000000	4000000	4000000	4000000	4000000	4000000	4000000	4000000	4000000	4000000	4000000	4000000
Total Pulp	1082317	1082317	1082317	1082317	1082317	1082317	1082317	1082317	1082317	1082317	1082317	1082317	1082317	1082317	1082317	1082317
Revenues																
Pulp Sales	713.1	713.1	713.1	713.1	713.1	713.1	713.1	713.1	713.1	713.1	713.1	713.1	713.1	713.1	713.1	713.1
Energy Sales	21.6	21.6	21.6	21.6	21.6	21.6	21.6	21.6	21.6	21.6	21.6	21.6	21.6	21.6	21.6	21.6
RECs	21.6	21.6	21.6	21.6	21.6	21.6	21.6	21.6	21.6	21.6	21.6	21.6	21.6	21.6	21.6	21.6
Total Revenue	756.3	756.3	756.3	756.3	756.3	756.3	756.3	756.3	756.3	756.3	756.3	756.3	756.3	756.3	756.3	756.3
Capital Costs																
Mill																
Pipelines																
Transport																
Total Capital Cost																
Operating Cost																
Fibre Cost																
Stumpage																
FST Native	-11.2	-11.2	-11.2	-11.2	-11.2	-11.2	-11.2	-11.2	-11.2	-11.2	-11.2	-11.2	-11.2	-11.2	-11.2	-11.2
FST Plantation	-4.1	-4.1	-4.1	-4.1	-4.1	-4.1	-4.1	-4.1	-4.1	-4.1	-4.1	-4.1	-4.1	-4.1	-4.1	-4.1
Private Plantation	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0
Total Stumpage	-114.3	-114.3	-114.3	-114.3	-114.3	-114.3	-114.3	-114.3	-114.3	-114.3	-114.3	-114.3	-114.3	-114.3	-114.3	-114.3
Other Fibre Costs																
FST Native	-43.4	-43.4	-43.4	-43.4	-43.4	-43.4	-43.4	-43.4	-43.4	-43.4	-43.4	-43.4	-43.4	-43.4	-43.4	-43.4
FST Plantation	-5.6	-5.6	-5.6	-5.6	-5.6	-5.6	-5.6	-5.6	-5.6	-5.6	-5.6	-5.6	-5.6	-5.6	-5.6	-5.6
Private Plantation	-87.0	-87.0	-87.0	-87.0	-87.0	-87.0	-87.0	-87.0	-87.0	-87.0	-87.0	-87.0	-87.0	-87.0	-87.0	-87.0
Total Other	-135.9	-135.9	-135.9	-135.9	-135.9	-135.9	-135.9	-135.9	-135.9	-135.9	-135.9	-135.9	-135.9	-135.9	-135.9	-135.9
Total Fibre Cost	-250.2	-250.2	-250.2	-250.2	-250.2	-250.2	-250.2	-250.2	-250.2	-250.2	-250.2	-250.2	-250.2	-250.2	-250.2	-250.2
Fixed Costs																
Labour	-45.5	-45.5	-45.5	-45.5	-45.5	-45.5	-45.5	-45.5	-45.5	-45.5	-45.5	-45.5	-45.5	-45.5	-45.5	-45.5
Maintenance	-41.1	-41.1	-41.1	-41.1	-41.1	-41.1	-41.1	-41.1	-41.1	-41.1	-41.1	-41.1	-41.1	-41.1	-41.1	-41.1
Total Fixed Cost	-86.6	-86.6	-86.6	-86.6	-86.6	-86.6	-86.6	-86.6	-86.6	-86.6	-86.6	-86.6	-86.6	-86.6	-86.6	-86.6
Variable Costs																
Chemicals & Energy	-63.7	-63.7	-63.7	-63.7	-63.7	-63.7	-63.7	-63.7	-63.7	-63.7	-63.7	-63.7	-63.7	-63.7	-63.7	-63.7
