The Economic Appraisal of Investment Projects at the EIB

Version March 2013 – Under review

European Investment Bank

The EU bank

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Projects Directorate

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(Under review)

30/10/2020 – Note to the Reader

The EIB Projects Directorate conducts technical and economic appraisal of the projects financed by the Bank, and JASPERS includes economic appraisal in its project preparation assistance. Economic appraisal plays a central role in the operations of the EIB. It allows the Bank to judge whether an investment project will contribute to the economic growth and cohesion of the EU and the economic progress of its partners.

This guide, which was published in April 2013 in the EIB website, illustrates how the Bank conducts economic appraisal across the sectors of the economy where it operates.

The transformation of the EIB into the EU Climate Bank, as well as research advances in some of the elements of the appraisal require that the guide be revised. Amongst some of the elements requiring revision there are: the cost of carbon, the value of time (VoT) in transport and the value of transport safety.

This version under review provides links to updated documents for their use until the new version of the guide is available by end of 2021 at the latest.

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List of Abbreviations and Acronyms

3G:	Third generation (of mobile telecommunications technology)
ACP:	Africa, Caribbean and Pacific Mandate of the EIB
AIC:	Average incremental cost
B/C:	Benefit-cost (ratio)
BGC:	Behavioural generalised cost
BREEAM:	Building Research Establishment Environmental Assessment Method
CAPM:	Capital asset pricing model
CBA:	Cost-benefit analysis
CCGT:	Combined cycle gas turbine
CEA:	Cost-effectiveness analysis
CF:	Conversion factor
DDGS:	Dried distiller grains and solubles
DH:	District heating
DSL:	Digital subscriber line
EC:	European Commission
EE:	Energy efficiency
EIA:	Environmental impact assessment
EIB:	European Investment Bank, or “the Bank”
EIRR:	Economic internal rate of return (also referred to as ERR)
ENPV:	Economic net present value
EPO:	European Patent Office
ERDF:	European Regional Development Fund
ERIAM:	Economic Road Infrastructure Appraisal Model
ERP:	Enterprise resource planning
ERR:	Economic rate of return (also referred to as EIRR)
ETS:	(EU) Emissions Trading Scheme
EU:	European Union
FDI:	Foreign direct investment
FEMIP:	Facility for Euro-Mediterranean Investment and Partnership
FIRR:	Financial internal rate of return (also referred to as FRR)
FNPV:	Financial net present value
FP:	(EU Research) Framework Programme
FRR:	Financial rate of return (also referred to as FIRR)
FTTH:	Fibre to the home
FTTx:	Fibre to the (home/building/curb)
GC:	Generalised cost
GHG:	Greenhouse gas
GJ:	Giga Joule
GMO:	Genetically modified foods
GDP:	Gross domestic product
GSM:	Global System for Mobile Communications
HEV:	Hybrid electric vehicle
HGV:	Heavy goods vehicle
HR:	Human resources
HSPA+:	Evolved high-speed package access
HV:	Heavy vehicle (transport context) or high voltage (energy context)
IATA:	International Air Transport Association
ICE:	Internal combustion engine
ICT:	Information and communications technologies
IFI:	International financial institution
ILUC:	Indirect land-use change
IM:	Infrastructure manager
IO:	Input-output
IP:	Intellectual property
IPPC:	Integrated Pollution Prevention and Control
IRR:	Internal rate of return
IT:	Information technology

JASPERS:	Joint Assistance to Support Projects in European Regions
kV:	kilo Volt
KWh:	Kilowatt-hour
LC:	Levelised cost
LCU:	Local currency units
LCOE:	Levelised cost of energy
LNG:	Liquefied natural gas
LTE:	Long-term evolution
LV:	Light vehicle (transport context) or low voltage (energy context)
MBT:	Mechanical biological treatment
MCA:	Multi-criteria analysis
MLD:	Mega litre
MV:	Medium voltage
MVA:	Megavolt-ampere
MW:	Megawatt
MWh:	Megawatt-hour
NPC:	Net present cost
NPV:	Net present value
OCF:	Operating cash-flow
OECD:	Organisation for Economic Co-operation and Development
O&M:	Operations and maintenance
OPEX:	Operating expenditure
OPS:	Operations Department of the EIB
PC:	Personal computer
PHEV:	Plugged-in hybrid electric vehicle
PJ:	Projects Department of the EIB
PPP:	Public-private partnership
PSO:	Public service obligation
PV:	Present value
R&D:	Research and development
RDI:	Research, development and innovation
RI:	Research infrastructure
RM:	Risk Management Department of the EIB
ROA:	Real option analysis
ROIC:	Return on invested capital
RU:	Railway undertaking
SAAS:	Software as a service
SME:	Small and medium-sized enterprises
SP:	Stated preference
SPL:	Structural programme loan
SRAS:	Single radio access network
STPR:	Social time preference rate
STS:	Ship to shore
SW:	Solid waste
SWM:	Solid waste management
TAC:	Track access charge
TEU:	Twenty feet equivalent (container) unit
TSO:	Transmission system operator
TTM:	Time to market
TWh:	Terawatt-hour
UGS:	Underground gas storage
UMTS:	Universal mobile telecommunications system
UNWTO:	United Nations World Tourism Organisation (UNWTO)
VAT:	Value-added tax
VHV:	Very high voltage
VOC:	Vehicle operating costs
VOT:	Value of time
VPD:	Vehicles per day
WACC:	Weighted average cost of capital
W&S:	Water and sanitation

WHO:	World Health Organisation
WOP:	Without project
WP:	With project
WTO:	World Trade Organisation
WTE:	Waste to energy
WTP:	Willingness to pay
WWTP:	Wastewater treatment plant

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Foreword

The EIB Projects Directorate conducts technical and economic appraisal of the projects financed by the Bank, and JASPERS includes economic appraisal in its project preparation assistance. Economic appraisal thus plays a central role in the operations of the EIB. It allows the Bank to judge whether an investment project will contribute to the economic growth and cohesion of the EU and the economic progress of its partners.

Some projects have poor financial performance, and therefore may not be financed by the private sector at reasonable terms, or at all. Private sector investors evaluate projects using standard financial appraisals that focus on private financial returns. Economic appraisal, in turn, takes a broader view to include other benefits and costs to society, accounting for all resources used by the project, whether human, technological, or natural, and gauges the value the project generates to all stakeholders, to determine whether society at large gains from the investment.

The economic viability of a project can be seen as synonymous with sustainability, cohesion and growth in many respects. A project that is economically viable generates products or services that are valued by society and that may contribute to improving productivity and growth for the economy. Any employment generated by an economically sound project would involve jobs that are sustainable over the long run. By accounting for environmental costs and benefits, economic appraisal sees that any impact on the environment is not gratuitous, while giving full credit to the benefits of environmentally efficient technologies. Finally, economic appraisal ensures that any financial support by the government or from European funds to a viable project is public money well spent.

This guide illustrates how the Bank conducts economic appraisal across all the sectors of the economy where it operates. The Bank uses standard economic appraisal techniques, including Cost-Benefit Analysis, Cost-Effectiveness Analysis and, more recently, Multi-Criteria Analysis, taking into account the evolving circumstances of each sector. Indeed, economic appraisal is not a static discipline. The development of new sectors and technologies, and the advancement of techniques and publication of new findings by academia, require that the methodologies and parameters used in project appraisal evolve. For this reason, the Bank continuously engages in revisions of methodologies and updates key variables used in appraisals, most often in cooperation with academia and other consultants, as will become apparent to the reader.

Given the wide range of sectors, the treatment of each in the guide is necessarily schematic. Still, by combining discussions of the application of techniques to each sector with case studies, the document provides a comprehensive picture of appraisal practice in the Bank. Methodology themes of particular interest are treated separately in more detail and, whereas the guide is intended for as wide an audience as possible, technical precision is provided where needed for the benefit of the specialist reader.

The guide should allow the reader to gain a thorough understanding of how the EIB looks beyond commercial considerations to ensure that investment projects are supported for their contribution to cohesion, employment, growth and sustainability of the EU and its partners.

Christopher Hurst
Director General, Projects Directorate

1 Introduction

J. Doramas Jorge-Calderón[1]

1.1 Objective of the guide

This document presents the economic appraisal methods that the EIB (the Bank) uses in order to assess the economic viability of projects. It is not intended as a manual, nor is it meant to instruct the reader about how to conduct the economic appraisal of a project – a “how to do it” guide – as there are already many textbooks and guides widely available.[2] Likewise, the aim here is not to review the theory behind economic appraisal, as many widely available references are suitable for that purpose. Rather, this guide describes “how the EIB does it,” giving the general reader an overview of the methods used, and the specialist a guide to the application of analytical tools across sectors by the Bank.

The document has been written by EIB economists working on project appraisal. There are nearly 30 authors, each of them writing on their areas of specialisation. Economic appraisal is an ever-evolving field, and individual contributors have identified areas where there is ongoing work to update parameters or revise methods. This is thus a snapshot of economic appraisal practice at the time of writing and lends itself to updates over time.

It is also worth underlining that the guide covers economic appraisal only. The overall appraisal of a project by the Projects Directorate also involves technical, environmental and procurement aspects. More broadly, every Bank operation also involves credit and legal assessments.

This introductory chapter goes on to present the case for economic appraisal, which complements financial appraisal in measuring the returns of a project to society. It then describes how the conditions under which the Bank operates shape the type of appraisal suitable for providing the answer the Bank’s governing bodies require to help them channel financing to projects that fulfil the Bank’s objectives. It finishes by making a general introduction to the structure of the guide.

1.2 The need for economic appraisal

In competitive, undistorted markets with well-defined property rights, the revenues generated by an investment project measure the value that the output of the project generates for its users, and the money costs of the project measure the value (or opportunity cost) of resources used in producing the output. In other words, prices for inputs and outputs are valid measures of value and scarcity. In addition, since projects tend to be marginal in relation to the size of the economy at large, they do not affect prices more than marginally, and hence there is no need to make additional considerations about consumer or producer surplus. Under such circumstances, the financial return on capital of the project would be a necessary and sufficient indicator to determine whether the project is worth undertaking or not from the social welfare point of view.

However, markets are not always sufficiently competitive, prices are often distorted, and property rights are at times not well defined, leaving externalities with no price assigned to them. For these reasons, a project’s financial return may not be an adequate indicator for the desirability of the project for society at large. At times, as in some public goods, a financial

[1] This introduction builds partly on the note to the Board of Directors of 2008 “The Economic Appraisal of Projects: An Overview of the Approach within the Bank” 08/580 prepared by J. Doramas Jorge-Calderón and Edward Calthrop with the cooperation of all PJ departments.

[2] The DG Regio Guide to Cost-Benefit Analysis has such a pedagogic element. In addition, it sets the principles that applicants for European Cohesion Fund financing must follow in their preparation of CBAs, adding an element of “how we want it done.” See European Commission (2008) *Guide to Cost Benefit Analysis of Investment Projects*. European Commission Directorate General Regional Policy: Brussels. Available at: http://ec.europa.eu/regional_policy/information/evaluations/guidance_en.cfm#5

return may not exist at all. Provision of public goods may be made free of charge to the user and generate no revenues to the investor, such as a dyke to preserve an eroding beach.

The standard economic appraisal technique, which helps assess the socio-economic desirability of the project, is cost-benefit analysis (CBA). It is designed to produce a measure of project returns corrected for the various distortions and constraints to markets mentioned above.

CBA has a long tradition within Europe. Its origin as a discipline is attributed to a French engineer, Jules Dupuit (1848), before being developed by economists. It has become a standard part of public decision-making in many Member States, notably as a means to justify the use of public funds. At the European level, projects that apply for grant funding from the European Commission are required to present an economic justification – in 2008 DG Regio updated an appraisal manual to help promoters and consultants to provide robust analysis (see footnote 2). In addition to the EIB, many other International Financial Institutions (IFIs) and international organisations also appraise projects' economic desirability.

The outcome of a CBA is summarised in two complementary figures – the economic rate of return (ERR) and the economic net present value (ENPV). The ERR of a project is the average annual return to society on the capital invested over the entire life of the project. It is, in other words, the interest rate at which the project's discounted benefits equal discounted costs, both valued from the entire society's point of view. A project is accepted if the ERR is equal to or exceeds a certain threshold (the social discount rate). The ENPV of a project is the difference between discounted benefits and costs at a given discount rate. The correct discount rate equals the threshold rate just mentioned. Projects are accepted if the ENPV is positive.

Despite this seemingly schematic way of applying CBA, it is worth emphasising that economic appraisal by means of CBA is more than just a mechanical exercise. Good analysis can help clarify the aim of the project; estimate what will happen if the project is undertaken, and what will happen if it is not; evaluate whether the proposed project is the best option available; identify whether components of the project are the most efficient; identify who wins and who loses from the project; quantify the overall impact on government's fiscal position; evaluate whether the project is financially sustainable; evaluate the risks in the project; and – ultimately – provide an informed view to decision-makers as to whether the project is worthwhile for society.

CBA measures the difference between the flow of costs and benefits with the project and those without (the "with project" and "without project" scenario). Policy choices are rarely between a project and no project – rather, there are usually several plausible policy alternatives (e.g. the construction of a new greenfield motorway for 100km, or greenfield for the first 50km only, with upgrading of existing road for remainder, or upgrading existing road for the entire length). Economic analysis will typically compare several policy scenarios against a common "without project" baseline. Moreover, as infrastructure and other capital assets typically have long lives, these different scenarios must measure flows over many years.

Depending on the nature of the alternatives to be assessed, and the type of data available, a comprehensive CBA may not be possible. In such cases, the CBA may be replaced by a cost-effectiveness analysis (CEA, focusing on the cost of attaining a given target) or perhaps a multi-criteria analysis (MCA). These alternatives are not necessarily substitutes for each other and may well be seen as complementary to full CBA, particularly if economic viability is to be weighed with other policy considerations. However, as discussed below, the Bank makes a discrete choice among the methodologies, applying CBA where feasible, CEA where the project focuses on choice of technology, and MCA where the other methods are deemed impractical.

Much depends on the extent to which output variables, and benefits in particular, can be measured and monetised. There are cases where benefits are hard to quantify, in which case a traditional CBA cannot be applied, and a cost-effectiveness analysis becomes more appropriate. In such cases the decision to carry out a certain type of investment or program is determined as part of the political process and a cost-effectiveness analysis is used to determine the best project to achieve the desired results, generally the one that achieves the greatest output per unit of input.

MCA, in turn, consists of combining various evaluation techniques addressing different criteria, and applying weightings to each of them in order to arrive to a single score used to compare alternative projects. Typical criteria would include affordability tests, income distribution considerations, compliance with strategic objectives, quality of the internal decision-making of the promoter, visual appeal, etc.

In general, the suitability of the three techniques to project circumstances can be summarised as in Table 1.1. The two drivers are the extent to which the output variables can be measured (and monetised) and the degree to which the project produces multiple outputs.

Table 1.1:
Suitability of methodologies across project circumstances

		Number of output variables	
		High	Low
Degree to which output variables can be easily measured and monetised	High	CBA CEA	CBA CEA
	Low	MCA	CEA

The aim of all three techniques is to go beyond financial flows, and to correct for distortions that may be present in markets, to reflect wider benefits and costs to society, in order to assess the viability of the project to meet society's needs.

1.3 Economic appraisal at the EIB

The Bank finances projects in a very broad range of sectors, essentially covering all industries with the exception of only a few. Sectors include competitive industries, oligopolies and natural monopolies, as well as public goods. The outputs produced include both manufactured goods and services. The latter case includes, among others, basic services where consumer surplus may be impracticable to measure, for reasons that will become apparent in the sector presentations.

Such variety implies that the Bank must use an array of methodologies rather than a single, homogeneous one. In the Bank, about half of project appraisals rely on ERR calculations, and the other half on other methods. This variety means that the results of studies across sectors are not always directly comparable. Nonetheless, it is necessary for them to be compatible and consistent, meaning that the application of alternative methodologies to projects, where feasible, would yield the same decision as to the suitability for Bank financing.

1.3.1 Context of Bank appraisals

The previous section provided an overview of the role economic appraisal can play in informing political choice on the socio-economic value of a project. This is of primary benefit to national authorities themselves, not least in justifying the use of public funds to taxpayers. This type of appraisal is most useful when performed early in the project cycle, when very different possible courses of action may be taken (e.g. fossil-fuel versus renewable energy; high-speed rail versus upgrade to conventional rail system etc.). Indeed, in many Member States, economic appraisal is a sizeable industry in itself. A large project may require something in the order of five to ten person-years in consultancy work, developing models, collecting data, analysing different scenarios. In some sectors, such as road transport, economic appraisal is often undertaken by Bank services on the basis of an economic feasibility study provided by the project promoter.

In other sectors the Bank's services must normally construct the economic appraisal from scratch, on the basis of business plans and financial projections.

If the promoter has produced an economic appraisal, and if the promoter's studies were of consistent high quality, the services review and summarise the available material and their suitability for decision-making. In practice, however, there are several possible problems that may be encountered when discussing the economic justification of a project with the promoter, as discussed below.

1.3.2 Possible problems with studies presented to the Bank

"No appraisal". In some countries, there is only a weak tradition of justifying the selection of a particular project via an explicit analysis of costs and benefits. Whilst regular attempts are made to improve this situation, often initiated by the Bank itself,[3] the fact remains that, for the time being, many projects come accompanied with little more than a financial model. In addition, if the domestic political decision to fund has already been made, there may be inadequate incentives for the promoter to go back and quantify the impact of discarded options or a "without project" scenario. In this case, the Bank's services perform their own economic appraisal.

"Deficient appraisal". Whilst views may differ on specific points (e.g. the assumptions of a particular model), a feasibility study prepared by a consultant may not meet the minimum standards required in terms of transparency, rigour and internal consistency (for example, by the DG Regio guide). In this case, the Bank extracts the key assumptions behind the existing work, discusses the main assumptions with the promoter, and then reworks the analysis within a consistent appraisal framework. In this respect deficiencies may concern the use of impacts on the regional economy or on jobs created as part of the project benefits, which constitutes mostly double counting and confuses benefit and impact analysis.[4]

"Over-optimistic appraisal". In some cases, promoters are over-optimistic on future demand patterns for their project – indeed, this may even be a strategic response to the need to outbid other competing claims for national and European funds. As a result, Bank services revisit the promoter's basic model but with different key assumptions – lower growth, perhaps, or including a more realistic implementation schedule, as well as extending the sensitivity analysis. For this the Bank makes use of its extensive experience in appraising other similar projects. If the Bank does not have access to the promoter's model, it is necessary to "translate" the promoter's model into a simplified format, and then explore how robust findings are to different assumptions on key inputs.

1.3.3 Need for consistent tools within the Bank

Given the varied quality of promoters' studies, even within Europe, there is a need for Bank services to have a common approach when presenting projects to the Board. That is to say, even where promoters provide studies that are plausible, rigorous and transparent, there is a need to develop internal tools to provide a consistent view on projects across different countries.

For those sectors where a financial appraisal is only a poor proxy for economic appraisal, the discussion above makes the case for the Bank's services to develop simple, practical appraisal tools that can be rapidly applied to a wide variety of projects. This is exactly what has happened – and the nature and type of models have developed over time.

1.3.4 Use of methodology across sectors

In appraising the economic viability of projects, the EIB uses CBA, CEA and MCA as substitutes rather than complements, as mentioned above. In general, the Bank would use CBA whenever possible. In some sectors an estimate of the benefits yielded by a project may not be practical, since the service is deemed too basic a necessity. This is generally the case in sectors such as electricity provision, water and sanitation. Moreover, in such cases the policy context implies that the service level must be supplied. The project appraisal then focuses on whether the project constitutes the most efficient alternative to supply the good or service. CEA is only

[3] Reference is made to RAILPAG and JASPERS.

[4] See chapter 6 on Wider Economic Impacts.

practicable when the output or service is homogeneous and easily measurable. Whereas this may well be the case in the provision of, say, electricity, it is generally much more difficult in sectors such as education, health and projects addressing the urban environment, where output can have many dimensions and may not be easily measurable. In such cases MCA would constitute a more fitting version of CEA, or a proxy to CBA.

Table 1.2 summarises the use of methodologies across sectors. The table is indicative, as the choice of appraisal technique is ultimately determined by the circumstances of each project.

Table 1.2: Methodology use in the EIB across sectors

CBA	CEA	MCA
Agro-industry Energy Manufacturing Telecommunications Tourism Transport Water and wastewater	Energy Solid waste management Water and wastewater	Education Health Urban and Regional Development

1.4 Structure of the guide

The document is structured into three parts. The first two parts describe methodological topics that have relevance across many sectors (Part 1), and topics that are sector–specific (Part 2). These parts do not seek to present an exhaustive guide to preparing a CBA or economic appraisal; instead, they describe how the EIB addresses key methodological issues. Future versions of the guide may address additional issues as a response, for instance, to methodological developments deemed noteworthy. Part 3 describes the application of appraisal methods to specific sectors, including a description of the key variables and circumstances affecting economic appraisal in individual sectors and an overview of important parameters and assumptions used. It also presents one or more short case studies for each sector.