Ocean Freight	-89.1	-89.1	-89.1	-89.1	-89.1	-89.1	-89.1	-89.1	-89.1	-89.1	-89.1	-89.1	-89.1	-89.1	-89.1	-89.1
Water	-0.9	-0.9	-0.9	-0.9	-0.9	-0.9	-0.9	-0.9	-0.9	-0.9	-0.9	-0.9	-0.9	-0.9	-0.9	-0.9
Total Variable Cost	-153.7	-153.7	-153.7	-153.7	-153.7	-153.7	-153.7	-153.7	-153.7	-153.7	-153.7	-153.7	-153.7	-153.7	-153.7	-153.7
Total Cost	-490.4	-490.4	-490.4	-490.4	-490.4	-490.4	-490.4	-490.4	-490.4	-490.4	-490.4	-490.4	-490.4	-490.4	-490.4	-490.4
Net Benefit	265.9	265.9	265.9	265.9	265.9	265.9	265.9	265.9	265.9	265.9	265.9	265.9	265.9	265.9	265.9	265.9
IRR	7.7%															
NPV	3%	5%	8%													
	1,971.1	907.7	-81.6													

1	**Proponent Analysis NFP**	($AUS millions)															
2	**Year**	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
3	**Net EBITDA**	-1100.0	-1100.0	178.0	179.1	179.8	180.2	180.1	179.7	178.9	177.7	176.2	174.3	265.9	265.9	265.9	265.9
4	**Finance**																
5	Capital	770.0	770.0	-54.5	-56.4	-58.3	-60.4	-62.5	-64.7	-66.9	-69.3	-71.7	-74.2	-76.8	-79.5	-82.3	-85.2
6	Interest			-53.9	-52.0	-50.0	-48.0	-45.9	-43.7	-41.4	-39.1	-36.6	-34.1	-31.5	-28.9	-26.1	-23.2
7	Total Finance	770.0	770.0	-108.4	-108.4	-108.4	-108.4	-108.4	-108.4	-108.4	-108.4	-108.4	-108.4	-108.4	-108.4	-108.4	-108.4
8																	
9	Depreciation			-107.8	-100.3	-93.2	-86.7	-80.6	-75.0	-69.7	-64.9	-60.3	-56.1	-52.2	-48.5	-45.1	-42.0
10																	
11	Taxable Income			16.3	26.9	36.6	45.5	53.6	61.0	67.7	73.8	79.2	84.1	182.2	188.5	194.7	200.8
12	Business Tax			-4.9	-8.1	-11.0	-13.6	-16.1	-18.3	-20.3	-22.1	-23.8	-25.2	-54.7	-56.6	-58.4	-60.2
13																	
14	Net Equity Return	-330.0	-330.0	64.7	62.7	60.5	58.2	55.7	53.0	50.2	47.2	44.1	40.8	102.9	101.0	99.1	97.3
15																	
16	**Year**	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31
17	**Net EBITDA**	265.9	265.9	265.9	265.9	265.9	265.9	265.9	265.9	265.9	265.9	265.9	265.9	265.9	265.9	265.9	265.9
18	**Finance**																
19	Capital	-88.1	-91.2	-94.4	-97.7	-101.2	-104.7										
20	Interest	-20.2	-17.1	-13.9	-10.6	-7.2	-3.7										
21	Total Finance	-108.4	-108.4	-108.4	-108.4	-108.4	-108.4										
22																	
23	Depreciation	-39.0	-36.3	-33.8	-31.4	-29.2	-27.2	-25.3	-23.5	-21.8	-20.3	-18.9	-17.6	-16.3	-15.2	-14.1	-13.1
24																	
25	Taxable Income	206.7	212.5	218.2	223.9	229.5	235.1	240.7	242.4	244.1	245.6	247.0	248.3	249.6	250.7	251.8	252.8
26	Business Tax	-62.0	-63.7	-65.5	-67.2	-68.9	-70.5	-72.2	-72.7	-73.2	-73.7	-74.1	-74.5	-74.9	-75.2	-75.5	-75.8