PART 1:

METHODOLOGY TOPICS: CROSS-SECTOR

2 Financial and Economic Appraisal

Harald Gruber and Pierre-Etienne Bouchaud

2.1 Financial appraisal

The essence of financial appraisal is the identification of all expenditures and revenues over the lifetime of the project, with a view to assessing the ability of a project to achieve financial sustainability and a satisfactory rate of return. The appraisal is usually done at constant market prices and in a cash flow statement format. It is the difference of all revenues and expenditures at the time at which they are incurred.

2.1.1 Revenues

The cash flow statement sets out the revenues to be derived from a project. These revenues can take several forms. The easiest to identify are the products and services from the project sold through normal commercial channels as well as any commercially exploitable by-products and residues. Revenue valuation is then simply a matter of estimating the sales values of these products and services.

2.1.2 Expenditures

The cash flow statement embraces both capital and operational expenditures. Capital expenditures are simply the expenditures of those items needed to set up or establish the project so that it can be operated. Operating expenditures are those incurred in operating and maintaining the project. Capital expenditures usually cover items related to construction of facilities, including site preparation and other civil costs; plant and equipment, comprising not only the acquisition cost but also the cost of transport, installation and testing; vehicles; and working capital.

Operating expenditures typically comprise raw materials, labour and other input services, repairs and maintenance. Pre-operating expenses, sunk costs, and working capital may be included under certain conditions. In a financial appraisal used as the basis of an economic appraisal, other costs such as depreciation, interest and loan repayments are not included. Depreciation is excluded, because it would double count the capital cost. Interest payment and loan repayment are not included, because one of the major purposes of deriving the cash flow is to determine the rate of interest the project can bear.

Some projects do not lead to any direct increase in revenues, but achieve their objective by reducing operating expenditures. When these can be quantified, they are included in the cash flow as negative operating expenditures.

This can be quite straightforward with “greenfield” projects. However, where the project is instead an addition to an existing activity, then a difference between the “with” and “without” project is established. The entire output of the enterprise cannot be treated as the outcome of the project, either in terms of increased revenues or decreased operating expenditures. Only the impact of the project ought to be counted. Care must be exercised in constructing a counterfactual, for some increases in expenditures or revenues that occur after the establishment of a project would have occurred even without the project. "Before and after" is not the same as "with and without", and in project analysis it is the "with and without" comparison that matters. In cases of this kind it has proven more effective to prepare two separate cash flows, one with the new project and one without it, and then to treat the differences as the project impact.

2.1.3 Financial profitability

The financial profitability evaluates the returns to the financial stakeholders in the project, by calculating the rates of return to the holders of equity and therefore providing indications about improvements in the financing structure of the project. The cash flow statement describes the ability of a project to raise its own financing and to assess whether it is financially sustainable. The latter is summarised by indicators such as the financial internal rate of return (FRR), i.e.

the discount rate that yields a zero net present value of the cash flow over the lifetime of the project. The FRR is then compared with the overall cost of funding rate. If the FRR falls below it, the project as defined is financially not worth undertaking, and therefore requires a redesign and/or additional sources of funding such as for instance grants and subsidies. A frequently used alternative indicator is the Net Present Value (NPV) of the project, which is calculated by using the cost of funding rate[5] as discount rate. The project is financially viable if the NPV is positive. The FRR and NPV capture different aspects of the project return, but in any case lead to the same conclusions with respect to viability.

2.2 Economic appraisal

2.2.1 Elements for economic appraisal

Indications of financial profitability do not necessarily provide reliable estimates of the value of a project from a "social" or “European” point of view, as they focus rather on the investors' perspective. In some cases there is a coincidence of interest, making the financial appraisal a valid starting point to assess the economic viability of a project (and sometimes, financial profitability can even be valid guidance for economic profitability). In most cases, however, this is not the case, for instance when there are important spillovers or externalities. These can be costs or benefits that would arise as a direct consequence of a project, but which accrue to agents in the economy other than those who sponsor the project or who are outside the primary market. Such indirect effects can be very important, especially when environmental or information resources such as innovation are involved, and it is clear that they should be considered when deciding whether or not to accept a project proposal. In this case, the analysis has to be broadened to include these external benefits of projects. For example, in the transport sector such economic benefits typically are: (i) the value of time saved by the users; (ii) the diminution of vehicle operating costs; (iii) the reduction in accidents; and (v) environmental benefits linked with a reduction of CO_2 emissions. In contrast, economic external costs can be increased maintenance costs or any of the above-enumerated benefits if the project has a detrimental impact in their regards (e.g. CO_2 emissions could increase as a result of induced traffic, higher travel speeds or a longer route).

Differences between the financial and economic profitability can also be due to price distortions induced through taxes or subsidies. This may occur where inputs or outputs of the project enjoy favourably distorted prices. A project may be profitable for its sponsors because it benefits from elements of subsidies or regulated prices. This is a common situation where the project’s products or inputs compete with others paying “market prices”. The consequence is that either the government loses revenue or consumers have to pay higher prices than would otherwise pay, with the risk that the economy becomes a high-cost producer and cannot compete internationally.

Another case is when some payments that appear in the expenditure streams of financial analysis do not represent economic costs and are merely a transfer of the control over resources from one group in society to another group. For example, taxes and subsidies are generally transfer payments, not economic costs.[6] When looking at the project from the point of view of the project entity, taxes and subsidies affect the revenues and expenditures of the project, but when looking at the project from society’s viewpoint, a tax for the project entity is an income for the government and a subsidy, since the entity is an expense to the government. The flows net out. Transfer payments affect the distribution of project cash flows and hence are important to assess who gains and who loses from the project. Usually, the government collects the taxes and pays the subsidies. In these cases, the difference between the financial and the economic analyses accounts for a major portion of the fiscal impact of the project.

Some care must be exercised in identifying taxes. Not all charges levied by governments are transfer payments; some are user charges levied in exchange for goods sold or services rendered. Water charges paid to a government agency, for example, are a payment by farmers

[5] This is normally indicated by the cost to a promoter of raising funding, such as the weighted average cost of capital (WACC).
[6] This of course ignores that the mere act of raising taxes may itself cause economic costs and inefficiency.

to the irrigation authority in exchange for the use of water. Whether a government levy is a payment for goods and services or a tax depends on whether the levy is directly associated with the purchase of a good or a service and accurately reflects the real resource flows associated with the use of the service. For example, irrigation charges frequently do not cover the true cost of supplying the service; thus, while they indicate a real resource flow as opposed to a pure transfer payment, the real economic cost would be better measured by estimating the long-run marginal cost of supplying the water and showing the difference as a subsidy to water users.

Subsidies are taxes in reverse, and for purposes of economic analysis should be removed from the receipts of the projects. From society's point of view, subsidies are transfers that shift control over resources from the giver to the recipient, but do not represent a use of resources. The resources needed to produce an input (or import it from abroad) represent the input's true cost to society. For this reason, economic analysis uses the full cost of goods, not the subsidised price.

In some cases, a project may not only increase output but also reduce the price of the output to consumers. Output price changes typically (but not only) occur in power, water, sanitation, and telecommunications projects. When a project lowers the price of the project's output, more consumers have access to the same product and the old consumers pay a lower price for the same product. Valuing the benefits at the new, lower price understates the project's contribution to society's welfare. If the benefits of the project are equated with the new quantity valued at the new price, the estimate of benefits ignores consumer surplus: the difference between what consumers are prepared to pay for a product and what they actually pay. In principle, this increase in consumer surplus should be treated as part of the benefits of the project. The benefits include the increase in consumer surplus of existing users (thanks to lower prices induced by lower costs) and the willingness to pay of new consumers net of incremental cost.

2.2.2 Shadow prices

Costs and benefits used in the financial analysis are valued at the prices that the project entity is expected to pay for them. Usually these are prices set by the market, although in some cases they may be controlled by government. However, these prices do not necessarily reflect economic costs to society. The economic values of both inputs and outputs may differ from their financial values because of market distortions created either by the government, the macroeconomic context or the private sector. Such distortions or market biases are government controls, over- or undervaluation of the domestic currency and imperfect market conditions, including low labour mobility and large underemployment of labour. To compensate for such distortions "shadow" prices can be calculated to reflect more closely the opportunity costs and benefits of the project. In contrast to possibly distorted market prices, shadow prices better reflect the willingness to pay and willingness to accept compensation values in the face of these market imperfections. Shadow pricing chiefly applies to:

- Situations where the official exchange rate of a country does not properly reflect the scarcity value of foreign exchange. This is because the costs of imports are held artificially low (in case of overvaluation) or high (in case of undervaluation), and the demand for them is therefore arbitrarily altered. To estimate shadow exchange rates that reflect the scarcity value of foreign exchange, a recommended approach is to use conversion factors, which establish the correct relationship between the prices of internationally traded goods and services relevant to a project and the prices of goods and services that are not so traded. Distortions arise from many sources, such as import or export taxes or subsidies, quantitative restrictions on trade, and so on. Because the distortions affect different goods differently, conversion factors are, in theory, needed for each commodity involved in a project. Since this is not practical, a single conversion factor corresponding to the economy wide shadow exchange rate, and referred to as the standard conversion factor, can be calculated. It is a summary indicator of trade distortions that are expected to prevail in the future.
- In countries where the labour market functions smoothly, the wage actually paid is adequate for both financial and economic analysis. However, government interventions in some labour markets (e.g., minimum wage legislation, legal

impediments to labour mobility and especially high taxes) introduce distortions that could justify using shadow wage rates to reflect the opportunity cost of using labour in a project. In this case, the monetary cost of labour is not necessarily equal to the marginal output of labour and needs to be corrected. Most commonly, in an environment where unemployment or under employment prevails, the economic cost of unskilled labour is less than the monetary cost of labour paid by the project. Reducing labour costs through shadow pricing increases the net present value of the project (social net benefits) in comparison with its financial value.

Box: The use of shadow prices

Shadow prices can be a useful construct in assessing the value of relaxing a resource constraint for the economy. In analytical terms, the shadow price is the “Lagrange multiplier” of the constraint in the context of the optimisation problem for an objective function (e.g. social welfare) subject to a constraint (e.g. resource). The shadow price is the value of relaxing the constraint by one unit. This should be used in project appraisal when there is strong evidence for non- performing markets or when administrated prices are far away from matching supply and demand.

For instance, in the case of a persistently high unemployment rate (say in excess of 10%) the excess supply of labour compared to the market clearing level means the shadow wage would be below the going wage rate. This wedge between the two values could be explained by contributions and taxes added on top of wages. To account for this in project appraisal, one can introduce the provision that the price labour input should be valued at the wage rate before taxes and social contributions, in particular in the case that a country is suffering from a high unemployment rate. Mere inspection of actual data* shows that the wedge can be a large share of labour cost, up to one-third in some countries. A practical solution to determine the shadow price for labour for project appraisal can be the reduction of unit labour costs by a percentage determined the share of contributions and taxes in labour cost. See chapter 4 for the case of pricing carbon emissions, another common externality requiring a shadow price adjustment.

Bank appraisals use conversion factors available from national governments or from development agencies. The EC DG Regio Guide to CBA** includes a good summarised version of standard international practice. Consideration is currently being given to determine standard conversion factors to be used across Bank appraisals, and common methods to estimate conversion factors when no estimates are available. Whereas this would have the benefit of improving the comparability of Bank appraisals, the exercise would require addressing many markets in many countries and would need to be revised regularly.

* http://epp.eurostat.ec.europa.eu/statistics_explained/index.php/Labour_cost_structural_statistics#Labour_cost_and_earnings

** European Commission (2014) *Guide to Cost Benefit Analysis of Investment Projects*. European Commission Directorate General Regional Policy: Brussels.

2.2.3 Economic profitability

After taking into account all the costs and benefits of the project, the economic analysis has to give an indication on whether or not the project is worth undertaking. The Bank uses the economic rate of return (ERR) as benchmark, i.e. the discount rate that yields a zero net present value of the economic net benefits over the lifetime of the project. The ERR is then compared to the social discount rate (see chapter 8). If the ERR falls below the social discount rate, the project as defined is economically not justified and should therefore not be undertaken, as it would constitute a misallocation of economic resources. An ERR at or above the social discount rate is a prerequisite for the project to be financed by the Bank. The Net Present Value of the project can be calculated using the social discount rate. The project is economically justified if the NPV is positive.[7]

[7] If the decisions concern more than one project, the ERR should be used for ranking the contributions of projects for welfare purposes.

3 Defining the Counterfactual Scenario

J. Doramas Jorge-Calderón

3.1 Introduction

The economic and financial profitability of projects is estimated by considering the incremental benefits and costs resulting from the project. That is, the estimated project profitability does not measure the total benefits and costs to stakeholders resulting from the activities of the promoter. Instead, it measures the additional or incremental benefits and costs brought about by the project, over and above what would have happened without the project.

Assessing the total benefits of production would aim at measuring the total reservation price of consumers, and would be largely of descriptive use rather than a decision-making tool about investment viability. Measuring total benefits would not need to make any assumptions regarding what would happen in the absence of the project, since the counterfactual would effectively consist of no production activity at all.

Instead, when measuring incremental returns, the analyst must make an assumption about what would happen in the absence of the project – a counterfactual or "without project" scenario. Two broad possibilities arise, involving the degree of competition in the market concerned. In competitive markets, where entry and exit is free, and the goods or services produced by the project face close substitutes in the market, the "without project" scenario would consist of other competitors taking the place of the project promoter. There is no need to construct an ad hoc counterfactual, as the without project scenario is the opportunity cost of the resources devoted to the project, including the cost of capital. Indeed, if the promoter does not invest in keeping up its competitiveness, it will be pushed out of the market.

Where markets are not competitive, entry is restricted, and substitutes are very inferior, in the absence of the project the promoter would continue operating without the incremental benefits and costs brought about by the project. The project appraisal must necessarily involve an assumption as to what would happen in the absence of the project. This counterfactual scenario constitutes a benchmark against which to compare the benefits and costs of the project, reflecting the incremental nature of any investment decision.

This section summarises the criteria to be used in defining counterfactual scenarios across the various methodologies used by the Bank, namely Cost-Benefit Analysis (CBA), Cost-Effectiveness Analysis (CEA), and Multi-Criteria Analysis (MCA) in situations where markets lack sufficiently close competing substitutes.

3.2 Types of counterfactual

3.2.1 The three basic types

The projects financed by the Bank involve capital formation, whether tangible or not, and therefore always consist of capacity investment, whether new or upgraded, and never of stand-alone corporate finance. In this sense, the project, or "with project" scenario always consists of a "do something" scenario. There are three basic types of counterfactual or "without project" scenarios against which to compare the project, including:

1. "Do nothing": This scenario assumes that in the absence of the project, no investment takes place at all. Capacity will gradually deteriorate, reducing the future ability of the facility to meet demand. This type of "without project" scenario is suitable for projects that consist of capacity rehabilitation.
2. "Do minimum": Assumes that there will be sufficient investment to keep existing capacity operational in the future. It is a suitable counterfactual for capacity expansion or upgrading projects. The investment analysis would compare the project with the

counterfactual scenario of carrying out necessary investments to keep installed capacity operational for the full length of the life of the project.

3. “Do something (else)”: As mentioned above, the “with project” scenario is already a “do something” scenario. A “do something (else)” scenario would consist of an alternative approach to meet the objectives pursued by the project. This may consist of an alternative technology, a different project scale, or an alternative project location. It is an appropriate counterfactual for analysing project options, timing or phasing, once it has been recognised that “something” must be done.

As mentioned in the introduction to this guide, Bank appraisal methods must fit the remit of the Bank. It is not the remit of the EIB to act as a planning agency and decide on the best project option. Most projects are proposed for Bank financing once the project option has been chosen and preparatory work or construction has already begun. Likewise, the Bank does not engage in a budgeting exercise whereby only the projects with the highest returns are financed. Bank operations are embedded in the commercial lending market, and the Bank has limited visibility about future project pipelines. Instead, the Bank focuses on ensuring that the projects to be financed are viable and generate sufficient economic value. For these reasons, Bank appraisals do not formally evaluate project options, and economic appraisals do not consider “do something (else)” counterfactual scenarios. Instead, Bank appraisals aim at yielding an eligible/non-eligible, viable/non-viable opinion. Bank appraisals therefore only rarely use “do something (else)” as a counterfactual. Instead, the counterfactuals used in project appraisals follow the “do minimum” criterion for capacity expansion or upgrade projects and the “do nothing” criterion for capacity rehabilitation projects.

The above does not mean that the Bank does not evaluate project options where it is useful for the promoter and the project. However, such analysis is not the norm for lending operations. Moreover, it is only of use in the few instances when the Bank or, more frequently, JASPERS, appraises the project early in the project definition process.

3.2.2 Cost-Benefit Analysis

For CBAs the Bank uses the “do minimum” scenario by default, except for capacity rehabilitation projects. For capacity expansion or upgrade projects, the analysis asks the question: “Do we expand capacity or keep it at current levels?” The analysis then compares the “do something” with a “do minimum”. If the analyst instead compared the “do something” with a “do nothing”, the project would not be one of capacity upgrade versus no capacity upgrade, but rather one of capacity upgrade versus letting capacity deteriorate potentially into inoperability. The consequence of using a “do nothing” instead of a “do minimum” counterfactual would normally be to overestimate the returns of the capacity expansion project, since the “do minimum” scenario includes fewer benefits or higher costs to users. This is illustrated in the example further below.

In rehabilitation projects, the nature of the project itself calls for comparing a “do something” with a “do nothing”. Generally a pure rehabilitation project involves keeping existing capacity constant, rather than expanding it. That is, the “with project” scenario involves no growth in capacity. In that sense, and although it is just a matter of semantics, a rehabilitation project could be viewed as comparing a “do minimum” with a “do nothing.”

3.2.3 Cost-effectiveness Analysis

CEA analysis starts from the premise that the good or service concerned must be supplied. There is no room therefore for a “do nothing” scenario, requiring as the counterfactual at least a “do minimum” scenario. The appraisal then focuses on whether the chosen technology meets the minimum required cost performance criteria. Should there be room for selecting among alternative options, the result of the analysis may evaluate alternative “do something” options to help identify the most efficient option, effectively comparing a “do something” against a “do something (else).”

3.2.4 Multi-Criteria Analysis

A MCA-based appraisal can be constructed with the same array of scenarios as the CBA, and MCA in the Bank uses the same criteria to define counterfactuals as for CBA. That is, for a capacity expansion or upgrade project, the comparison is between a "do something" and a "do minimum," and on rehabilitation projects it is between a "do something" and a "do nothing."

MCA, like CBA, lends itself to considering alternative project options – that is, to an analysis comparing "do something" versus "do something (else)". However, as mentioned in the introduction, the Bank focuses on ensuring that the option financed is economically viable. Only where critical does it try to determine whether the proposal is the best option that might be adopted.

3.3 Illustrating the impact of an inadequate counterfactual

A common source of error while building scenarios for capacity enhancement projects involves mixing a "do nothing" with a "do minimum" counterfactual. As mentioned above, when the appraisal asks the question "should capacity be expanded or kept constant?" the "with project" scenario should be compared with the scenario of keeping existing capacity constant. If instead it is compared with the "do nothing" scenario, the question being asked is rather: "Is it worth rehabilitating and expanding existing capacity as opposed to letting it degrade?" If management asks the former question but the project analyst performs the appraisal with the latter question in mind, the economic returns of the capacity expansion would be overestimated, which may lead management to take a wrong decision, probably by overinvesting.

Table 3.1 illustrates the issue by presenting net operating benefits and investment costs for three possible scenarios in a hypothetical project: "do something," "do minimum", and "do nothing". Although the scenarios are mutually exclusive, the technologies in the different scenarios could be thought of as cumulative. The "do something" scenario involves investing EUR450 million, and will result in benefits growing by 5% per year. It includes an element of rehabilitating existing capacity plus an element of expanding capacity. The "do minimum" scenario involves investing EUR30 million, followed by constant benefits. It involves only rehabilitating existing capacity. The "do nothing" project involves no investment at all, and letting existing capacity deteriorate over time, affecting the amount of output the facility can produce, and causing a fall in net benefits of 5% per year. The first numerical column includes the present value of the flows, discounted at 3.5%.