27																	
28	Net Equity Return	95.5	93.8	92.1	90.4	88.7	87.0	193.7	193.2	192.7	192.2	191.8	191.4	191.0	190.7	190.4	190.1
29																	
30	**IRR**	10.6%															
31	**NPV**	3%	5%	8%													
32		1266.07	721.44	240.32													

1	**Efficiency Analysis NFP**		($AUS millions)														
2	**Year**	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
3	**Revenues**																
4	Pulp Sales			528.5	539.3	549.7	559.7	569.3	578.5	587.4	595.9	604.0	611.8	713.1	713.1	713.1	713.1
5	Energy Sales			16.0	16.6	17.2	17.7	18.3	18.8	19.4	20.0	20.5	21.1	21.6	21.6	21.6	21.6
6	RECs			16.0	16.6	17.2	17.7	18.3	18.8	19.4	20.0	20.5	21.1	21.6	21.6	21.6	21.6
7	**Total Revenue**			560.6	572.5	584.0	595.1	605.9	616.2	626.2	635.8	645.1	654.0	756.3	756.3	756.3	756.3
8	**Capital Costs**																
9	Mill	-1000	-1000														
10	Pipelines	-100	-100														
11	Transport	-100	-100														
12	**Total Capital Cost**	-1200	-1200														
14	**Fibre Cost**																
15	**Stumpage**																
16	FST Native			-67.5	-63.0	-58.5	-53.9	-49.4	-44.9	-40.4	-35.9	-31.4	-26.9	-22.4	-22.4	-22.4	-22.4
17	FST Plantation			-4.1	-4.1	-4.1	-4.1	-4.1	-4.1	-4.1	-4.1	-4.1	-4.1	-4.1	-4.1	-4.1	-4.1
18	Private Plantation			-18.2	-27.6	-36.9	-46.3	-55.6	-65.0	-74.3	-83.7	-93.0	-102.4	-111.7	-111.7	-111.7	-111.7
19	Total Stumpage			-89.8	-94.6	-99.4	-104.3	-109.1	-114.0	-118.8	-123.7	-128.5	-133.3	-138.2	-138.2	-138.2	-138.2
20	**Other Fibre Costs**																
21	FST Native			-130.6	-121.8	-113.1	-104.4	-95.7	-87.0	-78.2	-69.5	-60.8	-52.1	-43.4	-43.4	-43.4	-43.4
22	FST Plantation			-5.6	-5.6	-5.6	-5.6	-5.6	-5.6	-5.6	-5.6	-5.6	-5.6	-5.6	-5.6	-5.6	-5.6
23	Private Plantation			-14.2	-21.5	-28.8	-36.0	-43.3	-50.6	-57.9	-65.2	-72.4	-79.7	-87.0	-87.0	-87.0	-87.0
24	Total Other			-150.3	-148.9	-147.4	-146.0	-144.6	-143.1	-141.7	-140.2	-138.8	-137.3	-135.9	-135.9	-135.9	-135.9
25	**Total Fibre**			-240.1	-243.5	-246.9	-250.3	-253.7	-257.1	-260.5	-263.9	-267.3	-270.7	-274.1	-274.1	-274.1	-274.1
26	**Fixed Costs**																
27	Labour			-31.8	-32.9	-34.0	-35.1	-36.2	-37.4	-38.5	-39.6	-40.7	-41.8	-42.9	-42.9	-42.9	-42.9
28	Maintenance			-30.5	-31.5	-32.6	-33.7	-34.7	-35.8	-36.9	-37.9	-39.0	-40.1	-41.1	-41.1	-41.1	-41.1
29	**Total Fixed Cost**			-62.3	-64.5	-66.6	-68.8	-71.0	-73.2	-75.3	-77.5	-79.7	-81.9	-84.0	-84.0	-84.0	-84.0
30	**Variable Costs**																