Table 3.1: Project return under alternative counterfactuals

	Scenarios				**PV**	**1**	**2**	**10**	**21**
(1)	Do something		Net benefit	(EURm)	1058	45	47	70	119
(2)			Investment	(EURm)	435	450			
(3)	Do minimum		Net benefit	(EURm)	661	45	45	45	45
(4)			Investment	(EURm)	29	30			
(5)	Do nothing		Net benefit	(EURm)	442	45	43	28	16
(6)			Investment	(EURm)	0	0			
	Project returns								
	"With project"	"Without project"							
(7)=(1)-(2)-(3)+(4)	Do something	Do minimum	Net flows	(EURm)	**-9**	-420	2	25	74
			IRR		**3%**				
(8)=(1)-(2)-(5)+(6)	Do something	Do nothing	Net flows	(EURm)	**182**	-450	5	41	103
			IRR		**6%**				
(9)=(3)-(4)-(5)+(6)	Do minimum	Do nothing	Net flows	(EURm)	**191**	-30	2	17	29
			IRR		**28%**				

The last three rows of Table 3.1 present the calculation of (incremental) project returns for the three possible combinations of scenarios. Row (7) presents the capacity expansion scenario, comparing a project to expand capacity with a situation where capacity is left constant. It is calculated by comparing the “do something” with the “do minimum” scenario, as the “do minimum” scenario includes the necessary investments to keep current capacity constant for the entire life of the project against which it is being compared. The project presents a return of 3%. If instead the capacity expansion project is compared to the “do nothing” scenario, the return increases to 6%. But there the analysis would not be estimating the returns from increasing capacity; it would be estimating the returns of both increasing capacity and maintaining existing capacity. The choice facing the operator would be: “Do we maintain and expand capacity or do we let it degrade?” rather than: “Do we expand or not (and keep capacity constant)?” Reporting 6% as the return on capacity expansion would be incorrect as the low returns on expansion, equal to 3%, are being masked by the high returns of rehabilitating existing capacity, equal to 28%. If the threshold for accepting projects was 5%, then clearly the capacity expansion would not be viable, but it would appear viable using an alternative “do nothing” counterfactual.

If the social discount rate is 3.5%, it would be viable to maintain existing capacity but not to expand it. In evaluating the expansion project with a “do nothing” counterfactual instead of a “do minimum” counterfactual, the capacity expansion would be undeservedly supported.

4 Incorporating Environmental Externalities

Edward Calthrop

4.1 Introduction

Standard project evaluation typically focuses on measuring the benefits and costs of a project to the direct users of the infrastructure or asset in question. However, projects may also result in costs borne by wider society, usually referred to as external costs or externalities.[8] For example, most capital-intensive infrastructure projects – transport networks, power plants, industrial production facilities – are associated with significant emissions of greenhouse gases, which result in global warming. Most combustion processes, even where compliant with EU legislation, result in residual emissions of localised air pollutants: nitrous oxide, sulphur dioxide, or small particulate matter, which may have a negative impact on the health of vulnerable people in the local community. Projects involving land use change can result in loss of wider ecosystem services, notably biodiversity.

In order to assess the costs and benefits to society as a whole, therefore, it is necessary to adjust the economic analysis to take into account such externalities. In conceptual terms, this is relatively straightforward: external costs need to be added alongside operating and maintenance costs over the economic lifetime of the asset. This requires an estimate of the volume of externality (e.g. tonnes of greenhouse gas emissions per year, increase in decibels of noise to the exposed population) and an appropriate unit price, or marginal external cost estimate (euros per tonne of carbon dioxide equivalent; euros per extra decibel per person).

Whilst conceptually straightforward, however, the merit of this exercise ultimately depends on whether external costs can be meaningfully valued. This is a challenge, particularly in the case of global warming. Impacts are global, persistent over very long time periods, uncertain and potentially catastrophic. Valuing the loss of ecosystem services also raises complex empirical and conceptual issues. A decade or so ago, the response of many practitioners was simply to ignore such external costs as “It is all too difficult’’. This is ill-judged. Ignoring external costs is equivalent to assuming a value of zero – which is almost certainly wrong, no matter what the range of uncertainty. Significant progress has been made over recent decades in establishing and applying external cost estimates. Several public administrations have developed guidance in recent years for practitioners on the values of externalities to be used systematically across project appraisals.

The Bank began to integrate a cost for environmental externalities (carbon and local air pollutants) into project appraisal in the late 1990s, notably for energy and transport projects. The external cost values have been updated on several occasions subsequently, in light of new evidence, as well as applied more systematically across all relevant sectors of Bank operation.

This section briefly summarises the Bank's approach to date towards integrating environmental externalities into its economic appraisal techniques. It does so in three steps. Firstly, it presents the unit values of environmental externalities, notably carbon, currently used by the Bank. Secondly, it presents the main methodology through which environmental externalities have been integrated into project appraisal at the Bank.

[8] Baumol and Oates (1988) define an externality as being present whenever some individual’s (say A) utility or production relationship include real (i.e. non monetary) variables whose values are chosen by others without particular attention to the effects on A’s welfare (pg. 17).

4.2 Estimates of external costs

The value of carbon currently applied by the Bank is shown in Table 4.1 below. It consists of a central estimate for the damage associated with an emission in 2020 of EUR40 per tonne of carbon dioxide equivalent,[9] plus a high estimate of EUR69 (all measured in 2016 constant euros).

Table 4.1: Value of carbon in EIB appraisal (EUR/t CO_2e)

	Value 2020 emission	Value 2030 emission	Value 2040 emission	Value 2050 emission
High	69	96	146	231
Central	40	54	79	121

These parameter values are drawn from a EIB-funded research contract with the University of Venice, which surveyed results since the Stern Review[10] report published in 2017

The Bank also integrates local air pollution, water and noise externalities. The unit values applied by the Bank are drawn from a review of the literature, notably the 2008 HEATCO study.[11] In the case of transport projects, Table 4.2 presents the values currently applied by the Bank converted into per passenger kilometre terms (in constant 2008 euros).

Table 4.2: Values of local air pollutants and noise

Mode	EUR per passenger kilometre	
	Local air pollution	Noise
New Rail	0.0049	0.0029
Existing Rail	0.0049	0.0039
Car	0.0173	0.0057
Plane	0.0019	0.0036

[9] Carbon dioxide equivalency is a quantity that describes, for any greenhouse gas, the amount of carbon dioxide that would have the same global warming potential when measured over a specific timescale. Recognised conversion factors have been established by the International Panel on Climate Change.
[10] In 2017, a High Level Commission on Carbon Prices (HLCCP), under the co-chairmanship of Professor Joseph Stiglitz and Lord Nicholas Stern, published a report designed to identify indicative corridors of carbon prices that can be used to guide the design of policy to help deliver the temperature targets (High-Level Commission on Carbon Prices. 2017. Report of the High-Level Commission on Carbon Prices, Washington, DC. License: Creative Commons Attribution CC BY 3.0 IGO. The report is available at https://www.carbonpricingleadership.org).
[11] See http://heatco.ier.uni-stuttgart.de/ for results, in particular Deliverable 5 for unit values. The same institute has developed a useful web-based calculator EcoSense LE: http://ecoweb.ier.uni-stuttgart.de/EcoSenseLE/scenario_definition.php

4.3 Integration into project analysis

The previous section presents the values adopted for environmental externalities by the Bank. This section shows in a simplistic way how such values are integrated into the economic analysis, distinguishing between cost-benefit analysis and cost-effectiveness. To simplify matters, assume a single pollutant, perhaps carbon, associated only with the operating phase of a project. The framework presented can be extended in a rather straightforward manner to include emissions from construction or de-commissioning, where relevant.

In the case of cost-benefit analysis, assume a simple capital investment in year zero (C_0), leading to a stream of benefits (B) over the life of the asset (to year T), net of fixed and variable operating costs[12] (C) and external costs (EXT), including climate change. At discount rate *r*, the net present value (NPV) of the investment is given by:

$$NPV(r) = \sum_{t=1}^{T} \frac{B_t - C_t - EXT_t}{(1+r)^t} - C_0$$

in which $EXT_t = V_t \times E_t$ i.e. the annual emissions[13] (*E*) multiplied by the value (in euros) per unit of emissions (*V*). This approach, using the unit values described in section 2 above, is applied for road, rail and urban transport projects appraised by the Bank, relative to a baseline scenario.

Two points follow with relation to the unit external cost estimate (V):

- ceteris paribus, as expected, the higher the external cost estimate, the lower the net benefit of a project that results in a net increase in emission – i.e. the numerator of the first term – and thus the lower the overall net present NPV or ERR;

- In the case of carbon, the unit value of an emission is assumed to grow in real terms over time ("adders"). To simplify matters, assume a constant growth rate, *g*, i.e. $V_t = V_0(1+g)^t$. The net present value of the externality becomes:

$$V_0 \times \sum_{t=1}^{T} \left(\frac{1+g}{1+r}\right)^t E_t$$

  The growth rate in the value of the carbon externality – the numerator – is offset by the discount rate – the denominator. In the special case that *g* equals *r*, the net present value of emissions is simply the sum of emissions valued at current value.[14]

The Bank also employs cost-effectiveness analysis, notably for some energy projects. Where the benefit (electricity or heat) is homogenous, the analysis for mature technologies focuses on the relative cost per unit of energy produced. Environmental externalities are included as a cost and hence penalise relatively polluting or carbon-intensive generation technologies.

Under a similar set of assumptions, the total life cycle cost (*TC*) of electricity for any particular mature generation technology, *j*, becomes:

[12] Benefits and costs are measured in resource terms; hence (carbon) taxes, where present, would be stripped out. This avoids double counting for instance a fuel exercise duty on petrol with the external cost of road emissions.

[13] The Bank estimates the absolute and relative greenhouse gas emissions from large projects (primarily investment loans) with emissions beyond a certain threshold. See http://www.eib.org/about/documents/footprint-methodologies.htm

[14] As is well-established in the climate economics literature, the estimate of V_0 in fact depends to a significant degree on the discount rate, in turn dependent on the pure rate of time preference. However, it is standard practice to differentiate between the social discount rate for a marginal investment decision (i.e. *r*) and the discount rate emerging from the optimal path of consumption in long run climate-economy models. In this sense, there is no formal link between the assumed pure rate of time preference embodied in V_0 and the discount rate *r*.

$$TC_j = C_0^j + \sum_{t=1}^{T} \frac{\left(C_t^j + \left(V_t \times E_t^j\right)\right)}{(1+r)^t}$$

where C_t^j contains both fixed operating and maintenance costs as well as fuel input costs.

Projects are assessed on the basis of what is referred to as the levelised cost of electricity.[15] The two points raised above concerning the value of the externality *V* in the case of cost-benefit analysis apply equally here too: the larger the value, the larger the penalty applied to relatively carbon-intensive technology; secondly, the growth rate in *V* over time (adders) will in effect be traded off in the model against the discount rate.

Table 4.3: Percentage value of EXT in levelised cost

Power generation technology	Value for carbon scenario	
	Central	High
Combined Cycle Gas Turbine	13%	20%
Coal or lignite	31%	44%

As discussed in chapters 0 and 18 below, this methodology can be applied both to renewable and conventional power generation projects. For instance, when assessing a loan for a mature renewable energy project within the Union, the Bank appraises it against the alternative marginal plant on the system, which in many cases may be a combined-cycle gas turbine. Whilst the exact results are project specific, Table 4.3 shows for a simple example that the external cost of carbon can comprise 13-20% of the levelised cost for a combined cycle gas turbine, depending on whether the central or high value of carbon value is used. For a coal/lignite plant, in this particular example, the external cost comprises 30 to 45% of the levelised cost.

4.4 Conclusions

In order to be fit for purpose in evaluating many projects with impact on the environment, economic analysis needs to be able to integrate environmental externalities. Significant progress has been made in recent years in refining the estimates (or distributions) of values and improving methods to integrate such values into economic analysis.

The Bank has for some time been incorporating global and local pollutants into projects. However, the Bank needs to remain vigilant to developments in this field, both empirically and theoretically. Moreover, attention is required in order to integrate this approach across all sectors in which the Bank operates, as well as to broaden the range of externalities considered (e.g. loss of biodiversity and ecosystem services).

[15] This is the cost per unit of energy that equals the TC once aggregated and discounted back to the base year.

5 Land Acquisition and Resettlement

Edward Calthrop

5.1 Introduction

Many infrastructure projects financed by the EIB involve land acquisition.[16] This change in land use may lead to some degree of physical or economic displacement of people living on the land, or using it. Unless undertaken as part of free market transactions where affected individuals or communities have the right to refuse land acquisition, the displacement is considered involuntary.[17] In principle, the full opportunity cost of this land, and associated services, needs to be taken into account in the economic appraisal of the project. This is not always straightforward. One proxy, where land markets operate, might be the market price for land, but when is this likely to be a reasonable approximation? When should the analyst be concerned; and what can be done to improve the estimate?

This short note identifies the basic issue and offers some initial guidance. However, it is clear that further work is needed in this area, and the Bank will continue to monitor developments in this field. On involuntary resettlement in particular, the reader is directed to a detailed sourcebook published in 2004 by the World Bank.[18]

5.2 The opportunity cost of land – going beyond the market price

In the context of a well-developed and liquid land market, the market price may generally be a good indicator of the opportunity cost of land.[19] Indeed, in several countries, compensation under compulsory purchase orders is tied to market valuation.[20] In the case of resettlement, this would need to be augmented by the resource cost of organising and administering any resettlement programme.

However, in the case of developing countries, notably in rural areas, there may be no market at all. Property rights, including access and use, may be unclear: the affected persons may not be the owners of the land they are using, but instead may hold customary tenure to the land or be squatters. If so, the opportunity cost of rural land may be calculated as the agricultural and/or minimal husbandry output foregone, measured at economic prices – i.e. the value of the income to be earned from that land over a period of time, although this narrow measure may need to be expanded to include non-market, subsistence-related income from land (charcoal, medicinal plants, bushmeat, etc.). However, the real value to the local community in the land may be as a cultural asset vested with spiritual significance: shrines and places of prayer, burial grounds, and access to social services. As discussed in the earlier chapter on environmental externalities, the value of the land may also involve ecosystem services, including biodiversity provision and carbon sequestration. If so, the appraisal framework needs to account for these benefits foregone by the project.

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[16] The Bank is mandated to finance asset creation. As a result, it typically excludes land purchase from its estimation of project cost and thus potential loan to an operation. However, the Bank does include the opportunity cost of land within the economic analysis of a project.

[17] Resettlement is considered involuntary when affected individuals or communities do not have the right to refuse land acquisition resulting in displacement. This occurs via (a) land acquisition, (b) expropriation or restrictions on land use based on eminent domain, (c) forfeiting of a livelihood/subsistence strategy dependant on the use of natural resources, and (d) negotiated settlements in which the buyer can resort to expropriation or impose legal restrictions on land use if negotiations with the seller fail.

[18] World Bank (2004) Involuntary Resettlement Sourcebook: planning and implementation in developing projects; EIB Social Assessment Guidance Note on Involuntary Resettlement (2009).

[19] The price is likely to be a good approximation for surplus when land acquisition is marginal and demand is relatively elastic.

[20] This would be complemented by additional compensatory elements assuring the attainment of the full replacement cost principle. Such principle, in turn, guarantees that all costs arising out of the resettlement have been effectively addressed by the global compensation offered to each affected party.

The same principle applies in an urban context. Given existing spatial patterns, urban derelict space may have little or no formal market value. Yet the opportunity cost of the land should nevertheless reflect the value the land provides to those currently using it. In short, the market price of land, even where available, may provide only a lower bound to the opportunity cost of the land.

5.3 Valuation techniques

In principle and where appropriate, economic valuation techniques can be used to estimate the “willingness to accept compensation" for resettlement of displaced people in order to capture valuations of, at least, cultural assets and nonmarket benefits. However, valuation techniques based on surveys – known as contingent valuation – need to pay careful attention to problems of free riding and moral hazard, framing and starting point bias. Willingness-to-accept studies are also relevant to market assets because of the likely presence of consumer surplus, that is, valuations of assets over and above the market price of those assets. There is a large literature reviewing such valuation techniques in the field of environmental economics (see, for example, Hanley 2008); however, there appear to be few applications in the field of involuntary resettlement programmes in practice.

5.4 Measuring economic cost in practice

Where no such valuation studies are available, a replacement cost approach may be used to estimate value, albeit recognising that this is likely to be only a lower bound to the true opportunity cost:

- For agricultural land, it is the pre-project or pre-displacement – whichever is higher – market value of land of equal productive potential or use located in the vicinity of the affected land, plus the cost of preparing the land to levels similar to those of the affected land.
- For land in urban areas, it is the pre-displacement market value of land of equal size and use, with similar or improved public infrastructure facilities and services and located in the vicinity of the affected land.
- For houses and other structures, it is the market cost of the materials to build a replacement structure with an area and quality similar to or better than those of the affected structure, or to repair a partially affected structure, plus the cost of transporting building materials to the construction site, plus the cost of any labour and contractors' fees.

In determining the replacement cost, depreciation of the asset and the value of salvage materials are not taken into account, nor is the value of benefits to be derived from the project deducted from the valuation of an affected asset.

Where such replacement cost rules are used to determine actual compensation, the financial cost of resettlement therefore becomes a lower bound for the actual opportunity cost in the economic appraisal of the project.

5.5 Equity and Bank social standard

Economic appraisal tends, in practice, to focus on economic efficiency, implicitly valuing a euro of additional income equally across different income and social classes. Explicit welfare weights can be introduced in theory, but have proven difficult to apply in practice – and arguably simply transfers the problem to one of how to establish appropriate welfare weights. This shortcoming can be exposed in projects that displace some of the poorest and most vulnerable in society. In addition, as argued above, in practice the replacement cost is likely to represent only a lower bound to the true opportunity cost, at least from an efficiency perspective. In part, the issue of social equity can be partially remedied through the application of performance standards applied by the Bank in determining whether to support a project or not. For this reason, the Bank requires that – outside of any cost-benefit calculation – the Bank's social guidelines are observed as a precondition for financing a project.[21]

[21] The EIB's Environmental and Social Handbook is available online: http://www.eib.org/about/publications/environmental-and-social-practices-handbook.htm

6 Wider Economic Impacts

Edward Calthrop

6.1 Introduction

Suppose that a project is judged to be economically weak. More precisely, suppose the economic internal rate of return (ERR) of the proposed investment, measured using the standard appraisal techniques described elsewhere in this report, including externalities, is below the social discount rate. Is this a sufficient condition for the Bank to reject the project? Or could it be that the standard techniques somehow fail to capture all the relevant benefits?

This Chapter briefly reviews the evidence for including "wider economic impacts" into economic appraisal, i.e. tangible benefits or costs to the economy that stem from an investment, but are not included in standard economic appraisal techniques.[22] It tries to identify conditions under which it may be valid to include wider impacts (although they may be difficult to measure) and distinguish these from inherently weak projects. This is necessary: with many projects competing for scarce public funds, there may be a temptation for project promoters to exaggerate the benefits and minimise the costs (Flyvberg, 2003).

Discussion of wider economic benefits is often beset by a confusing array of terminology and concepts ranging from external benefits, economic multipliers, job creation, impact on public finances, regional or urban development. This Chapter is therefore structured as follows. Firstly, building on a simple distinction between primary and secondary markets, it sets out the conditions under which including impacts on secondary market is valid and when, on the other hand, it would constitute double counting. Secondly, it explores other notions of wider economic impacts, notably on growth and public finance. Thirdly, it examines some developments in evaluating wider benefits in the context of transport projects.

6.2 Impacts on secondary markets

6.2.1 The basic framework

In this section, a wider economic impact is taken to mean the impact of investment in a primary market on secondary markets. For instance, suppose a new road increases urban labour supply by reducing commuting times. Should the impact of the (secondary) labour market be included in the appraisal? Or has the direct time savings on the (primary) transport market already captured this benefit? Equivalently, should the benefits of a new steel factory to the (primary) regional steel market also include the boost in productivity to the (secondary) automobile manufacturing industry?

Imagine an investment in a primary market (e.g. good A). As shown in Figure 6.1, the marginal cost of producing a unit of A before the investment equals c_A^1. After the investment,[23] it falls to c_A^2. In a competitive market, consumer prices equal unit costs, and hence prices fall from c_A^1 to c_A^2. As shown by the shaded area, consumer surplus increases by the reduction in cost (Δc_A) to existing customers (q_A^1), and by the triangular benefit to new customers. Using conventional appraisal techniques, the project would pass a cost-benefit test when:

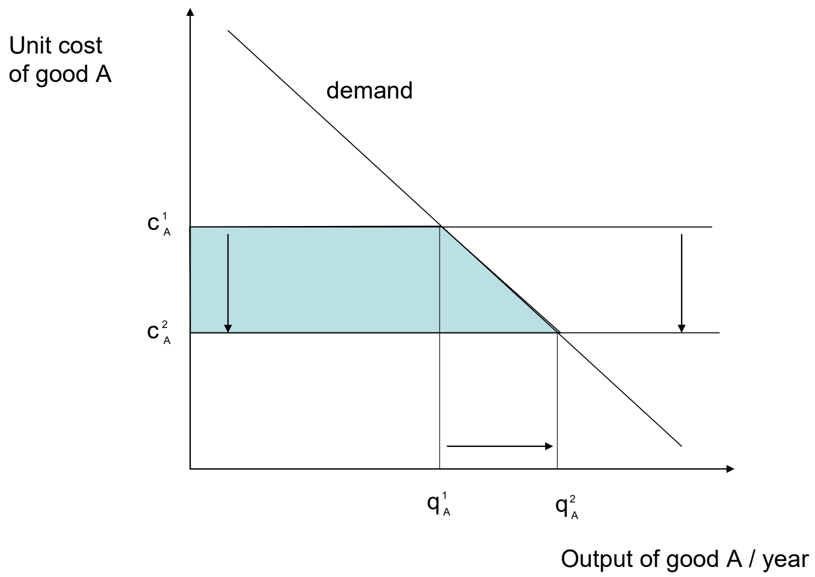
[22] The definition of wider economic impacts will be made more precise below. Clearly, there can also be simple errors in applying standard appraisal techniques, including data input errors or poor forecasting techniques. As this is more an issue of quality assurance, it is not considered further.