31	Chemicals & Energy			-47.2	-48.8	-50.5	-52.1	-53.8	-55.4	-57.1	-58.7	-60.4	-62.0	-63.7	-63.7	-63.7	-63.7
32	Ocean Freight			-66.1	-68.4	-70.7	-73.0	-75.3	-77.6	-79.9	-82.2	-84.5	-86.8	-89.1	-89.1	-89.1	-89.1
33	Water			-1.2	-1.2	-1.2	-1.2	-1.2	-1.2	-1.2	-1.2	-1.2	-1.2	-1.2	-1.2	-1.2	-1.2
34	**Total Variable Cost**			-114.4	-118.4	-122.4	-126.3	-130.3	-134.2	-138.2	-142.1	-146.1	-150.0	-154.0	-154.0	-154.0	-154.0
35	**Total Mill Cost**			-416.8	-426.3	-435.9	-445.4	-454.9	-464.5	-474.0	-483.5	-493.1	-502.6	-512.1	-512.1	-512.1	-512.1
36	**Additional External Effects**																
37	Forest standing value			-0.2	-0.2	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1
38	Road congestion cost			-0.4	-0.4	-0.4	-0.4	-0.4	-0.4	-0.4	-0.4	-0.4	-0.4	-0.4	-0.4	-0.4	-0.4
39	Local pollution health costs			-4.3	-4.3	-4.3	-4.3	-4.3	-4.3	-4.3	-4.3	-4.3	-4.3	-4.3	-4.3	-4.3	-4.3
40	Effluent Cost			0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
41	Total Additional External Costs			-4.9	-4.9	-4.9	-4.9	-4.9	-4.8	-4.8	-4.8	-4.8	-4.8	-4.8	-4.8	-4.8	-4.8
42	**Net Benefit**	-1200	-1200	138.9	141.3	143.3	144.9	146.1	146.9	147.4	147.5	147.2	146.6	239.4	239.4	239.4	239.4
43	IRR	6.4%															
44	NPV	3%	5%	8%													
45		$1,407.5	$465.5	-$405.6													

Efficiency Analysis (continued)																
Year	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31
Revenues																
Pulp Sales	713.1	713.1	713.1	713.1	713.1	713.1	713.1	713.1	713.1	713.1	713.1	713.1	713.1	713.1	713.1	713.1
Energy Sales	21.6	21.6	21.6	21.6	21.6	21.6	21.6	21.6	21.6	21.6	21.6	21.6	21.6	21.6	21.6	21.6
RECs	21.6	21.6	21.6	21.6	21.6	21.6	21.6	21.6	21.6	21.6	21.6	21.6	21.6	21.6	21.6	21.6
Total Revenue	756.3	756.3	756.3	756.3	756.3	756.3	756.3	756.3	756.3	756.3	756.3	756.3	756.3	756.3	756.3	756.3
Capital Costs																
Mill																
Pipelines																
Transport																
Total Capital Cost																
Fibre Cost																
Stumpage																
FST Native	-22.4	-22.4	-22.4	-22.4	-22.4	-22.4	-22.4	-22.4	-22.4	-22.4	-22.4	-22.4	-22.4	-22.4	-22.4	-22.4
FST Plantation	-4.1	-4.1	-4.1	-4.1	-4.1	-4.1	-4.1	-4.1	-4.1	-4.1	-4.1	-4.1	-4.1	-4.1	-4.1	-4.1
Private Plantation	-111.7	-111.7	-111.7	-111.7	-111.7	-111.7	-111.7	-111.7	-111.7	-111.7	-111.7	-111.7	-111.7	-111.7	-111.7	-111.7
Total Stumpage	-138.2	-138.2	-138.2	-138.2	-138.2	-138.2	-138.2	-138.2	-138.2	-138.2	-138.2	-138.2	-138.2	-138.2	-138.2	-138.2