[23] This is a very general (and simple) example. It could apply to reduced travel time from new transport infrastructure, which lowers the generalised cost of travel, lower electricity prices from new power generation, or lower product prices from an industrial facility.

$$\Delta c_A\left(q_A^1 + \frac{\Delta q_A}{2}\right) > INV \qquad (1)$$

where *INV* denotes the annuitised investment cost of the project.

Figure 6.1: Impact of investment on primary market A



Investment reduces the unit cost of good A from c^1 to c^2. In a competitive market, where consumer price equals unit cost, demand increases from q^1 to q^2. The welfare benefit (on the primary market) is given by the shaded area.

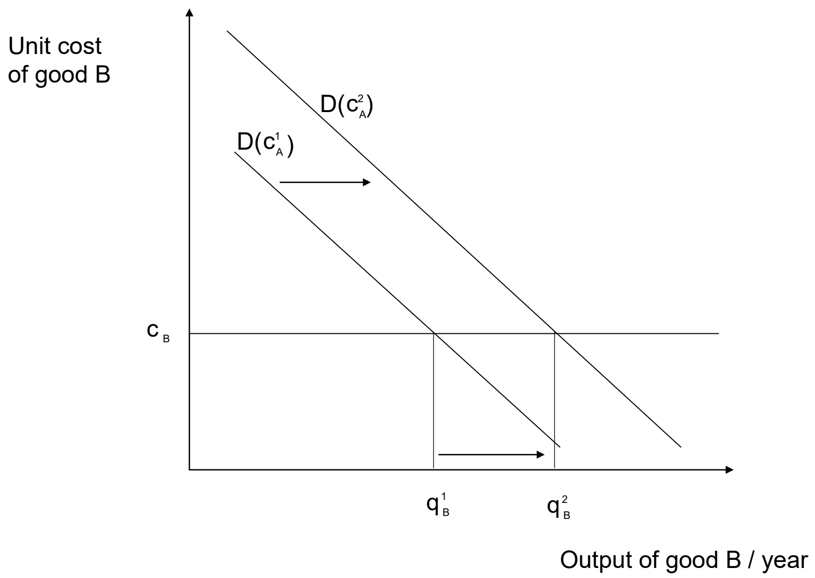
Thus far, attention has been exclusively on the primary market, A. , but now let us assume that the reduction in cost for good A impacts a secondary market – good B. Does this also need to be included in our appraisal formula (1)?

The answer turns out be somewhat intuitive. When the secondary market is perfectly competitive – i.e. the price equals the marginal cost of production – no additional adjustment is required. This is because the direct benefits measured on the primary market capture all relevant benefits. Equation 1 suffices. This is shown in Figure 6.2. In this case, any attempt to add impacts on secondary markets would amount to double counting.

However, if a "distortive wedge" exists between price and marginal cost on market B, an additional to equation 1 is required. Such a distortive wedge may exist for numerous reasons: the presence of taxes or subsidies, imperfect competition, returns to scale, externalities, asymmetric information etc. If the consumer price (i.e. marginal benefit) is higher than marginal cost for the last unit, welfare increases if the proposed investment boosts demand on market B. Conversely, if the investment were to reduce demand on B further, the subsequent reduction in welfare should be included. The former case is shown in Figure 6.3. The welfare gain on the secondary market is shown by the shaded rectangle. Equation 1 becomes:

$$\Delta c_A\left(q_A^1 + \frac{\Delta q_A}{2}\right) + \left(p_B - c_B\right)\Delta q_B > INV \qquad (2)$$

Figure 6.2:
Impact of investment on secondary market B in absence of market distortions



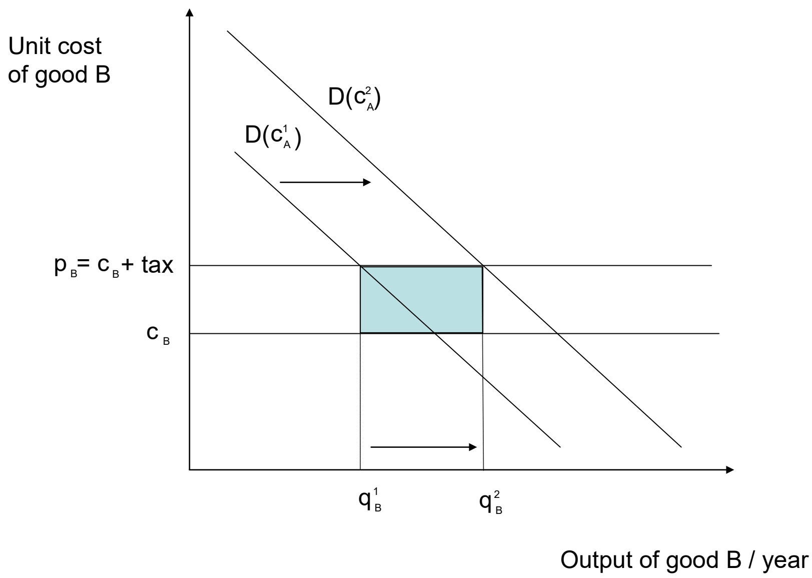
> The investment on the primary market causes the demand for good B to increase, i.e. A and B are complements. Demand for good B therefore shifts out from $D(C^1)$ to $D(C^2)$. Equilibrium output of good 2 rises from q^1 to q^2. However, if market B is perfectly competitive, there is no welfare impact. Rather, this is just the equilibrium response to the investment (and welfare benefit) on the primary market.

When might this adjustment matter in practice? In other words, when is the second term in equation 2 likely to be relatively large in absolute terms? This is the case if: (i) there is a relatively large pre-existing distortive wedge between price and cost on the secondary market; and/or, (ii) there is a relatively large cross-price elasticity between the primary and secondary market. Note that the sign of this second term can be positive or negative: the secondary market can be complement or substitute for the primary market; there can be taxes or subsidies on the secondary market. In general, there can be wider economic benefits or costs from an investment.

This result was established in Harberger's work on monopoly pricing (see Harberger 1974): it has been subsequently generalised in the academic literature, most notably Dreze and Stern (1987, 1990), and is reflected in several practical appraisal guides (e.g. European Commission 2008, World Bank, SACTRA 1999, ITF 2011). The appendix to this chapter provides a more formal derivation of the basic result.

In reality, of course, market distortions are pervasive. Hence, even when measured accurately, equation (1) is only an approximation of the total benefit. This might suggest that appraisal should consider numerous secondary markets, including labour markets – i.e. it should be general equilibrium rather than partial equilibrium in nature. However, in practice, general equilibrium models are rarely used to appraise individual projects: in many cases, the added complication and expense of including many secondary markets would not be justified by the (relatively small) refinement in net benefit estimated by a partial equilibrium approach (see ITF, 2011 for a review).

Figure 6.3:
Impact of investment on secondary market B in presence of pre-existing distortions



In contrast to Figure 6.2, in this case the secondary market is characterised by a pre-existing distortive wedge between consumer price (p) and unit cost (c), perhaps due to a tax. As a result, before the investment, marginal benefit $D(p_B, c_A^1)$ is higher than marginal cost c_B. Investing in the primary market shifts out the demand curve for good B, thus increasing output for a good that is undersupplied. This increases welfare by the shaded amount.

An alternative approach is to approximate wider distortions through converting market prices (on primary markets) into shadow prices (reflecting distortions on secondary markets). This approach was set out in the mid-1970s by Little and Mirrlees (1974), most famously arguing for the use of border prices to value tradable goods and long run marginal cost for non-traded goods. A rather abstract approach to using shadow prices to perform cost-benefit analysis in distorted economies is set out in Dreze and Stern (1990). Shadow pricing is further discussed in chapter 2.

6.2.2 Implications for analysing labour market impacts

Let us apply this framework to consider the impact on local labour markets of an investment project, e.g. a new road. In particular, we might distinguish three different impacts that may be relevant:

- A short-term increase in demand for labour during construction;
- A long-term increase in demand for labour during operation;
- In the case of transport projects, an increase in labour market supply resulting from improved accessibility.

Recall that the theory suggests it is valid to include wider impacts if secondary markets are distorted. This is generally the case with labour markets, not least given the presence of taxes. Given the difficulties in constructing a labour market model, however, standard practice is to adjust market prices for shadow wages (see chapter 2; and EC, 2008). The size of the adjustment (per hour of labour) clearly depends on the size of the market imperfection (recall that it is equal to $p_B - c_B$ in equation 2) as well as the impact of the project on local labour supply (skilled, unskilled etc.). This adjustment requires detailed information on the local labour market as well as estimates of the job creation by the project. In short, equation 2 helps develop the intuition needed to capture secondary labour market benefits.

6.3 Wider impacts on public finances and GDP

Section two has focused on the impact of investments on secondary markets. However, other interpretations of wider economic impacts also exist. This section briefly reviews two.

6.3.1 Impacts on public finances

As is well known, the cost of a project is measured in terms of the opportunity cost of resources. Taxes or subsidies do not correspond to a resource flow and hence are usually considered as a pure transfer and stripped out.[24]

This approach is correct if governments have access to non-distortive instruments to raise public revenues (so-called lump sum transfers). In reality, this is not the case: governments use an array of distortive taxes on income and consumption. As a result, each euro of government tax revenue has an opportunity cost – the welfare cost from the distortion in consumer and producer behaviour induced by the tax (see Riess, 2008, for a review). In the literature this welfare cost per unit of tax revenue raised is usually referred to as the marginal cost of public funds. Where the marginal cost of public funds is greater than one, the welfare cost of raising one euro is greater than the tax received.

A large empirical literature has attempted to estimate the marginal cost of public funds from different tax instruments (see e.g. Myles, 1995 or Riess, 2008). In general, it is estimated to be larger than 1, although, in the case of reform of the tax structure, the marginal cost of funds depends both on the instrument used to raise revenue and to recycle it (see Goulder *et al* 1997).

Large investment projects – even when wholly financed by the private sector – can have a significant impact on regional and even national net tax receipts. For example, indirect impacts on public finances of a new urban rail line in London, presented in the section below, are estimated to equal approximately one-quarter of the total user benefits. If the marginal cost of public funds is one, no value is placed on this transfer of resource. If it is above one, an additional cost is placed on the fact that governments need to address this loss of tax revenue through raising distortive taxes elsewhere in the economy.

The practice of the Bank – in line with a number of practical guidelines, including EC (2008) – is to abstract from these wider fiscal costs, i.e. to assume that the marginal cost of public funds equals one. This is questionable, at least in principle, particularly at a time of acute strain on public finances. However, where the primary purpose of the Bank's analysis is to screen out relatively poor projects from within a single sector, the degree of inaccuracy introduced may be rather small.

6.3.2 Impacts on GDP

Cost-benefit analysis estimates the impact of an investment on social welfare. When done well, it should quantify the impact on all relevant people and firms affected by the project. In this sense, it is a wider concept than aggregate income, captured by GDP. Nevertheless, many policymakers remain sceptical about its merits, preferring to know the contribution of the project to economic growth (Worsley, 2011). This is legitimate in its own right; but as witnessed in Europe in response to the 2008 crisis, it can become elevated to new heights during times of economic crisis when investment in "shovel-ready" projects is seen as a means to boost aggregate demand.

The impact of projects on GDP growth can in principle be measured. However, in general, this is a separate metric from welfare. As discussed in UK Dept. of Transport (2005), care is required not to add welfare measures with GDP measures. In many cases, impacts are captured by both measures, and consequently adding would lead to double counting.

[24] There are exceptions to this rule. In the case of a distorted market, the tax revenue from increased demand resulting from the investment can be used as a measure of social surplus.

The impact of public investment on productivity (and GDP) has been a lively area of research over the last twenty years. Early research by Aschaeur (1989) found that public infrastructure has a large and positive impact on productivity, but other studies quickly found contrasting results. For a survey of this strand of literature, including the methodological difficulties inherent to it, see De la Fuente (2000).

In conclusion, although measures can be developed for the impact of projects on GDP, these are largely separate from welfare measures and should not in general be added. In some cases, in the absence of measures of welfare, GDP can provide an approximation of benefit.

6.3.3 Focus on transport infrastructure

The wider benefits of transport projects, perhaps more than any other sector financed by the Bank, are often espoused by project promoters. This may reflect legitimate concerns to capture the full range of benefits of a transport infrastructure within a wider regional network, in contrast for example with the more narrowly defined cost-effectiveness analysis required to compare alternate power generation technologies for a single power generation project. However, it may also reflect the fact that many transport infrastructure projects are publicly funded to some extent and hence compete for scarce public funds. The higher the stated benefits, the higher the chance of public funding.

As a result, there remains a lively academic debate over wider economic impacts in the field of transport (see ITF, 2007 and ITF, 2011). This section identifies two transport-specific issues: agglomeration benefits and property price increases. Other more general issues, such as impact on government finances, or labour market influences, have been discussed above.

6.3.3.1 Economies of agglomeration

A recent and controversial development in transport appraisal concerns the benefit of providing better access to dense, urban agglomerations (see UK DfT, 2005 for a review; or ITF 2011). In economic theory, a case can be made for including an additional agglomeration benefit given the impact of the project in effect to bring firms closer to one another and hence boosting productivity.[25] Standard appraisal techniques would capture part of the benefit, via the reduction in generalised cost valued at gross wage rate. However, given the returns to scale[26] (or externality) in the firms' production function, it can be shown that the social returns from investment exceed private returns.

In a discussion paper in 2005, the UK Department of Transport proposed a methodology to measure agglomeration benefits in practice. The result for a large urban rail project in London (Crossrail) is shown in Table 6.1 and for a new intercity high speed rail line (HSR2) in Table 6.2. These results suggest that the magnitude of agglomeration impact will depend strongly on the context of the individual project: in the case of Crossrail, agglomeration impacts could account for approximately an additional quarter of conventional time savings benefits, whilst for the high speed line it is estimated at less than ten percent.

However, some recent studies (Graham and Van Dender, 2009; de Palma, 2011) have challenged the techniques used to estimate agglomeration economies, concluding that it may not be precise and solid enough for inclusion in routine transport project appraisal. Whilst the conceptual case remains, it is difficult to transfer this evidence to the context of a typical project. An OECD workshop in 2007 concludes that using a rule of thumb to account for agglomeration benefits should not be considered best practice.

Table 6.1: Wider Benefits of Crossrail project

[25] In fact, two different effects need to be distinguished. For a given pattern of location, the investment reduces generalised travel cost. However, the investment may alter location decisions, as firms or people move in response to the investment. In particular, some firms may respond to the improved access to relocate from core to periphery. The net impact on agglomeration levels in the core is ambiguous and needs to be determined empirically on a case-by-case basis.

[26] This is consistent with the model presented in section 2. One of the conditions required to ignore impacts on secondary markets was precisely (locally) constant returns to scale.

	Welfare (GBP million)
Business time savings Commuting time savings Leisure time savings	4,487 4,152 3,833
Total transport user benefits	12,832
Agglomeration benefits Increased competition Imperfect competition Exchequer consequences	3,094 0 485 3,580
Addition to conventional appraisal (percentage of conventional)	7,159 (55%)
Total (excluding externalities)	19,991

Source: UK Department of Transport (2005). Crossrail is an urban rail project in London estimated by the promoter to cost GBP16bn. For an update, see Worsley (2011).

Table 6.2: Wider Benefits of High Speed Rail 2 (HSR2)

	Welfare (GBP million)
Business time savings Commuting and leisure savings Other benefits: accidents, air quality, noise	17,600 11,100 <100
Total transport user benefits	28,700
Agglomeration benefits Increased competition Imperfect competition Exchequer consequences	2,000 0 1,600 0
Addition to conventional appraisal (percentage of conventional)	3,600 (13%)
Total	32,300

Source: UK Department of Transport (2010). The project is a new high speed rail line between London and Birmingham (with possible extensions northwards). The project is estimated by the promoter to cost GBP25.5bn.

6.3.3.2 Local property prices

In urban infrastructure projects, for instance upgrading a metro line, promoters sometimes add the positive impacts on local property prices as a benefit. In general, this constitutes double counting, since the benefits have already been measured on the primary transport market i.e. as time savings, improved reliability etc. However, there may be impacts on local public finances through property taxation – but, as discussed above, this is only a resource cost if the marginal cost of funds is assumed to be larger than one.

6.4 Conclusions

When the net present value of the benefits of a project, measured using standard appraisal techniques, fail to outweigh the costs, it may be tempting for promoters to search for "wider economic impacts".

This chapter has briefly reviewed several candidates for inclusion as wider benefits, including exacerbating pre-existing distortions on secondary markets, impacts on public finances and GDP. Particular attention has been given to transport projects, given widespread application of full cost-benefit techniques and the common need to justify the use of public funds.

Based on this review, it seems appropriate to draw the following conclusions for appraisal work:

- In line with standard practice in this field, the central focus of the economic appraisal is to capture accurately the flows on relevant primary markets (e.g. relevant transport network; energy markets; industrial sector). In this sense, there is a presumption against including wider impacts on secondary markets, GDP or public finances. This is to avoid double counting project benefits and thus biasing the funding decision.

- Under some strict conditions, however, economic theory would support including specific wider benefits. From the Bank's perspective, however, if the ERR estimated using standard techniques exceeds the social discount rate, the funding decision can already be made.[27] Under these conditions, any additional benefits are of academic interest only.

- Where appropriate, one practical way of dealing with impacts on secondary markets may be to convert market prices into shadow prices (e.g. to capture structural rigidities in the local labour market). Even here, it is likely that the overall impact on results is likely to be within the range of sensitivity testing performed on the standard model.

- Exceptionally, secondary markets may be considered more explicitly by the promoter, e.g. the impact of an urban rail scheme on business productivity. This will be considered by the Bank on a case-by-case basis, with a view to ensuring consistency of approach between evaluations of similar projects across different countries. In such cases, good practice would require the project analyst to provide clear justification, based on quantifiable evidence of the impact on pre-existing market distortions.

- Whilst it is fair to say that there have been relatively strong developments surrounding the theoretical basis for wider economic impacts in recent years, there remains little established practice on how to translate these ideas into robust techniques for individual projects. This justifies a cautious approach by the Bank, although it underlines the importance of monitoring closely developments in this field.

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[27] Strictly speaking, this need not be true. In theory, wider economic impacts could work in either direction. Thus it is possible that the true ERR is below the estimated ERR based on standard techniques, but there is little evidence for this in practice.

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Appendix: Formal presentation of section 6.2

This section provides a more formal treatment of the discussion in section 6.2. A very simple setting[28] is assumed to illustrate the main result. Let us assume an economy with three goods: x_1, x_2 and x_3. Quantities are defined in units such that producer price (without investment) equals 1. Let x_1 be the untaxed numeraire, hence $p_1 = 1$. We assume government can invest by an amount *k* in a second market to reduce the price such that $p_2 = 1 - k$. Finally, the third market is subject to a distortive wedge between consumer and producer prices: $p_3 = 1 + \tau$. This set-up equates to the example given graphically in section 2 above, with x_2 equivalent to market A and x_3 equivalent to market B.

Consumer problem
A representative consumer is assumed to maximise a utility function with standard properties defined over the three goods $U(x_1, x_2, x_3)$ subject to a budget constraint in which $x_1 + (1-k)x_2 + (1+\tau)x_3 \le G$. Solving this problem leads to demand functions $x_j(k, \tau, G)$. Substituting these back into the utility function gives an indirect utility function $V(k, \tau, G)$. Using Roy's identity, this implies $\frac{\partial V}{\partial k} = \lambda x_2$ where $\frac{\partial V}{\partial G} = \lambda$.

Government budget constraint
The government collects taxes from good 3, pays for investment c(k) and returns any balance to the consumer. Hence the budget constraint is given by: $\tau x_3 - c(k) = G$.

Welfare impact of marginal investment
The welfare impact of marginal investment is given by:

$$\frac{1}{\lambda}\frac{\partial W}{\partial k} = \frac{1}{\lambda}\left(\frac{\partial V}{\partial k} + \frac{\partial V}{\partial G}\frac{dG}{dk}\right)$$

Substituting the various terms and rearranging gives the result:

$$\frac{1}{\lambda}\frac{\partial W}{\partial k} = x_2 - c'(k) + \tau\frac{dx_3}{dk}$$

This result is the formal equivalent of both Figure 6.1 and Figure 6.3. At the margin, the benefit of the investment on the primary market is given by x_2 (equal to the shaded area in Figure 6.1 as the dQ is very small) minus the cost of the investment. The welfare impact on the secondary market is measured by the distortive wedge (τ) multiplied by the change in demand. In the special case that no distortion exists (τ =0), analysis of the primary market alone suffices.

[28] See Calthrop *et al.* (2010) for a more general model, including labour market distortions and a full set of feedbacks. Note that – as pointed out by Professor Johansson – care is required when generalising the simple result presented here. For instance, once lump sum taxes are not available, it is in general not correct to adjust costs on the primary market by a marginal cost of funds parameter and, in addition, retain the tax wedge on the secondary market.

7 Economic Life and Residual Value

Diego Ferrer

7.1 Introduction

The need to estimate a project's economic life is twofold: firstly, life is a basic parameter in the evaluation of the economic profitability of the project; and secondly, economic life is a reference to determine the maturity of the loan financing the project.

In line with sound banking practice, the Bank ensures that the maturity of its loans is shorter than the underlying project life. When the Bank is lending to guaranteed public sector projects, the main reason for capping the maturity of the loan is to make beneficiaries pay for the project, avoiding potential inter-generational transfers that may arise in detriment of future generations. When the Bank lends to the private sector, and in particular in project finance, the "user pays principle" tends to inherently apply to the project, and the link between loan maturity and project life relates mostly to credit risk considerations.

In general, the assessment of a project's economic life is left to a large extent to the discretion of the PJ team and depends on the sector and specifics of the project. In 2002, following internal discussions on the economic life of high speed railway lines, the Bank decided to adopt a specific methodology.

7.2 Definitions of life

The literature addresses various notions of life, raising the possibility of confusion. Terms such as average life, useful life, economic useful life, effective life or mean life are used in different contexts, sometimes wrongly. PJ has retained three main life definitions: economic, physical and financial. The notion of design life is closely related to physical life.

The following generally accepted definitions are inserted here for convenience and as an introduction to the PJ methodology.

7.2.1 Economic life

The period over which an asset is expected to be usable, with normal repairs and maintenance, for the purpose it was acquired, rented, or leased. Expressed usually in number of years, process cycles, or units produced, it is usually less than the asset's physical life.

At each point in time, a project may be considered economically alive if it has a positive net present value. On the cost side, economic life depends on the same factors determining physical life (see below). On the benefit side, economic life depends primarily on the level of demand and on the economic value attached to this use, which in turn depend on exogenous variables such as market risk (competition, possible change of use) and risk of obsolescence. Externalities may also affect the benefits stream and thus the economic life of a project.

7.2.2 Physical life

The physical life is the life for which the facility is designed under given operating conditions. The notion of physical life of a project is related to the physical deterioration of its components over time. It depends on the intrinsic quality of the project's components (initial capital investment), on the type of maintenance applied (operation and maintenance regime), on the usage rates (demand) and on the environmental conditions (e.g. storms, salinity or humidity levels). While the first two variables are mainly endogenous (i.e. can be controlled by the promoter and/or operator), the latter two are primarily exogenous (i.e. cannot be controlled and therefore need to be estimated, largely on the basis of empirical evidence).

Predicting physical life is a difficult exercise. Efforts concentrate on empirical evidence and statistical approaches, aiming at the estimation of a minimum physical life, sometimes referred to as design life.

The design life of an infrastructure project is the minimum physical life, as defined in the project's technical specifications. Design life is a notion that adapts well, for instance, to an industrial product such as rolling stock. Load, fatigue and corrosion tests can be made to predict nominal design lives of individual components. Despite uncertainty on a number of factors, engineers are normally able to determine the asset's design life with some accuracy. In general, the capability to achieve a physical life in excess of the design life is related to both the quality of the available empirical evidence at design stage and to the safety factors employed.

7.2.3 Financial life

The concept of financial life can be defined when a project generates a financial cash flow. Similarly to the methodology illustrated for the economic life, the project can be considered financially alive as long as the NPV of the future net financial cash flow is above the financial residual value of the project's components. The financial life could be affected by fiscal and/or accounting considerations, and also by the promoter's opportunity cost of capital considered as discount rate.

7.3 EIB methodology to assess economic life

The approach to estimating the economic life of an infrastructure project is to first estimate the average physical life. Average physical life is defined as the cost-weighted average of the physical life of the components of the project under normal operating and maintenance conditions.

The calculation is normally done by the Bank engineer appraising the project, on the basis of cost information obtained from the promoter and a set of tables including physical life values for the project components. Reference values are available for the main components of transport projects, but also water and building operations.

PJ reports on the average physical life and provides an analysis of the factors affecting the project's economic life. This can be supported by CBA modelling and sensitivities. If applicable, a risk matrix will be developed to assess risks associated to the intrinsic quality of the asset, the operation and maintenance policies, the use of the asset and the environmental conditions. The PJ team will also assess the probability that the economic life is finally shorter, or perhaps in some cases longer, than the average physical life.

PJ should report on the project's average physical life, but should avoid calling it economic life. Qualitative or statistical considerations should provide an indication on the expected economic life relative to the calculated average physical life. As an example, a tramway project would be as illustrated in Table 7.1.

The calculated average physical life for the project is 36 years, with the shortest life corresponding to equipment, 20 years. In order to assess the economic life, additional considerations are taken into account. From a functional point of view, the project is pioneering an innovative type of rolling stock on tyres, which is able to operate both as a tramway and as a trolleybus. This type of technology has no precedent and despite thorough testing, it could suffer from market risk. In particular, if users do not accept it relative to alternative technological options, it could quickly become obsolete. Because of these risks, the project team deemed prudent to limit the economic life to 25 years.

Table 7.1:
Calculation of average project physical life

COST	M EUR	%	Physical life	Average project physical life
Infrastructure	59	34%	60	20.5
Energy & signalling	36	21%	25	5.2
Equipment	9	5%	20	1.1
Workshop	1	1%	25	0.2
Urban works	28	16%	20	3.2
Rolling stock	40	23%	25	5.8
TOTAL	175	100%		**35.9**

7.4 Residual value

In general, the PJ team determines the residual value to be considered in the project's economic appraisal on the basis of the nature of the technology concerned and the market risks surrounding it. For example, in the case of rail projects, where rolling stock is normally replaced after 20-25 years of operation, the in-house CBA models assume by default that the residual value at the end of the project's physical life is 0.

8 The Social Discount Rate

Armin D. Riess [29]

8.1 Introduction

One objective of this chapter is to set out what the social discount rate is for, which factors determine it, and how it can be estimated. An equally important and related objective is to guide Bank appraisal practitioners in choosing the "right" social discount rate. In this context, the chapter warns against making seemingly plausible but wrong *ad hoc* adjustments to social discount rates. As to terminology, note that what is called "social discount rate" here is called "economic discount rate" in Bank appraisal. This use of terminology is in line with the CBA literature, which also uses both terms synonymously.

The remainder of this chapter is structured as follows. Section 8.2 provides a reminder of the purpose of discounting. Section 8.3 sets out the concept of the "social time preference rate" (STPR), which recent literature reviews have found to be the most appropriate parameter for setting social discount rates (see, for instance, Spackman (2004) and OECD (2007).[30] Section 8.4 provides figures for the STPR. Section 8.5 briefly explains why risk and uncertainty have (almost) no impact on the social discount rate. Section 8.6 summarises, highlights practical implications for project appraisal, and suggests social discount rates for the appraisal of Bank projects.

8.2 What is the social discount rate for?

The sole purpose of the social discount <u>rate</u> (*s*) is to make costs and benefits that arise at different points in time comparable. Specifically, from today's perspective ($t = 0$), the economic value that society attaches to a net benefit (benefit – cost) of EUR1 accruing in period *t* is $d = 1/(1+s)^t$, with d being the discount <u>factor</u>. For $s > 0$ and $t > 0$, $d < 1$; what is more, d declines over time, suggesting that society attaches greater weight to near benefits than to distant ones.[31]. If s is big, d is small and, thus, society weighs near benefits particularly high relative to distant ones.

To make things clear, it does not hurt to consider numerical examples.

Suppose $s = 0.11$ and, thus, the social discount factor linking two consecutive periods is $d = 0.9$. From today's perspective (the current period), society attaches a weight of 0.9 to a benefit of EUR1 tomorrow (the next period). This implies that society values EUR0.9 today as much as EUR1 tomorrow. One rationale for valuing EUR0.9 today as much as EUR1 tomorrow is time preference, implying that people and the society they constitute prefer to have good things sooner rather than later.

Alternatively, suppose $s = 0.25$ and thus $d = 0.8$. This implies that society values EUR0.8 today as much as EUR1 tomorrow. With the time preference rationale for discounting, a comparison of both cases suggests the following: $s = 0.25$ reflects a higher time preference than $s = 0.11$; this is because for $s = 0.11$ society's preference for the present is such that EUR0.9 today would be of the same value as

29 Thanks to Edward Calthrop and Marco Springmann for their excellent comments.

30 Spackman, M. (2004), "Time discounting and the cost of capital in government", *Fiscal Studies, Vol 25, no.4*, pp 467-518 OECD (2007).
OECD (2007). Working Party on National Environmental Policies – Use of discount rates in the estimation of costs of inaction with respect to selected environmental concerns. Paper drafted by Cameron Hepburn.

31 More formally, the discount rate (s) is the rate of change of the discount factor (d) over time. This is easy to see in the continuous form expression of the discount factor, i.e. $d_t = e^{-st}$.

EUR1 tomorrow; by contrast, for $s = 0.25$, preference for the present is so strong that a mere EUR0.8 today suffices to be of equal value to society as EUR1 tomorrow.

In sum, the social discount rate (s) is a parameter that determines the discount factor $d(t)$, which in turn is nothing but a weight that society gives to benefits accruing in period t. Future benefits are valued less than present ones. One rationale for this is that societies prefer the present over the future. Reflecting this rationale, the social discount rate (s) is called "social time preference rate" ($STPR$). Other reasons for discounting relate to social opportunity costs or the mere existence of interest rates. The next section will explore the $STPR$ and sketch the link between the $STPR$, social opportunity costs and interest rates.

8.3 The social time preference rate (*STPR*): concept

The classic approach to $STPR$ (and thus s) is the Ramsey equation:[32]

$$(1) \qquad s = STPR = a + b\,g$$

According to (1), the $STPR$ has two components: a and the product of b and g. Thus, there are two reasons why society prefers having things sooner rather than later. The first is captured by a, which is the so-called pure time preference rate; $a > 0$ reflects the hypothesis that society prefers today's consumption[33] over tomorrow's purely because of its precedence in time.[34]. All other things being equal, the social time preference rate ($STPR$) is the higher, the higher the pure time preference rate (a).

The second reason why society prefers having things sooner rather than later is captured by $b\,g$. In turn, $b\,g$ reflects a combination of two things. Firstly, the hypothesis that consumption possibilities grow over time (at the rate g) and, secondly, that the additional welfare that society derives from an increase in consumption declines – an effect captured by b (an economic interpretation of b will follow below). All other things being equal, the higher $b\,g$, the higher the $STPR$.

To illustrate, suppose consumption possibilities do not grow ($g = 0$); society can therefore not look forward to a level of consumption that is higher in the future than at present. In these circumstances, there is no reason for society to prefer present over future consumption simply because future consumption possibilities are expected to be higher than today's (they aren't) and $STPR$ would be determined by a alone – and if a were zero (or close to zero), $STPR$ would be zero (or close to zero) and, thus, there would be no discounting (or near-zero discounting).

To offer another illustration for the term $b\,g$, assume that consumption possibilities are expected to grow at 2% a year ($g = 0.02$), ignoring – for the sake of simplicity – pure time preference ($a = 0$), and consider alternative values for b, say, $b = 1$ and $b = 4$ ($b = 1$) means that a 1% increase in consumption reduces the marginal welfare of consumption by 1%;

32 This Ramsey equation, developed in the late 1920s, assumes a particular iso-elastic functional form for utility, constant population, no inequality within society and perfect certainty. All of these assumptions have been relaxed in subsequent work (e.g. see Gollier, C., 2001, *The Economics of Risk and Time*), although the basic intuition remains.

33 Reflecting the economic model underpinning the social time preference rate, we will talk about "consumption" rather than net benefits.

34 For projects with very long time horizons that span across generations, several economists (e.g., Frank Ramsey, Amartya Sen, and Robert Solow) have argued that the only sound ethical basis for a positive pure time preference rate is the uncertainty over whether the world will exist. The use of near-zero pure rates of time preference is raised in the context of the social cost of carbon (see chapter 4).

$b = 4$ means that a 1% increase in consumption reduces the marginal welfare of consumption by 4%).[35] According to equation (1), $STPR$ would be 0.02 (i.e., 2%) for $b = 1$ and 0.08 (i.e., 8%) for $b = 4$.

An intuitive explanation why $STPR$ increases with b runs as follows: b measures the pace at which the additional (marginal) welfare arising from an increase in consumption declines; if this decline is fast (b is high), society has a relatively strong preference for consumption when the level of consumption is still relatively low, which is today because of $g > 0$. As b is a parameter that indicates how society's welfare responds to an increase in the level of consumption, it has no effect on the $STPR$ when no increase in consumption is expected, that is, when $g = 0$.

In sum, the $STPR$-based social discount rate is driven by three factors: society's pure time preference (a), a measure of how fast marginal welfare falls with an increase in consumption (b), and expected per capita consumption growth (g). In more general settings, it may also depend on other factors, such as the degree of inequality across society. The impact of uncertainty is discussed below. The welfare economics perspective championed in this section also indicates, too, what the social discount rate is not: it is not a parameter representing opportunity costs (public or private), market interest rates, government borrowing rates, and the like. That said, as set out in Box 1, these variables are related to the $STPR$ and they are candidates for estimating s in the absence of direct estimates of $STPR$. The next section presents results from directly estimating $STPR$.

Box: Social time preference rate, social opportunity cost, and market interest rates

The purpose of this box is to explore the link between the $STPR$, social opportunity cost, and market interest rates.

To fix ideas, it is useful to consider a perfectly competitive economy. Such an economy comprises identical, profit-maximising firms and identical, utility-maximising individuals; there is no government (and, thus taxation), no public goods and other market failures, and no uncertainty. In such an economy, the interactions between profit-maximising firms and utility-maximising individuals result in an intertemporal allocation of consumption that maximises society's welfare. The intertemporal allocation of consumption is such that (1) the rate at which individuals willingly forgo present consumption for an increase in future consumption just equals (2) the rate at which firms can transform present output (which could be consumed today) into future output, and both rates are linked by (3) the market interest rate. Thus, equality of three rates characterises a welfare-maximising intertemporal allocation of consumption. Introducing a little more terminology, let us look at this equality in greater detail.

(1) The rate at which individuals willingly forgo present consumption for an increase in future consumption is called the marginal rate of substitution (MRS) and it can be expressed as $1/(1+ITPR)$, $ITPR$ being the time preference rate of a representative individual;

[35] To offer another interpretation of b, imagine a doubling of consumption between the present and the future (e.g., 20 years from now). With $b = 1$, doubling the level of consumption reduces the marginal welfare of a unit consumption by one-half; with $b = 4$, doubling consumption reduces the marginal welfare of a unit of consumption by one-sixteenth.

for now, let us assume that this rate reflects society's time preference, too, that is, $ITPR = STPR = s$

(2) The rate at which firms can transform output not consumed today into future output is the marginal rate of transformation (MRT) and it can be expressed as $1/(1+r)$, r being the marginal productivity of capital, that is, of resources not consumed today but invested with a view to increasing future consumption possibilities; thus, r captures the opportunity cost of present consumption. For now, let us assume that this rate also reflects society's opportunity cost (*SOC*), that is, $r = SOC$

(3) The link to the market interest rate m in this perfect economy is that $1/(1+m) = MRS = MRT$, implying $s = STPR = SOC = m$.

In sum, in this perfect world, $s = STPR = SOC = m$. That is, the social time preference rate $STPR$ is equal to the social opportunity cost of capital SOC, and both are identical to the market interest rate m. In these circumstances, choosing the social discount rate s is easy: one simply selects the (observable) market interest rate, knowing that it measures social time preference (and social opportunity costs).

Departures from this ideal benchmark make the choice of the social discount rate complex and controversial. For instance, information asymmetries, risk, externalities, capital market imperfections, and distortionary taxes undo the equality between $STPR$, SOC, and m. A tax on interest income, for instance, drives a wedge between the social opportunity cost of capital and the social time preference rate. More precisely, a tax on interest income reduces the after-tax return to individuals and, in equilibrium, makes $STPR$ lower than the before-tax marginal productivity of capital (SOC). Should one use $STPR$ or SOC as the social discount rate (s) – or a combination of the two? If funds for a project had been consumed in its absence, there is an argument for using $STPR$. In contrast, if the project crowds out investment, it is tempting to make a case for choosing SOC – that is, the social opportunity cost of capital – as the discount rate. Finally, there appears to be some logic to using a weighted average of $STPR$ and SOC as the discount rate if the funds committed to the project replace consumption and investment.

This being said, setting the discount rate on the basis of the opportunity cost of capital is contentious – even if the project examined fully crowds out investment. A neat way to illustrate the point is to consider a cost-effectiveness analysis – an analysis comparing the discounted costs of project alternatives that have the same non-monetised benefits. In this case, there is no logic to using a discount rate based on forgone benefits, or opportunities, because valuing the benefits of these alternatives is not the purpose of the analysis in the first place.

To summarise, in a perfect world (including the assumption that individual time preference equals social time preference and that firms' opportunity costs equal society's opportunity costs), the market interest rate reflects the social discount rate that should be used to make costs and benefits occurring at different points in time comparable. Outside this world, this is no longer true and how to set the social discount rate becomes controversial – with considerable practical implications, such as the choice between public-private partnerships and traditional public procurement.[36] Obviously, things become even more complicated if, contrary to what we have assumed so far, there are reasons to believe that individual time preference is not equal to social time preference (that is, $STPR \neq ITPR$), and that private opportunity cost do not coincide with social opportunity cost (that is, $SOC \neq r$). The finance literature – centred on the efficient market hypothesis – considers market interest rates an appropriate measure for the social time preference rate. Perhaps reflecting this approach, American

[36] The choice between PPP and traditional public procurement ought to be informed by comparing the present value of net benefits that a PPP provides with those of a public-sector comparator. Since the discount rate used for the PPP reflects financial risks it is typically higher than the rate used for the public-sector comparator. There is debate as to whether or not this builds in an "unfair" bias against PPP. For a comprehensive discussion see Grout, P. (2005), "Value-for-money measurement in public-private partnerships". *EIB Papers* Vol. 10, No 2, pp 32-56.

economists often prefer a SOC based approach (see Burgess and Zerbe (2011), for instance). By contrast, the welfare economics literature mostly finds market interest rates misleading – for a variety of reasons. Weighing the pros and cons of the controversy – as set out in Spackman (2004), for instance – this section subscribes to the welfare economics approach to determining the social discount rate, a position also emerging from a recent OECD (2007) paper on the subject. Cognizant of this judgment, section 8.4 presents figures for the $STPR$ and its components (that is, a, b, and g in equation (1)).

8.4 The social time preference rate (*STPR*): figures[37]

While the welfare economics approach to social discounting sees market interest rates as inappropriate for estimating the $STPR$ and, by extension, choosing the social discount rate (see Box 1), the government borrowing rate is often considered a lower bound for the $STPR$. Considering real yields on long-term government bonds, this would imply a lower bound of 1-2%.[38]

An upper bound for the $STPR$ could be the individual time preference rate ($ITPR$), which could be as high 25% reflecting people's observed willingness to borrow at these rates. However, it is plausible and broadly accepted that the $STPR$ is lower than the $ITPR$. One reason is that the pure time preference rate (a in equation (1)) is lower for society at large than for individuals. In fact, there are ethical arguments for choosing a zero (or near-zero) pure time preference rate for society despite evidence for a higher individual pure time preference rate. Based on the literature reviewed in Spackman (2004), society's pure time preference rate a can be posited to range from 0 to 3%, with "some consensus in the literature on a value over a few decades of around 1.5% per year" (the qualification "over a few decades" is important, and we will return to it when discussing the argument for a social discount rate that is not constant but declines over time).

The parameter b – that is, the consumption elasticity of the marginal welfare of consumption – can be gauged from both normative views and revealed behaviour (e.g., of society as reflected in a country's income tax regime and of individuals as reflected in personal saving behaviour or attitudes towards risk). Seen as normative parameter in a growing economy, a low (high) value of b would imply that decision-makers give little (much) weight to the fact that people living in the future might be richer than people living today. As b thus reflects views about the distribution of income across time, its value might be inferred from society's view about the distribution of income at any point in time which – in turn – could be seen as reflected in a country's personal income tax system. Empirical work drawing on the UK tax regime in 1990s suggests a figure for b of around 1.3 to 2; similar work for the US in the 1960s point to a figure of 1.5. Estimates based on personal saving behaviour range from close to 0.2 to around 5.5; and estimates based on direct evidence on personal risk aversion suggest four as a plausible value.