Other Fibre Costs																
FST Native	-43.4	-43.4	-43.4	-43.4	-43.4	-43.4	-43.4	-43.4	-43.4	-43.4	-43.4	-43.4	-43.4	-43.4	-43.4	-43.4
FST Plantation	-5.6	-5.6	-5.6	-5.6	-5.6	-5.6	-5.6	-5.6	-5.6	-5.6	-5.6	-5.6	-5.6	-5.6	-5.6	-5.6
Private Plantation	-87.0	-87.0	-87.0	-87.0	-87.0	-87.0	-87.0	-87.0	-87.0	-87.0	-87.0	-87.0	-87.0	-87.0	-87.0	-87.0
Total Other	-135.9	-135.9	-135.9	-135.9	-135.9	-135.9	-135.9	-135.9	-135.9	-135.9	-135.9	-135.9	-135.9	-135.9	-135.9	-135.9
Total Fibre	-274.1	-274.1	-274.1	-274.1	-274.1	-274.1	-274.1	-274.1	-274.1	-274.1	-274.1	-274.1	-274.1	-274.1	-274.1	-274.1
Fixed Costs																
Labour	-42.9	-42.9	-42.9	-42.9	-42.9	-42.9	-42.9	-42.9	-42.9	-42.9	-42.9	-42.9	-42.9	-42.9	-42.9	-42.9
Maintenance	-41.1	-41.1	-41.1	-41.1	-41.1	-41.1	-41.1	-41.1	-41.1	-41.1	-41.1	-41.1	-41.1	-41.1	-41.1	-41.1
Total Fixed Cost	-84.0	-84.0	-84.0	-84.0	-84.0	-84.0	-84.0	-84.0	-84.0	-84.0	-84.0	-84.0	-84.0	-84.0	-84.0	-84.0
Variable Costs																
Chemicals & Energy	-63.7	-63.7	-63.7	-63.7	-63.7	-63.7	-63.7	-63.7	-63.7	-63.7	-63.7	-63.7	-63.7	-63.7	-63.7	-63.7
Ocean Freight	-89.1	-89.1	-89.1	-89.1	-89.1	-89.1	-89.1	-89.1	-89.1	-89.1	-89.1	-89.1	-89.1	-89.1	-89.1	-89.1
Water	-1.2	-1.2	-1.2	-1.2	-1.2	-1.2	-1.2	-1.2	-1.2	-1.2	-1.2	-1.2	-1.2	-1.2	-1.2	-1.2
Total Variable Cost	-154.0	-154.0	-154.0	-154.0	-154.0	-154.0	-154.0	-154.0	-154.0	-154.0	-154.0	-154.0	-154.0	-154.0	-154.0	-154.0
Total Mill Cost	-512.1	-512.1	-512.1	-512.1	-512.1	-512.1	-512.1	-512.1	-512.1	-512.1	-512.1	-512.1	-512.1	-512.1	-512.1	-512.1
Additional External Effects																
Forest standing value	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1
Road congestion cost	-0.4	-0.4	-0.4	-0.4	-0.4	-0.4	-0.4	-0.4	-0.4	-0.4	-0.4	-0.4	-0.4	-0.4	-0.4	-0.4
Local pollution health costs	-4.3	-4.3	-4.3	-4.3	-4.3	-4.3	-4.3	-4.3	-4.3	-4.3	-4.3	-4.3	-4.3	-4.3	-4.3	-4.3
Effluent Cost	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total Additional External Costs	-4.8	-4.8	-4.8	-4.8	-4.8	-4.8	-4.8	-4.8	-4.8	-4.8	-4.8	-4.8	-4.8	-4.8	-4.8	-4.8
Net Benefit	239.4	239.4	239.4	239.4	239.4	239.4	239.4	239.4	239.4	239.4	239.4	239.4	239.4	239.4	239.4	239.4
IRR	6.4%															
NPV	3%	5%	8%													
	$1,407.5	$465.5	-$405.6													

1	**Referent Group Analysis NFP**	(S millions)															
2	Year	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
3	**Total Referent Group**	-166.0	-166.0	-37.3	-33.9	-30.7	-27.8	-25.1	-22.7	-20.6	-18.6	-16.9	-15.4	27.1	28.7	30.1	31.6
4	**Tasmania**																
5	*Tasmanian Government*																
6	Infrastructure Cost	-70.0	-70.0														
7	Payroll Tax			0.1	0.1	0.1	0.1	0.1	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
8	Forestry Tasmania			-33.7	-31.5	-29.2	-27.0	-24.7	-22.5	-20.2	-18.0	-15.7	-13.5	-11.2	-11.2	-11.2	-11.2
9	**Total Tasmanian Government**	-70.0	-70.0	-33.6	-31.3	-29.1	-26.8	-24.6	-22.3	-20.1	-17.8	-15.5	-13.3	-11.0	-11.0	-11.0	-11.0
10	*Tasmanian Community*																
11	Employment Benefit Workers			0.4	0.4	0.4	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.6	0.6	0.6	0.6
12	Tasmanian Shareholder Return	-66.0	-66.0	12.9	12.5	12.1	11.6	11.1	10.6	10.0	9.4	8.8	8.2	20.6	20.2	19.8	19.5
13	Water Cost Premium			-0.3	-0.3	-0.3	-0.3	-0.3	-0.3	-0.3	-0.3	-0.3	-0.3	-0.3	-0.3	-0.3	-0.3
14	Road Congestion			-0.4	-0.4	-0.4	-0.4	-0.4	-0.4	-0.4	-0.4	-0.4	-0.4	-0.4	-0.4	-0.4	-0.4
15	Forgone Non-timber Values			-0.2	-0.2	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1
16	Health Cost			-4.3	-4.3	-4.3	-4.3	-4.3	-4.3	-4.3	-4.3	-4.3	-4.3	-4.3	-4.3	-4.3	-4.3
17	Effluent Cost			0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
18	**Total Tasmanian Community**	-66.0	-66.0	8.2	7.8	7.4	6.9	6.5	6.0	5.4	4.8	4.2	3.6	16.1	15.7	15.3	14.9
19	**Total Tasmania**	-136.0	-136.0	-25.4	-23.6	-21.7	-19.9	-18.1	-16.4	-14.6	-13.0	-11.3	-9.7	5.0	4.7	4.3	3.9
20	**Federal government**																
21	Business Income Tax			4.9	8.1	11.0	13.6	16.1	18.3	20.3	22.1	23.8	25.2	54.7	56.6	58.4	60.2
22	Other Tax & Transfer			1.3	1.4	1.4	1.5	1.5	1.6	1.6	1.7	1.7	1.8	1.8	1.8	1.8	1.8
23	MIS Subsidy			-2.1	-3.1	-4.2	-5.3	-6.3	-7.4	-8.5	-9.5	-10.6	-11.7	-12.7	-12.7	-12.7	-12.7
24	RECs			-16.0	-16.6	-17.2	-17.7	-18.3	-18.8	-19.4	-20.0	-20.5	-21.1	-21.6	-21.6	-21.6	-21.6
25	Road Cost	-30.0	-30.0														
26	**Total Federal**	-30.0	-30.0	-11.9	-10.3	-9.0	-7.9	-7.0	-6.4	-5.9	-5.7	-5.6	-5.7	22.1	24.0	25.9	27.7
27	**Total**	-166.0	-166.0	-37.3	-33.9	-30.7	-27.8	-25.1	-22.7	-20.6	-18.6	-16.9	-15.4	27.1	28.7	30.1	31.6
28	**CHECK**	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
29	**NPV**	3%	5%	8%													
30	**Tasmanian Government**	-455.1	-396.0	-335.7													
31	**Tasmanian Community**	165.9	76.9	-0.1													
32	**Total Tasmania**	-289.2	-319.1	-335.8													