All in all, if we combine a value of 1.5% for society's pure time preference rate ($a = 0.015$) with a value of, say, two for the consumption elasticity of the marginal welfare of consumption ($b = 2$) and an expected per capita income growth of 2% ($g = 0.02$), we arrive at a social time preference rate of 5.5% ($STPR = 0.015 + 2 * 0.02 = 0.055$). Perhaps considering an even lower pure time preference rate, Spackman pictures an $STPR$ of around 4% to 5% in real terms for a typical developed economy with an expected annual per capita growth rate of 2%. Furthermore, he emphasises that this is above the risk-free government borrowing rate,

37 This chapter draws on Section V of Spackman, M. (2004).

38 Smithers, A. (2009). *Wall Street revalued*. 1% is the estimated real return on long-term UK government bonds in 1900-2007. 2% is the comparable estimate for the United States.

illustrating the view that the government borrowing rate is not equal to, though it is possibly a lower bound for, a social discount rate.

8.5 Why risk and uncertainty have (almost) no impact on the social discount rate

There is a seemingly conspicuous absence of risk and uncertainty in an $STPR$-based social discount rate. To put things into context, the discount rate used for financial analyses should reflect non-diversifiable risks (though not project-specific, that is, diversifiable risks). For instance, using the capital-asset-pricing model (CAPM), the risk premium would be a mark-up over the risk-free interest rate, with the mark-up determined by general market risk and the correlation between that risk and the non-diversifiable risk of the project under consideration. The question, then, is why this risk premium is irrelevant from society's perspective (more precisely: why it is irrelevant for how society should compare benefits that accrue at different points in time).

This question takes us back to the controversy between the finance literature and the welfare economics literature (featuring in Box 1), with the former arguing that the risk premium is as relevant from society's perspective as it is from the perspective of project financiers. In contrast, the welfare economics literature argues that the non-diversifiable risk faced by society is usually very small, largely reflecting the Arrow-Lind view that from society's perspective risk is spread widely (across all taxpayers), making its societal cost negligible.[39]

One socially relevant risk factor in discounting is the risk that society (or large parts of it) may not live to enjoy the future because of man-made or natural catastrophes (*e.g.*, bioterrorism, climate catastrophe, asteroid impact, and the eruption of a super-volcano). This argues for a positive, though perhaps small, value for society's pure time preference rate (a in equation (1)) even if preference for present consumption is rejected on ethical grounds.

Another socially relevant risk factor concerns uncertainty about the $STPR$ itself – in particular, the $STPR$ pertaining to the very long run, say, beyond 30-40 years. The most prominent case to which this issue applies is the estimation of the social cost of carbon (see chapter 4). Project examples for which uncertainty about the $STPR$ could be relevant include nuclear power plants, due to their decommissioning costs and the cost of storing nuclear waste over thousands of years. The literature on this issue reviewed in Spackman (2004) and OECD (2007) makes a convincing case in favour of discounting at lower rates in the very long-term. More specifically, the "consensus in the literature on a value [of society's pure time preference] <u>over a few decades</u> of around 1.5% per year" (see above) no longer holds and a value close to zero seems convincing on ethical grounds. For projects with a lifetime longer than, say, three decades, this would argue for a declining discount rate once that horizon has passed. That being said, there is still a case for society to discount if $bg > 0$. However, bg may also fall over time if there are limits to growth, implying that g falls over time, possibly approaching zero.

8.6 Summary, practical implications, and guide to choosing social discount rates

[39] Arrow, K.J. and Lind, R.C. (1970). "Uncertainty and the evaluation of public investment decisions", *American Economic Review*, Vol. 60, pp. 364-78. Subsequent literature has challenged the findings in the context of non-financial risk (e.g. exposure to radiation; explosion etc.) which may disproportionately impact local communities. There could then be an argument for using a discount rate higher than the *STPR*-based rate. Conversely, it has been observed that projects might be negatively correlated with the risks to the overall economy. For such projects, one could argue for a discount rate lower than the *STPR*-based rate. In practice, however, it is a challenge to ascertain with a reasonable degree of confidence when a project has these characteristics and, in any event, if the project is small relative to the economy, any societal benefit from diversification would be negligible and can be ignored.

- The sole purpose of the social discount is to make costs and benefits that arise at different points in time comparable.
- Welfare economics makes a convincing case for deriving the social discount rate on the basis of first principles, that is, social time preferences (equation (1)).
- As social time preferences might differ across countries, $STPR$-based social discount rates might also differ. Assuming for illustrative purposes the same pure time preference rate (a in equation (1)) and the same consumption elasticity of marginal welfare (b in equation (1)) for all countries, a poor country looking forward to strong growth in per capita consumption (g in equation (1) is big) will have a relatively high discount rate. Conversely, a relatively rich country with modest or no growth expectations will have a low discount rate.
- Indeed, European Commission (2008) argues that all $STPR$ components in equation (1) are country-specific, and thus advises that every EU Member State should assess its own country-specific social discount rate (although it goes on to make a case for some degree of homogeneity in social discount rate across the EU – see below).
- Table 8.1, taken from the OECD (2007) study, shows social discount rates and their basis (like *STPR* or *LIBOR*). It transpires that rates in the EU ranged from 1% (Czech Republic) to up to 6% (Denmark). The table also shows that France and the UK apply declining discount rates for the very long run – as ethics and economic reasoning suggest.
- European Commission (2008) also notes that differences in expected per capita consumption growth rate are the main reason for variations in the social discount rates across countries. That being said, European Commission (2008), recommends a social discount rate of 5.5% for Cohesion countries and 3.5% for other EU countries.
- In line with this view, for projects in the EU the Bank uses as a reference a real (that is, inflation-adjusted) social discount rate ranging from 3.5% to 5.5%, depending on the degree of maturity and expected growth rate of the national economy. Given that the determinants of $STPR$ are country-specific, there is scope for deviating from these benchmarks if country-specific reasons justify it. It follows that project-specific characteristics are no reason for deviating from the 3.5% and 5.5% benchmark (for more on this, see the bullet points after next).
- For Bank-financed projects outside the EU, setting the social discount rate is much harder. For most non-EU countries, it is reasonable to argue for a discount rate of at least 5.5%. A pragmatic approach would be to use estimates by development finance institutions (World Bank, Asian Development Bank, African Development Bank, and so on) if such estimates are available. If not, rules of thumb should apply. One would be to use, if available, real government borrowing cost – ideally related to (non-concessional) borrowing in foreign exchange. If this is unavailable, the analyst could use borrowing rates from countries with similar economic characteristics.
- As the social discount rate is a country-wide, national parameter, the same discount rate should be applied to all projects and sectors within a given country. For instance, the social discount rate for an energy project, a transport project, and a R&D project is the same (though the financial discount rate is bound to differ due to differences in risk premia).
- Seemingly, particularly beneficial projects (for instance, in health, education, and the environment) do not merit a lower discount rate. This also applies to projects that enhance security of energy supply to the host country. The particular beauty of these projects should be captured directly in the benefits (such as a premium on domestic energy supply relative to foreign supply). In a similar vein, there is no justification for a downward adjustment in the social discount rate to account for non-quantified benefits. The solution here is to quantify the benefits; or, to assess how big non-quantified benefits would have to be to make the project viable and then decide whether benefits of this size are reasonable or not. In any event, there is little logic for discounting all costs and benefits at a lower rate only because some of them are not or cannot be quantified.

- Discount rates are also used to calculate unit production costs (for instance, levelised electricity generating costs). Such an exercise could have two purposes. One is to compare, from society's perspective, mutually exclusive production technologies (e.g. coal *vs*. wind). The discount rate used in this exercise should be the social discount rate. The second is, for financial purposes, to compare unit production costs (again possibly for mutually exclusive production technologies) with market prices and tariffs. The discount rate used in this exercise should be a financial discount rate, which ought to include an appropriate risk premium for the project concerned. It follows that there is no contradiction in using for one and the same project a financial discount rate much higher than the social discount rate.
- Finally, it is useful to recall that the social discount rate sets a threshold for the social (or economic) internal rate of return ($EIRR^*$). For a project with a positive (zero) [negative] net present value at the relevant social discount rate, the $EIRR$ is above (at) [below] that threshold. In this context, it is useful to note that the $EIRR^*$ can be considerably below a similar threshold for the financial internal rate of return ($FIRR^*$). This is simply the mirror image of the view that the social discount rate should not include a risk premium and be net of any market distortions, while the financial discount rate should include such a premium and incorporates market distortions.

Table 8.1:
Practices regarding social discount rates across OECD countries

Country	OECD Response	Academic Response	Summary of Guidance on Discounting
Australia		√	Varies across the Australian States and depends on the type of project
Austria		√	No standardised discount rate
Belgium			—
Canada	√		TBS: 10% (sensitivity at 8% and 12%), Environment Canada: 7% (5% and 9%)
Czech republic	√		Ministry of Environment 1% (real, risk-free government borrowing rate)
Denmark	√		3% discount rate (SRTP), but ministry of finance employs 6%
European Commission	√		4% based on gilt yields and LIBOR rates, but 'reflects social time preference'
Finland	√		Discounting not widely used, 5% (Ministry of transport and communications)
France	√		4% for t < 30 years, 2% for t > 30 years since Jan 05 (reviewed on 5 year cycle)
Germany			—
Greece			—
Hungary		√	Depends upon the shape of the HUF and Euro zero coupon yield curves
Iceland			—
Ireland	√		5% for all public projects, as set by Department of Finance Reviewed regularly
Italy			—
Japan			—
Korea (South)			—
Luxembourg	√		Cost benefit analysis is not employed by the Ministry of Environment
Mexico			—
Netherlands			—
New Zealand	√		10% discount rate, with sensitivity analysis. Lower rates in some cases
Norway	√		
Poland			—
Portugal			—
Slovak Republic	√		5% discount rate based on EU guidance
Spain	√		5% discount rate , except for water infrastructure (4%), based on EU guidance
Sweden		√	4% discount rate, to be reviewed in May 2006
Switzerland		√	No standardised discount rate
Turkey		√	The discount rate is the interest rate on debt finance for the specific project
United Kingdom		√	3.5% rate (SRTP) for first 30 years, then declining schedule
United States	√	√	3.0% or 7.0% depending upon type of cash flow, lower rates for longer-term

Source: Excerpt of Table 2 of OECD (2007)

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9 Multi-Criteria Analysis (MCA)

Christine Blades

9.1 Introduction

Multi-criteria analysis (MCA) is an appraisal technique used to establish preferences amongst different options for delivering a given set of objectives. It does this with reference to an explicit set of criteria, which helps appraisers to assess the extent to which the investment objectives are met by the different solutions available to them. The problems addressed by MCA consist of a finite number of alternatives that are known explicitly at the beginning of the process. The purpose may be to identify the best alternative, rank options in preference order, or shortlist a number of options for more detailed appraisal. A standard tool of MCA is the "performance matrix", which compares the performance of each option against multiple appraisal criteria.

MCA can take different forms. These vary according to the nature of the decision and the time, resources and data available to appraise the alternatives, as well as by the skills of the analyst and the requirements of the organisation or culture in which the appraisal takes place. Whether simple or more sophisticated, explicit or implied, all MCA requires judgements to be made by the evaluator. The analytically more sophisticated form of MCA described in this chapter translates the "performance matrix" into a numerical value that provides an overall assessment of the relative contribution of options to delivering the objectives of the project. The assignment of these values is based on the informed judgement of the appraiser.

The advantages of MCA over judgement unsupported by analysis are that:

- The technique is transparent, open and explicit;
- It elucidates the problem or question being addressed and sets out the pros and cons of different solutions;
- The choice of objectives and appraisal criteria are open to analysis, as well as to challenge and change if they are judged to be inappropriate;
- Criteria "weights" and option "scores" are explicit, developed according to established techniques, can be cross-referenced to other sources of information and amended if necessary, provide a clear audit trail;
- It can provide an important means of communication, both within the decision-making body and between that body and external interested parties;
- Simple sensitivity testing can be used to assess the robustness (and/or decision turning-points) of appraisal conclusions.

Where full Cost-Benefit Analysis (CBA), Cost-Effectiveness Analysis (CEA) or other more standard quantitative appraisal techniques are not possible, MCA brings structure, transparency and consistency to the Bank's appraisal of investment projects. The method is also useful to inform and supplement CBA and other studies when it is not possible to express all costs and benefits in monetary terms. It can, therefore, contribute to Bank appraisals that generate ERRs or other economic indices but leave some relevant factors outside the calculations.

This chapter outlines the application of MCA principles to the appraisal of investment proposals prepared by promoters seeking to secure EIB funding for their projects in a way that is both transparent and contestable. In doing so, it focuses on the fuller form of MCA, in which the relative performance of options is expressed numerically (using "weights and scores") – and, as such, represents an "indicator" of project effectiveness in delivering investment objectives. The quantitative outcome of MCA is then compared with total project costs, represented by the outcome of a standard discounted cost analysis.

9.2 Stages of MCA

In summary, the steps of the MCA approach described in this chapter are six-fold:

1. Establish the decision context and the aims of the MCA.
2. Identify the options to be considered and compared, the project and relevant counterfactual(s).
3. Identify the investment objectives and constraints.
4. Identify the benefit criteria that reflect the value associated with the outcome of each option.
5. Assess the benefits:
   a) "weight" the benefit criteria for relative importance;
   b) describe the expected performance of each option against the criteria and "score" the ability of each to deliver the benefits; and
   c) combine the weights and scores to derive an overall value for each option (total weighted scores) and rank them accordingly.
6. Conduct sensitivity analysis to assess the robustness of MCA results to changes in weights and scores.

The stages of the analysis are outlined below, with supporting material provided in appendices.

Step 1 – Decision Context
The purpose of the EIB's appraisal of projects is to inform the Bank's funding decisions based on proposals prepared by Member State and other project promoters. In doing so, it focuses on the evaluation of the appropriateness and robustness of investment projects within the strategic context in which they have been developed – it does not make the investment decision (the promoter does), nor does it prioritise projects across different countries or sectors. In this context, MCA is a suitable appraisal alternative when other techniques cannot be used for reasons of insufficient or inadequate data and limited time and resources available to appraise projects. It enables a comparison of the project with other options, where appropriate, and facilitates the ranking of multiple options from best to worst, as a result of assessing the relative benefits of the project and other options for meeting the investment objectives.

EIB experience shows that its assessment of investment proposals for projects in certain sectors and/or countries are more suited to appraisal using MCA than other methods. In particular, sectors for which project benefits are difficult to measure and value pose a challenge for the EIB to appraise systematically using CBA/CEA techniques (and hence the calculation of project ERRs and ENPVs). This includes, for example, investments in education, health and urban development. Whilst the capital investment and operating costs of these projects are more straightforward for the Bank to appraise, the benefits are rarely expressed in monetary terms. For this reason, the MCA approach described below focuses on the assessment of a project's benefits, which are combined with project costs to facilitate an assessment of the overall economic robustness of the project. When combined with the total discounted costs of options, it enables an assessment of the comparative economic value of the project, where the economic decision-criterion is represented by a comparison of (incremental) costs and benefits, where the latter is expressed in total "weighted benefit scores".

Weighting of criteria and scoring of options are not exact sciences and represent, respectively, opinions about the relative importance of different criteria and the practical benefits that will be received from the implementation of each option. Although the method is itself transparent and systematic, it is important that the Bank's MCA based appraisals are undertaken by a small appraisal team (not an individual analyst in isolation) and that the results of the appraisal are queried and tested for robustness through sensitivity analysis.

Step 2 – Option Identification
MCA is an incremental approach to comparing alternatives. Differences in the costs and benefits of the situation *with* the project (i.e. do something specific) and one or more counterfactual scenarios *without* the project are compared in the option analysis. The "without" scenario could be represented by one or more of the following:

- "Do nothing" – a baseline option that should be realistically considered, which may or may not be acceptable or possible or could be catastrophic for the service/business in question.
- "Do minimum" – the minimum investment required if the project is not implemented, incorporating the costs of maintaining the current service/operation over the lifetime of the proposed project.
- "Do something else" – other projects that could be implemented to meet the objectives of the investment (typically, to differing degrees).

Project promoters variably consider and evaluate alternatives to the investment project that are submitted to the EIB for funding. At a minimum, however, the Bank's appraisal of its promoters' projects should always involve a comparison of the project with a "do nothing" or preferably, a realistic "do minimum" option (and not simply the static situation before and after the project is implemented) – see Chapter 3 of this guide.

The alternatives should be described, and wherever possible key descriptors should be quantified; where this is not possible, they should be described qualitatively. Examples include:

- Intended outcomes;
- Expected workloads and performance targets, planned capacity;
- Accessibility;
- Physical characteristics and infrastructure implications;
- Phasing and timing of implementation;
- Flexibility to accommodate future change;
- Staffing consequences;
- Impact on financial parameters;
- Effects on others (other aspects of the business, other parties).

Step 3 – Identify Objectives and Constraints
As a guiding principle, investment objectives and the benefits that flow from their achievement will be determined by the needs of the end users/intended beneficiaries. They focus on the required outputs/outcomes (i.e. "what" needs to be achieved) rather than the means of achieving them (i.e. "how" they will be delivered). Investment objectives may be expressed in terms of criteria, such as relevance, appropriateness, effectiveness, equity, efficiency, acceptability, etc.

The objectives must be consistent with the policies and strategies of the sector and the context in which the project has been designed and will function. They will reflect the business aims of the promoter, as established in existing business plans, and reflect how the investment will contribute to these. As far as possible, objectives should be SMART: specific, measurable, achievable, relevant and with a time dimension. Objectives that are important but difficult to express in SMART terms should be incorporated into appraisals with as much objectivity as possible. However, statements like "upgrade the quality of accommodation" or "improve the quality of information" are typically not useful objectives, as they:

- refer to a means rather than the desired ends (there may be multiple ways of delivering the outcome sought); and
- are not SMART – have no timescale and no standard for measuring improvement.

Constraints are factors that impact on strategic, business and investment objectives and, as such, set the boundaries for the investment. They may relate to policy commitments, the physical environment, availability of appropriate staff, appropriate timescales, minimum standards, and so on. Investment constraints may also be related to financial issues, such as, maximum capital value or a limit on the operating cost implications of an investment.

Step 4 – Identify Benefit Criteria
Benefit criteria are used to identify and evaluate the investment options that are compared during a project's appraisal (the project and at least one alternative, such as "do minimum"). Derived from the strategic and business objectives and constraints, they fall into the following categories:

- Benefits that can be quantified financially – these should be included in the cost analysis;
- Benefits that can be quantified, but not financially;
- Benefits that cannot be quantified.

There is no "right" answer to the appropriate number of benefit criteria, as this very much depends on the nature of the decision to be made and the availability of supporting information, time and resources. A large number of criteria means additional analytical work. At the same time, there is a danger that important attributes may be ignored if there is a very small number of criteria. It is good practice to check that duplicate, potentially redundant criteria or those that do not help to differentiate the options are removed and the key investment objectives (ends not means) are adequately reflected in the benefits appraisal. The aim is to produce a manageable number of relevant criteria (possibly between 5 and 10) consistent with a well-founded conclusion that effectively compares the project with other options.

Each criterion is described by a list of potential benefits and, where relevant, disbenefits. These are drawn from the hierarchy of objectives, starting from policy aims, the promoter's strategic and business objectives, through to those directly related to how the project will contribute to these objectives. Where benefits can be expressed in monetary terms (e.g. cost savings) they are included in the cost analysis and **not** treated as a benefit criterion – to do otherwise would lead to double-counting. Benefit criteria might, for example, reflect the following kinds of factors:

- Strategic fit and coherence;
- Meeting needs/demands;
- Quality of services/products delivered;
- Effectiveness/efficiency of service/product delivery;
- Accessibility of the project's services/products;
- Staffing factors (e.g. recruitment and availability of staff);
- Flexibility to respond to changing demands and technological developments;
- Environmental quality;
- Ease and timing of implementation.

Step 5 – Assess Benefits
The evaluation of project benefits focuses on the non-monetary implications of investment options. The benefits delivered by the project are assessed comparatively using the benefit criteria identified at Step 4. Where possible all benefits should be quantified. The construction of weighted benefit scores is preferable to, and more robust than, the simple ranking of alternatives, with no clear measure of the degree to which one option is better (or worse) than another.

Weight benefit criteria (Step 5a): the purpose of weighting is to establish the relative importance of each criterion *vis-à-vis* the others. There are different ways of identifying criteria weights, though the following approach is recommended for its simplicity and transparency:

- Rank the criteria in order of importance;
- Attribute the most important criteria a weight of (say) 100;
- Examine each of the remaining criteria relative to the highest ranking attribute using pair-wise comparison (e.g. if the most important is 100, what is the relative value of the second (say, 70), the third (say, 50) and so on);
- Repeat the process for each successive pair of benefit criteria until each has been weighted;
- Scale the outcome to 100 (%), thereby attributing each criterion a % that reflects its importance compared with the other criteria;

- Record the weights and the rationale behind them.

Score options (Step 5b): the following practical approach is recommended for scoring options for their relative performance against each of the benefit criteria:

- Examine each option against each criterion, using the option descriptions to help make comparative assessments;
- Score each between 0 and 10 on each criterion (again using the descriptions to help make assessments), the better the performs the higher the score;
- Record the scores and the rationale behind them.