33	**Federal Government**	251.0	132.1	31.6													

Referent Group Analysis (continued)																
Year	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31
Total Referent Group	33.0	34.4	35.8	37.1	38.5	39.8	62.8	63.3	63.7	64.0	64.4	64.7	65.0	65.2	65.5	65.7
Tasmania																
Tasmanian Government																
Infrastructure Cost																
Payroll Tax	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
Forestry Tasmania	-11.2	-11.2	-11.2	-11.2	-11.2	-11.2	-11.2	-11.2	-11.2	-11.2	-11.2	-11.2	-11.2	-11.2	-11.2	-11.2
Total Tasmanian Government	-11.0	-11.0	-11.0	-11.0	-11.0	-11.0	-11.0	-11.0	-11.0	-11.0	-11.0	-11.0	-11.0	-11.0	-11.0	-11.0
Tasmanian Community																
Employment Benefit Workers	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6
Tasmanian Shareholder Return	19.1	18.8	18.4	18.1	17.7	17.4	38.7	38.6	38.5	38.4	38.4	38.3	38.2	38.1	38.1	38.0
Water Cost Premium	-0.3	-0.3	-0.3	-0.3	-0.3	-0.3	-0.3	-0.3	-0.3	-0.3	-0.3	-0.3	-0.3	-0.3	-0.3	-0.3
Road Congestion	-0.4	-0.4	-0.4	-0.4	-0.4	-0.4	-0.4	-0.4	-0.4	-0.4	-0.4	-0.4	-0.4	-0.4	-0.4	-0.4
Forgone Non-timber Values	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1
Health Cost	-4.3	-4.3	-4.3	-4.3	-4.3	-4.3	-4.3	-4.3	-4.3	-4.3	-4.3	-4.3	-4.3	-4.3	-4.3	-4.3
Effluent Cost	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total Tasmanian Community	14.6	14.2	13.9	13.6	13.2	12.9	34.2	34.1	34.0	33.9	33.8	33.8	33.7	33.6	33.5	33.5
Total Tasmania	3.6	3.2	2.9	2.5	2.2	1.9	23.2	23.1	23.0	22.9	22.8	22.7	22.7	22.6	22.5	22.5
Federal government																
Business Income Tax	62.0	63.7	65.5	67.2	68.9	70.5	72.2	72.7	73.2	73.7	74.1	74.5	74.9	75.2	75.5	75.8
Other Tax & Transfer	1.8	1.8	1.8	1.8	1.8	1.8	1.8	1.8	1.8	1.8	1.8	1.8	1.8	1.8	1.8	1.8
MIS Subsidy	-12.7	-12.7	-12.7	-12.7	-12.7	-12.7	-12.7	-12.7	-12.7	-12.7	-12.7	-12.7	-12.7	-12.7	-12.7	-12.7
RECs	-21.6	-21.6	-21.6	-21.6	-21.6	-21.6	-21.6	-21.6	-21.6	-21.6	-21.6	-21.6	-21.6	-21.6	-21.6	-21.6
Road Cost																
Total Federal	29.4	31.2	32.9	34.6	36.3	38.0	39.6	40.2	40.7	41.1	41.5	41.9	42.3	42.7	43.0	43.3
Total	33.0	34.4	35.8	37.1	38.5	39.8	62.8	63.3	63.7	64.0	64.4	64.7	65.0	65.2	65.5	65.7
CHECK	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
NPV	3%	5%	8%													
Tasmanian Government	-455.1	-396.0	-335.7													
Tasmanian Community	165.9	76.9	-0.1													
Total Tasmania	-289.2	-319.1	-335.8													
Federal Government	251.0	132.1	31.6													