Preference ranking of options (Step 5c): to rank options and identify the preferred solution in terms of the **non-monetary benefits** of the project:

- Calculate total weighted scores;
- Rank options from highest to lowest weighted scores, thereby identifying the best way for achieving the investment objectives from the options selected for appraisal.

See Appendix 2 to this chapter for an illustrative assessment of the benefits of three investment options.

Step 6 – Undertake Sensitivity Analysis
Given the subjective (if systematic and transparent) nature of judgements made about benefit criteria weights and option scores, sensitivity testing is particularly important for assessing the robustness of the appraisal's conclusions. In the sensitivity analysis, facilitated by simple spreadsheet calculations, the weights and scores can be varied to understand how the preference ranking is affected by these factors.

The following steps are undertaken to assess the sensitivity of the appraisal conclusions (i.e. total weighted scores) to the scores assigned to options. For each option:

- Determine the agreed range of scores for each criterion;
- Alter the score of the first criterion within its agreed range;
- Repeat the analysis for scores of each of the other criteria;
- Note the implications for the total weighted benefit score when all scores for the option are at a maximum and when they are at a minimum.

Undertaking sensitivity analysis on criteria weights is complicated by the fact that altering the weight (%) of one criterion affects the weights of other criteria. In this case the process is as follows:

- Determine the agreed range weights for each criterion;
- For the first criterion to be examined, allocate the change in weight across the other weights (proportionately with the originally assigned weights of these);
- Adjust the weights arising from the change in weight of the first criterion and note the implications for the total weighted scores of options;
- Repeat the analysis for the weights of each of the other criteria.

See Appendix 2 to this chapter for some simple example sensitivity tests on option scores and criteria weights.

9.3 Incremental costs and benefits

As in other forms of economic appraisal, the analyst's conclusion on the value of the project submitted by a promoter for EIB funding is based on the balance of project costs and benefits relative to the alternatives, i.e. the incremental cost-benefits of the options examined in the appraisal. Costs are expressed as the total discounted costs of the investments under appraisal and benefits by the outcome of the MCA. By expressing project benefits in a single indicator (total weighted scores), the outcome of MCA approximates the "effectiveness" indicator used in CEA and the principles of CEA can be applied. In particular, the "cost-effectiveness plane" illustrated below is a useful way of comparing the project with other investment options, including when only one alternative (typically do nothing/minimum) is evaluated in the Bank's appraisal.

When this approach is applied to a comparison of an investment with the next best alternative (e.g. do minimum) the four-quadrant depiction, shown in

Figure 9.1, illustrates that:

- The project is better (more "cost-effective") if it offers higher benefits at lower costs than the alternative (south-east quadrant of the plane);
- The project is worse (less "cost-effective") if it delivers fewer benefits at higher costs that the alternative (north-west quadrant of the plane);
- Where the project is more costly but offers greater benefits (north-east quadrant) or is less costly but offers fewer benefits (south-west quadrant), incremental cost-effectiveness is unclear and the appraisal conclusion depends on the magnitude of the incremental cost-benefits.

Figure 9.1:
Cost-Effectiveness Plane (four quadrant depiction)

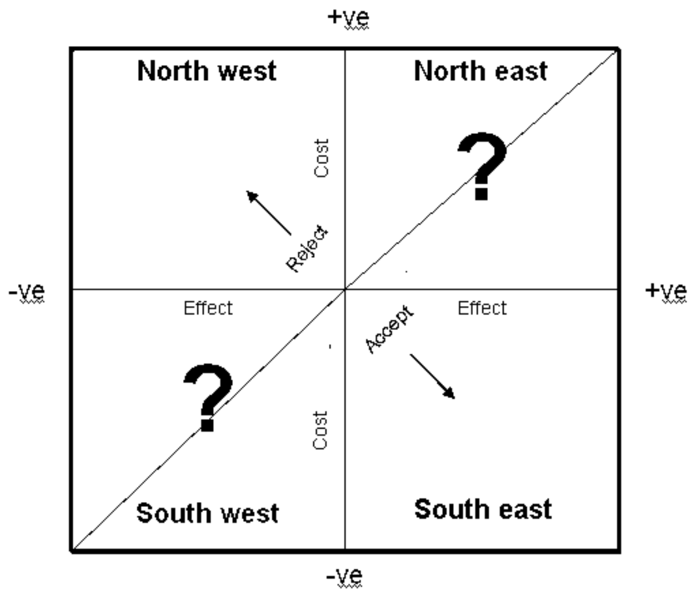


Table 9.1 below summarises the outcome of an illustrative investment appraisal involving three options, a minimum option and two major investment options. The more beneficial options are also the more costly, with Option 1 generating the lowest benefits (total weighed scores) for the lowest costs (NPC) and Option 3 the greatest benefits for the highest costs – such that Option 2 is in the north-east quadrant of the cost-effectiveness plane when compared to Option 1, and Option 3 is also in the north-east quadrant when compared to Option 2.

Table 9.1:
Illustrative incremental cost-benefit comparison of options

	Option 1	Option 2	Option 3
Costs (EUR m) & benefits:			
Initial investment costs	47.6	206.8	210.7
Life-cycle investment costs*	13.2	34.1	38.4
Annual operational cost	43.9	44.3	44.2
Net Present Cost (3.5% discount rate** , 30 years)	**752**	**1 050**	**1 069**
Cost preference rank	1	2	3
Total Weighted Score	**380**	**710**	**800**
Benefits preference rank	3	2	1
NPC/benefit point (EUR m)	1.98	1.47	1.34
Rank	3	2	1
Incremental CB comparison:			
Cost differences:			
NPC option 1	+752		
NPC option 1 vs. 2, EUR m		+298	
NPC option 2 vs. 3, EUR m			+19
Benefits differences:			
TWS option 1	+380		
TWS option 1 vs. 2		+330	
TWS option 2 vs. 3			+90
NPC/TWS differences:			
Option 1	1.98		
Option 1 vs. 2		0.90	
Option 2 vs. 3			0.21
Rank	3	2	1

* The investment costs incurred throughout the life of the Project (excludes annual maintenance)
** Non-convergence region

When compared to the minimum option (the "best" cost scenario), the NPC of Option 2 is EUR298 million higher and generates 330 more benefit points than Option 1. This balance represents an incremental "cost-benefit" ratio of 0.90, with each additional EUR1 million NPC spent generating 1.1 times as many additional benefits compared to Option 1. Likewise, when Options 2 and 3 are compared, the additional NPC is EUR19 million for 90 additional benefit points, representing a "cost-benefit" ratio of 0.21, with each additional EUR1 million NPC generating 4.7 times as many additional benefits. Overall therefore, and assuming Option 1 is a real option and options are mutually exclusive, Option 2 is more "cost-beneficial" than Option 1 and Option 3 more "cost-beneficial" than Option 2.

9.4 Other MCA considerations

9.4.1 Mutual independence and double-counting

An underlying principle of MCA is that preferences associated with the options are independent from one criterion to another, such that a score can be assigned to one criterion without knowing how the option scores on other criteria. If this proves not to be the case, there are a few ways this can be addressed, such as:

- By combining into one criterion the two non-mutually independent criteria;
- Establishing a minimum requirement for each non-independent criterion and rejecting options that do not satisfy it because their poor performance on one criterion cannot be compensated for by better performance on another;[40]
- More advanced models might be needed if simpler approaches fail to ensure that the independence of criteria scores is ensured.

As in CBA and other appraisal approaches, double-counting should be avoided, otherwise the appraisal will give undue importance (weight) to the elements that are double-counted when calculating the final outcome of the benefits assessment and reaching an appraisal opinion.

[40] This threshold usually ensures preference independence (i.e. independence of scores). All options need to meet the minimum performance, so that the preference on any one criterion is unaffected by those on others.

Care is needed to avoid double-counting by including duplicate factors in both cost and in benefit assessments, and/or by reflecting them in more than one of the benefit criteria. Critical review, checking and rechecking for consistency, mutual dependency, redundancy, etc. of criteria is important throughout the MCA exercise.

9.4.2 Timing of benefits

Major infrastructure investment projects have implications for many years, generating benefits over the total operating period of the project. On the cost side of an appraisal, discounting is used to reflect social time preference expressed in a single indicator of monetary value. In the absence of such approaches when assessing non-monetary benefits, MCA alternatives include, for example:

- Where the completion date is an important consideration (i.e. the point at which project benefits will start to be generated), it can be modelled by a separate criterion within the MCA technique;
- By incorporating time in the definition of other criteria so that temporary impacts are distinguished from permanent or longer–term impact, usually by being explicit about the time horizon over which benefits will be generated;
- Using some other principle for giving less (or more) importance to long-term implications.

Whichever approach is used, it is important that appraisers ensure all assessments of criteria and options are made on a common basis. Hence, if some impacts are immediate or one-off and others are longer term, and/or occurring in variable time patterns, these differences should be recognised explicitly in the scores awarded to option criteria during the appraisal.

9.4.3 Superior/inferior or dominant/dominated options

It is possible that one or more of the investment options examined through MCA might be superior (or inferior) to the other options, as demonstrated by the attribution of highest (or lowest) scores for every benefit criterion and hence for total weighted scores. For example, a new build facility might perform better on every criterion when compared to a “do nothing/minimum” counterfactual (better access/location, better service effectiveness, more flexible, the most modern accommodation, greater acceptability to end users, etc.). If options benefits were the decision-criterion, a clearly superior investment would not need to be appraised further but could be selected as the preferred way forward and, likewise, a clearly inferior option removed from the exercise (unless it has a role as a baseline comparator).

However, even if an investment alternative is shown to be superior in terms of the benefits delivered, as demonstrated through MCA,[41] total project costs must also be factored into the appraisal opinion. The project may deliver the largest benefits, but it is also likely to be a costly – perhaps the most costly alternative. Hence, a conclusion of dominance (or dominated) should not be made until the MCA results and costs have been brought together, as outlined above.

[41] Typically (hopefully) the Project that is submitted to the Bank for funding support.

Appendix 1: Checklist for consecutive stages of MCA

Step 1 – Decision Context

Summary actions/decisions:
• Evaluate the decision context – the nature of the decision required and the resources available to address the decision.
Outputs:
• An appropriate approach to MCA within the decision context; • An agreed process for undertaking appraisal judgments/decisions.

Step 2 – Option Identification

Summary actions/decisions:
• Develop an understanding and describe the realistic implications of not implementing the project (do nothing, do minimum); • Consider and explore the range of possible options capable of delivering the investment objectives (albeit to differing degrees); • Develop an understanding of the project and any other investment options in sufficient detail to undertake the MCA.
Outputs:
• Description of the options to be subjected to MCA (including a baseline, such as do nothing/do minimum)

Step 3 – Identify Objectives and Constraints

Summary actions/decisions:
• Identify the high-level policy aims for the sector and the promoter; • Identify and review the organisation's business aims and objectives; • Identify the objectives for the investment strategy that are SMART (specific, measurable, achievable, relevant and time-linked); • Check that the chosen objectives concentrate on results rather than the means of achieving them; • If possible, rank objectives from highest to lowest in order of priority; • Constraints.
Outputs:
• Statement of ranked/prioritised objectives for the investment; • Statement of constraints facing the investment.

Step 4 – Identify Benefit Criteria

Summary actions/decisions:
• Identify the benefits that will be realised by meeting the objectives set for capital investment; • Classify the benefits into groups of benefit criteria.
Outputs:
• List of benefits that the investment seeks to deliver; • Identification and definition of benefit criteria for the evaluation (comparison of alternatives).

Step 5 – Assess Benefits

Summary actions/decisions:
• Give a weight (0 to 100) to each benefit criterion; • Give a score (1 to10) to each option on each of the benefit criteria; • Multiply weights and scores to provide a total weighted score for each option; • Rank options in terms of the acceptability of the cost of incremental benefits.
Outputs:
• Weights for benefit criteria; • Scores for each criterion for each alternative solution; • Total weighted scores for alternatives; • Incremental costs and benefits; • A preferred “benefits” option.

Step 6 – Undertake Sensitivity Analysis

Summary actions/decisions:
• Conduct sensitivity tests on the weighted benefit scores of each option; • Identify critical factors that affect the ranking/preference of options on “benefits” grounds.
Outputs:
• Sensitivity analysis on benefit criteria weights and options scores; • Switching values/crossover points that alter the preferred option; • Conclusions on the robustness of the benefits assessments.

Appendix 2: Illustrative outputs of MCA assessments

Table 9.2:
Calculation of weighted benefit scores

Benefit Criterion	Weight	Option 1		Option 2		Option 3	
		Score	Total Weighted Score	Score	Total Weighted Score	Score	Total Weighted Score
Strategic fit	25	4	100	8	200	9	225
Quality	25	4	100	8	200	10	250
Equity	20	2	40	7	140	7	140
Environment	15	5	75	7	105	8	120
Flexibility	10	2	20	4	40	5	50
Implementation	5	9	45	5	25	3	15
Total	**100**		**380**		**710**		**800**
Preference rank			3		2		1

Table 9.3:
Example sensitivity tests – Changes to option scores

	Weight	Option 1		Option 2		Option 3	
		Score	Total Weighted Score	Score	Total Weighted Score	Score	Total Weighted Score
			Reduced score for equity:				
Strategic fit	25	4	100	8	200	9	225
Quality	25	4	100	8	200	10	250
Equity	20	2	40	7	140	*2*	*40*
Environment	15	5	75	7	105	8	120
Flexibility	10	2	20	4	40	5	50
Implementation	5	9	45	5	25	3	15
Total	**100**		**380**		**710**		***700***
Preference rank			**3**		***1***		***2***
			Reduced score for quality:				
Strategic fit	25	4	100	8	200	9	225
Quality	25	***8***	***200***	8	200	10	250
Equity	20	2	40	7	140	7	140
Environment	15	5	75	7	105	8	120
Flexibility	10	2	20	4	40	5	50
Implementation	5	9	45	5	25	3	15
Total	**100**		***480***		**710**		**800**
Preference rank			**3**		**2**		**1**

Table 9.4: Example sensitivity tests – Changes to criteria weights

Benefit Criterion	Weight	Option 1		Option 2		Option 3	
		Score	Total Weighted Score	Score	Total Weighted Score	Score	Total Weighted Score
Increased weight attributed to implementation:							
Strategic fit	*18*	4	*72*	8	*144*	9	*162*
Quality	*18*	4	*72*	8	*144*	10	*180*
Equity	*15*	2	*30*	7	*105*	7	*105*
Environment	*11*	5	*55*	7	*77*	8	*88*
Flexibility	*8*	2	*16*	4	*32*	5	*40*
Implementation	*30*	9	*270*	5	*150*	3	*90*
Total	**100**		***515***		***652***		***665***
Preference rank			**3**		**2**		**1**
No importance attributed to strategic fit:							
Strategic fit	*0*	4	*0*	8	*0*	9	0
Quality	*33*	4	*132*	8	*264*	10	330
Equity	*27*	2	*54*	7	*189*	7	189
Environment	*20*	5	*100*	7	*140*	8	160
Flexibility	*13*	2	*26*	4	*52*	5	65
Implementation	*7*	9	*63*	5	*35*	3	21
Total	**100**		**375**		***680***		**765**
Preference rank			**3**		**2**		**1**

Increased weight reassigned to implementation (+25%) is added to other criteria ("rounded") as follows:

Strategic fit	=> 25 x 25/95 = 7 (from 25% to 18%)
Quality	=> 25 x 25/95 = 7 (from 25% to 18%)
Equity	=> 25 x 20/95 = 5 (from 20% to 15%)
Environment	=> 25 x 15/95 = 4 (from 15% to 11%)
Flexibility	=> 25 x 10/95 = 2 (from 10% to 8%)

No importance assigned to strategic fit (2515%), reassigned to other criteria ("rounded") as follows:

Quality	=> 25 x 25/75 = 8 (from 25% to 33%)
Equity	=> 25 x 20/75 = 7 (from 20% to 27%)
Environment	=> 25 x 15/75 = 5 (from 15% to 20%)
Flexibility	=> 25 x 10/75 = 3 (from 10% to 13%)
Implementation	=> 25 x 5/75 = 2 (from 5% to 7%)

Appendix 3: Cost-benefit comparison

Comparison of Options 1 and 2:

- Option 1 has lower costs (+ve) but also offers lower benefits (-ve) than Option 2 – i.e. south-west quadrant of cost-effectiveness plane, where cost-effectiveness is questionable
- Are the additional benefits worth the additional costs?
- A lower NPC of EUR108 million for a higher TWS of 330 benefit points equates to a cost/benefit ratio of 0.90 (each additional EUR1 million NPC generates 1.1 additional benefit points).

Comparison of Options 2 and 3:

- Option 2 has lower costs (+ve) but also offers lower benefits (-ve) than Option 3 – i.e. south-west quadrant of cost-effectiveness plane, where cost-effectiveness is questionable
- Are the additional benefits worth the additional costs?
- A lower NPC of EUR19 million for a higher TWS of 90 benefit points equates to a cost/benefit ratio of 0.21 (each additional EUR1 million NPC generates 4.7 additional benefit points).

Where no intermediate option between “minimum” and “new build”, **(incremental) comparison of Options 1 and 3**:

- Option 1 has lower costs (+ve) but also offers lower benefits (-ve) than Option 3 – i.e. south-west quadrant of cost-effectiveness plane, where cost-effectiveness is questionable.
- Are the additional benefits worth the additional costs?
- A lower NPC of EUR317 million for a higher TWS of 420 benefit points equates to a cost/benefit ratio of 0.75 (each additional EUR1 million NPC generates 1.3 additional benefit points).

10 Risk Analysis and Uncertainty

J. Doramas Jorge-Calderón

10.1 Risk and economic returns

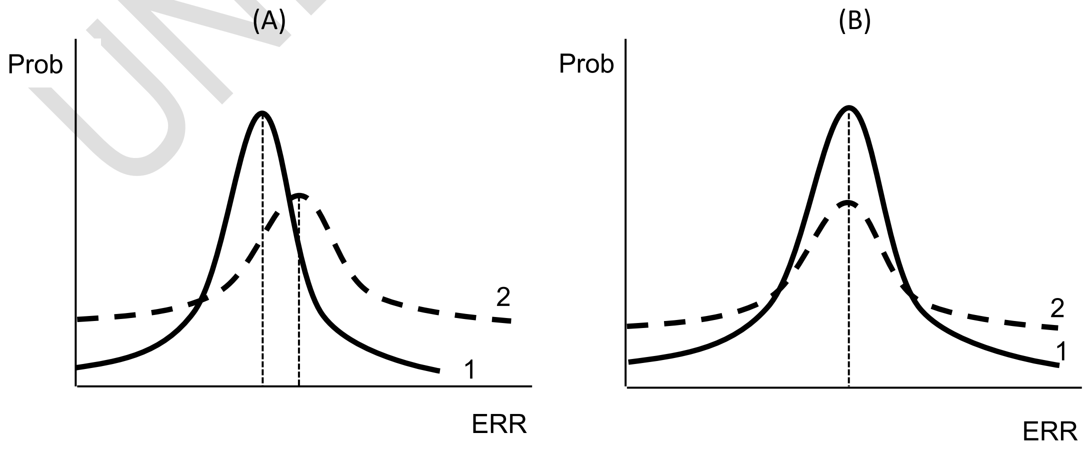
The most generally accepted means by which risk is incorporated into investment appraisal is through the capital-asset pricing model (CAPM), whereby the discount rate applied to the stream of future benefits and costs is adjusted by the risk premium corresponding to the expected volatility of such streams, volatility being taken as a measure of risk. For any level of volatility, the risk premium applied is also affected by factors such as the degree of risk aversion of market participants and the general degree of uncertainty in the economy at large.

Following the CAPM, the resulting net present value (NPV) of the investment then represents the value of the project including the effect of risk on such value. When the appraisal is based on the IRR method instead of NPV, the same risk premium can be incorporated into the threshold rate of return used to judge a project acceptable or otherwise.

As seen in chapter 8, however, to the extent that the non-diversifiable risk faced by society from the project is small, the social discount rate used in economic appraisal should not incorporate a risk premium. Non-diversifiable risk tends to be small to society when the size of the project is small relative to the size of the economy, which is normally the case for projects financed by the EIB. However, this conclusion does not imply that a risk analysis becomes irrelevant in the economic appraisal. The relevance of risk analysis to economic appraisal lies both in gauging the likelihood that the project will divert from the expected rate of return and in informing about possible mitigating conditions that could be applied to the financing.

This is illustrated in Figure 10.1, showing probability distributions of project ERR outcomes for two scenarios (A and B) involving two projects (1 and 2) each. Under scenario (A), project 1 has a narrower distribution of possible outcomes than project 2, meaning that project 2 is riskier than project 1. Following the CAPM, the private sector would carry out the riskier project only if the expected rate of return (assume in this case that ERR=FRR) is sufficiently above the return of the less risky project, in line with the situation in Scenario (A).

Figure 10.1:
Probability distributions of project outcomes



Scenario (B) shows a situation where projects 1 and 2 both have the same expected ERR but have different risk profiles. Despite the different risk profiles, both projects are equally attractive as far as society is concerned. The economic appraisal in effect assumes risk-neutrality. Risk analysis may appear unnecessary as far as determining the viability of the project is concerned. Still, information about the riskiness of the project is relevant to both the project analyst and decision-maker. As mentioned above, a risk analysis can help identify areas of particular vulnerability of the project and hence help in formulating mitigating conditions. In addition, there may be cases where the decision-maker may want to divert from risk-neutrality, such as when the risks concern irreversible damage – a condition often associated with climate change, for instance – or where the long-term potential benefits are hard to quantify, as tends to be the case in highly innovative projects.

10.2 Risk analysis in economic appraisal at the EIB

The type of risk analysis that can be applied to a given project depends on the data available to the analyst. The quality and availability of data varies widely among the promoters financed by the Bank. Under ideal circumstances, the analyst would have sufficient data to estimate the probability distribution of the key variables determining project performance. In such cases the analyst can conduct a fuller risk analysis, including the following steps:

1. Identifying the probability distribution of the main variables that may affect project return. This would determine both the most likely range of possible outcomes for each variable and the maximum ranges that can be reasonably assumed to occur.
2. Estimating the risk-weighted expected rate of return. The resulting figure constitutes the central case, or base estimate of project returns.
3. Estimating the probability that the rate of return of the project would perform above the threshold rate of return determining project acceptability.
4. Estimating the "switching value" – the value that a variable must assume to bring the project to the threshold of acceptability – for the main variables affecting profitability. This should inform the case for the desirability of any possible project conditions addressed at specific project elements.

This procedure involves performing a Monte Carlo simulation. The desirability of performing such a technique would depend on whether the data available enables a reliable estimation of the probability distributions for each of the main variables. There is little point in performing Monte Carlo simulations with probability distributions that are simply assumed, as this would involve a new layer of analysis that necessitates additional assumptions, without reducing the uncertainty surrounding the estimate of project returns.

Where insufficiently sound data exists to construct probability distributions, the assessment of the range and likelihood of possible values for each variable would rest on analyst judgement. In this regard, it may be more transparent to base the assessment on scenario building, where the assumptions used become more immediately apparent and visible, than running Monte Carlo simulations with assumed probability distributions, where the assumptions underpinning the distributions are less easily gauged.

In addition to a "base case" scenario, constituting the base ERR reported for the project, the scenario-based risk analysis can be based on two scenarios, as follows:

- A "pessimistic scenario," including a set of values for the main input variables depicting a probable, bad outcome. This would not consist of the worst possible or catastrophic scenario, but a set of variable values that is commensurate with past experience in the sector.
- A "switching scenario" where the analyst devises a scenario that would cause the project to miss the acceptable return threshold.

The analyst would then issue an opinion on the riskiness of the project on the basis of the three scenarios. Inevitably, the scenario-based analysis is more judgemental than a Monte Carlo simulation, the latter being based on empirical evidence about possible outcomes.

Nonetheless, it should be highlighted that past performance is no sure indication about future performance. If the analyst has reasons to expect that different conditions will prevail in the future from those observed in the past, scenario-based analysis may complement or substitute for Monte Carlo analysis.

An example of the results of risk analysis using Monte Carlo simulation is included in chapter 30 involving the roads sector.

10.3 Uncertainty and real options

When uncertainty is particularly high and investments are irreversible, having flexibility to adapt in the future becomes valuable. If in addition project components can be delayed, and waiting would clear uncertainty, then the promoter may design and phase the project in ways that leave options open regarding future lines of action. In such cases, measuring the full economic value generated by a project would require conducting a valuation of such options, involving real option analysis (ROA). In finance, an option is the right, but not the obligation, to follow a line of action, most commonly involving buying or selling a security. Instead, real options involve real assets, rather than financial securities, and whereas they can take the form of a legal right without an obligation – like financial options – they more generally involve gaining the possibility, but not the commitment, to follow a course of action.

Real options can consist, for example, of expanding or contracting capacity, deferring or abandoning an investment, or choosing among alternative technologies in the future, among others. Project promoters may use ROA in their decision-making process, helping with the definition of project components and their timing and phasing. However, generally, by the time a project is presented to the EIB for financing, it is already defined, and indeed it must be so before financing can be agreed. The value of real option analysis therefore lies less in assisting during project conception and more in attaching a value to any options embedded in the project. Since options generally come at the cost of additional capital investment, failing to attach a value to such options would penalise the estimated economic returns of the project. ROA becomes increasingly relevant in a context of climate change, where infrastructure operators and other promoters are increasingly conceiving their projects with sometimes costly preventive measures that grant them flexibility to adapt to future uncertain climatic conditions.[42] The same relevance applies to financing of innovative technologies, particularly under increased competitive markets.

ROA becomes relevant also to appraise the effects of new technologies on more traditional projects.

If the real option value of such preparatory investments was ignored, the project may appear oversized, and would see its ERR negatively affected. Instead, if it is recognised that the initial investment in “oversizing” the structures would create the option to expand and switch to an alternative (aircraft) technology, then such apparent oversizing would instead become a value-creating opportunity. Investing in that real option will be worthwhile so long as the option is worth more than the required investment to keep it alive. The question then is what value is attached to such apparent oversizing.

The estimation procedure of the value of a real option must be made specific to the nature of the option at hand, and can easily become complex. For some projects, calculating the real option value may be deemed too complex and require specialist advice. For others the investment in the option may be deemed so small relative to the size of the project as to not merit an additional estimation effort: the project may be economically justified even without accounting for the value of the option. However, for projects where the investment in the option is significant and the option may not be complex, a simple calculation may be sufficient.

[42] The usefulness of ROA for climate-change adaptation investment is illustrated in the Annex of Chapter 3 of Kolev *et al.* (2012).

10.4 Calculating the real option value

There are a number of methods to calculate the value of a real option.[43] For options that are not complex in nature, the most straightforward procedure is the Black-Scholes formula.[44] The analyst should judge whether the characteristics of the option are such that the method is valid or sufficiently close, or whether it merits the use of alternative methods. The Black-Scholes method is illustrated here, since it is the simplest to apply. For some projects it may be sufficient, and for others it may be useful as a first approximation to more complex real options. The formula is as follows:

$$C = N(d_1)S - N(d_2)Ke^{-rT}$$

Where C is the option value, S is the value of the underlying asset, or the present value of the free cash flow generated by the project, K is the strike price, or the eventual investment involved in exercising the option, r is the risk-free rate of return, T is the time to maturity of the option, N is the standard normal distribution, and d_1 and d_2 are option parameters, as follows:

$$d_1 = \frac{\ln\left(\frac{S}{K}\right) + \left(r + \frac{\sigma^2}{2}\right)T}{\sigma\sqrt{T}}$$

$$d_2 = d_1 - \sigma\sqrt{T}$$

where σ is the volatility of the cash flows of the underlying asset, (e.g. operating the aircraft in the example mentioned in the preceding section), which can be estimated as follows:

$$\sigma = \frac{\ln\left(\frac{S_{opt}}{S_{pes}}\right)}{4\sqrt{t}}$$

where S_{opt} is the underlying asset value under the optimistic scenario, S_{pes} is the underlying asset value under the pessimistic scenario, and t is the project lifetime.

10.5 Worked example of real option value

Assume that the Bank is considering to finance a manufacturing promoter which is building a new plant to produce product X. The plant is some EUR40m more expensive than normal (excluding any taxes, to reflect economic costs), as the promoter has readied the plant to make it expandable to include manufacturing capacity for a new product Y. The prospects for product Y critically depend on future regulatory developments, which are highly uncertain, but which are expected to be resolved in four years.

If the regulatory developments are favourable, product Y could generate a cash flow stream over the next 15 years with a present value of EUR400m which, after adding back taxes, would imply an economic present value of EUR500 million. If the developments are unfavourable the project would generate cash flows of EUR75 million, with an economic value of EUR100 million. Assuming that favourable and unfavourable regulatory developments are equally likely, the

[43] For a formal explanation of real option analysis see Dixit and Pyndick (1994) or Trigeorgis (1996). For more accessible applications see Kodukula and Papudesu (2006) or Koller *et al* (2010).

[44] The Black-Scholes method is applied to European options, options that can be exercised at a pre-specified date. Alternatively, American options can be exercised at any time before the expiry date, and require other methods. Whereas real options tend to be European in nature, institutional constraints often place limits on when they can be exercised. The analyst should judge whether assuming an American option is a close enough approximation, and apply other methods if not.

expected value of the economic benefits is therefore EUR300 million (=(0.5xEUR500m)+(0.5xEUR100m)). Developing the plant ready for producing product Y would have an economic cost of EUR250m. If the regulatory developments are favourable, the project would have an economic value of EUR250m (=EUR500m-EUR250m). If, instead, they are unfavourable, the project would have a value of -EUR150m (=EUR100m-EUR250m). The expected net present value of the project would therefore be EUR50m (=EUR300m-EUR250m, or =(0.5xEUR250m)+(0.5x(-EUR150m))), which may be deemed too small a return for the risk associated with the investment. If it is possible to delay the decision to invest in capacity for product Y until the regulatory uncertainty is resolved, then the negative payoff would be eliminated, and the investment would only be made if the regulatory development is favourable. It may be worthwhile to prepare the plant for product X to make it expandable to enable it to eventually produce product Y. The promoter has decided to spend EUR40m in granting itself such an option. The question is then how much the option is worth.

The first step would consist of calculating the volatility implied by the return estimates, as follows:

$$\sigma = \frac{\ln\left(\frac{500}{100}\right)}{4\sqrt{15}} = 10.39\%$$

With this estimate of volatility, and assuming a risk-free discount rate of 5%, the option parameter d_1 can be estimated as follows:

$$d_1 = \frac{\ln\left(\frac{300}{250}\right) + \left(0.05 + \frac{0.1039^2}{2}\right)4}{0.1039\sqrt{4}} = 1.2220$$

And with the value of d_1 the parameter d_2 is calculated as follows:

$$d_2 = 1.2220 - 0.1039\sqrt{4} = 1.0142$$

The formula of the value of the option would then be:

$$C = N(1.2220)300 - N(1.0142)250e^{-0.05x4}$$

The $N(d_1)$ and $N(d_2)$ functions are standard normal distributions, which come as default functions in standard spreadsheets. The resulting figures are:

$$N(1.2220) = 0.8891$$
$$N(1.0142) = 0.8448$$

The resulting value of the options is therefore:

$$C = (0.8891\,x\,300) - (0.8448\,x\,250)e^{-0.05x4} = 93.8359$$

The value of the option would therefore be EUR93.8m, which, since the value is higher than the EUR40m cost of the option, makes it worth investing in. The economic appraisal, incorporating the apparent "over-investment" of EUR40m, should now also include the EUR93.8m value of the option as a project benefit.

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PART 2:

METHODOLOGY TOPICS: SECTOR-SPECIFIC

11 Security of Energy Supply

Nicola Pochettino[45]

11.1 Objective

This chapter presents the methodology used for evaluating security of energy supply externalities as part of the economic analysis of energy projects. Such analysis involves the appraisal of the project's contribution to the economic welfare of a region or country, assessing whether the project improves, worsens, or does not affect the initial level of security of supply. For energy project appraisals, the systematic integration of such externalities in cost-benefit analysis is expected to support a more comprehensive and accurate ranking of projects and project alternatives.

11.2 Definition of security of energy supply

From an economic standpoint the concept of energy security encompasses a **physical dimension**, i.e. the availability, reliability and adequacy of energy supply and the related infrastructure, and a **pricing dimension**, i.e. the affordability and reasonableness of market-determined prices. The two dimensions of the problem are inextricably linked and only partially distinguishable. The physical disruption of supply can result in a sudden spike in price. A price shock can be seen as the equivalent of a supply disruption even when is caused by a demand increase that cannot be satisfied at the previous price. To assume that the market is always able to bring supply and demand in balance through price signals is to ignore the timing of the adjustment or the fact that the adjustment may occur at an unacceptable level. Our assumption is that the two dimensions can be treated separately, i.e. that we can prevent lack of supply at a given price and price increases above a certain level at a given demand.

11.3 Methodology to quantify the security of energy supply externalities

In line with the definition of energy security, we employ a methodology that evaluates the two constituent components of the issue – the physical component and the price component – separately, thus:

External cost = Physical availability component + Price increase component

In the analysis, the focus is on the supply of natural gas as a representative case, as gas imports through pipelines present the most critical case of import dependence compared to other fossil fuels; moreover, we assume that the corresponding externalities are not fully internalised. The basic idea of the methodology for assessing the costs of security of supply is to quantify the costs of any initiative that can counteract the damage to the welfare of society caused by a lack of security of supply.

11.4 Physical availability component

The European infrastructure standard stipulates that: "In the event of a disruption of the single largest gas infrastructure, the capacity of the remaining infrastructure determined according to the N-1 formula […] is able to satisfy total gas demand in the calculated area during a day of exceptionally high gas demand occurring with a statistical probability of once in 20 years" (art.6, par. 1 of Regulation (EU) 994/2010). The general formula of the standard to be used, taking into consideration also the possibility of demand-side measures (art. 6, par. 2), is the following:

[45] This chapter is a synthesis of De Paoli, Sacco and Pochettino (2011) "Evaluating Security of Energy Supply in the EU: Implications for Project Appraisal," EIB working paper.

$$\alpha(N-1) = \frac{EP_m + P_m + S_m + LNG_m - I_m}{D_{max} - D_{eff}} \geq 1 \qquad (1)$$

where:

$\alpha(N)$ is the share of a country's supplied energy (with respect to demand) through N infrastructures;
EP_m is the total daily capacity to deliver imported gas at the border entry points;
P_m is the total daily production capability that can be delivered at the internal entry points;
S_m is the total daily withdrawal capacity from internal gas storage;
LNG_m is the total LNG daily capacity to send-out gas at the internal entry points;
I_m is the daily capacity to supply gas from the single largest gas infrastructure. When several gas infrastructures are connected to a common upstream or downstream gas infrastructure and cannot be separately operated, they shall be considered as one single gas infrastructure;
D_{max} is the daily maximum demand occurring during a day of exceptionally high gas demand, occurring with a statistical probability of once in 20 years;
D_{eff} is the daily demand that can be covered with market-based demand-side measures.

The willingness to pay to avoid gas supply disruption can be calculated from the costs of meeting this standard.[46]. The implicit assumption is that society pursues security of supply until it is economically viable. In other words, we assume that use of control costs to value externalities implies that legislators are able to make optimal decisions when imposing policy instruments to achieve such outcome.

In summary, indications about the value that society gives to energy supply disruptions can be computed by assessing what it costs society to guarantee that the N-1 principle is always complied with. This reasoning can be applied in the appraisal of projects too. When a new project (especially the import of gas) is proposed, we must firstly investigate its impact on the compliance with the N-1standard. Three cases may be contemplated:

- If the standard is satisfied and remains so even with the new project, then the project does not engender either costs or benefits in terms of security of supply; therefore we can conclude that this cost has already been internalised.
- If the standard is met without implementing the new project, but not with its implementation, then the project has a cost in terms of security of supply. The least cost solution must be identified and that cost of meeting the N-1 standard should be added to the project under appraisal;
- If the rule is satisfied only when a new project is implemented, then the project involves a benefit in terms of security of supply, indicating positive externalities

In order to assess the cost (or benefit) of a project from the security point of view, it is possible to resort to the levelised cost (LC) approach to calculate the value to be added to (subtracted from) the price of gas. More specifically, the LC can be obtained by dividing the present value of the total cost (or the avoided cost, in case of benefits) of building and operating the least cost backup solution to meet the N-1 rule over its economic life by the present value of total energy supplied by the project under examination:

$$\text{LC} = \frac{\sum_{t=1}^{n} C_t \cdot (1+r)^{-t}}{\sum_{t=1}^{n} E_t \cdot (1+r)^{-t}} = \frac{total\ discounted\ costs\ to\ comply\ with\ the\ standard}{total\ discounted\ energy\ supplied\ by\ the\ project} \qquad (2)$$

where:

Ct = cost of the backup solution in the year t;

[46] The costs to meet the standard are not an externality as long as the industry invests according to the criterion. In many countries, however, the industry has not been investing according to this criterion; moreover, markets do not always provide sufficient incentives for the investments needed.

Et = supplied energy in the year t;
r = discount rate;
n = life of the system.

11.5 Price component

Addressing the "price risk" requires three different conceptual steps: firstly, assessing the loss incurred by society because of an energy price shock; secondly, evaluating the willingness to pay of a risk-averse society in order to limit the potential damage and lastly, identifying the least-cost tool to restrict the losses and assessing its costs.

11.5.1 Welfare loss

We define the economic losses experienced by society, as a result of energy price increase, in terms of society's loss of well-being. More specifically, we consider changes in GDP as an approximation of changes in the social welfare in net import countries.

In order to estimate the direct negative effect resulting from energy price shocks, we use the "simple net import model" developed by the World Bank. The basic idea is that rising energy prices imply an additional wealth transfer from importing countries to exporting countries, resulting in a reduction in GDP. We can estimate the direct impact of import energy price increase on GDP using the following formula:

$$\% \frac{\Delta \mathrm{GDP}}{GDP} = \% \frac{\Delta \mathrm{P}}{P} \times (1-\varepsilon) \times \left(\frac{NI}{GDP} \right) \qquad (3)$$

where:

- $\% \frac{\Delta \mathrm{GDP}}{GDP}$ is the percentage change in GDP;
- $\% \frac{\Delta \mathrm{P}}{P} = \frac{P_{t+1}-P_t}{P_t}$ is the percentage change in price of imported energy;
- ε is the price elasticity of demand (in absolute value);
- NI is the net import of energy (in monetary terms).

According to the model, the magnitude of the direct effect of a given energy price increase on GDP may vary, depending both on the extent of the price change (i.e. the level and the duration of the price increase) and the characteristics of the economy: the loss caused by energy price increases is a function of the weight of imported energy costs in the national income, the degree of dependence on imported energy, the energy intensity of the economy and the flexibility of the energy sector, i.e. the ability to reduce consumption and to switch from one source to another.

Expressing the welfare loss, in terms of impact on GDP, as a function of the price change, the formula enables the association of any price increase with a certain loss of well-being. Although energy demand appears more sensitive to further increases in price – i.e. the greater the increase in price the higher the energy price elasticity – we assume that price elasticity of demand remains constant with increasing price. This allows us to plot a growing line of welfare losses as function of energy price ratio: as the energy price goes up with respect to the actual price, the negative impact on GDP increases proportionally.

The external cost associated with energy price increases depends on its expected value. This value is obtained by multiplying the monetary consequences of the accident by the probability of occurrence of the accident. Knowing that price returns are normally distributed and that, in the case of natural gas, the mean is set equal to zero and the standard deviation is set based on the historical volatility, it is possible to weight any price rise, and consequently any welfare loss, with the corresponding probability. The result is the evaluation of the expected welfare loss that is the weighted average of all possible welfare losses. In quantitative terms, we have:

$$\textit{Expected Loss} = \int_0^{\infty}[Loss\left(\frac{\Delta P}{P}\right) \cdot Probability\ \left(\frac{\Delta P}{P}\right)]d\,\frac{\Delta P}{P} \qquad (4)$$

Therefore, the expected welfare loss is the average loss that an individual exposed to the price risk expects to bear.

11.5.2 Willingness to pay (of risk-averse individuals)

As consumers are risk-averse and typically take a more cautious approach than in the hypothetical case of a risk-neutral population, there is a need to integrate risk aversion within the assessment of the external costs: the expected damage, first calculated assuming risk-neutrality, must take individual-risk perception into account. According to our assumptions, the attitude towards risk basically depends on the country's import dependence: the higher the energy dependence, the greater the country's vulnerability to energy price shocks and, therefore, the higher the perceived price increase risk. As a result, it is possible to modify the formula of social welfare loss in order to include risk aversion, introducing a second order component so that the perceived social welfare losses rise as net import increases:

$$\%\ \frac{\Delta \mathrm{GDP}}{GDP} = \%\ \frac{\Delta \mathrm{P}}{P}\ \mathrm{x}\ (1\text{-}\varepsilon)\ \mathrm{x}\ (\frac{NI}{GDP} + \alpha\left(\frac{NI}{GDP}\right)^2) \qquad (5)$$

where α is the risk aversion coefficient: the higher α the higher economic losses.

This new formula shows that risk-averse individuals assign greater value to the potential welfare losses compared to the risk-neutral individuals. As a result, when we take into account the individual risk perception, the curve of welfare losses, as function of energy price, is shifted upwards compared to the initial one.

Also in this case, we compute the expected welfare loss perceived by risk-averse individuals, which will be higher than that for risk-neutral individuals:

$$\textit{Expected Loss with risk aversion} = \int_0^{\infty}[Perceived\ Loss\left(\frac{\Delta P}{P}\right) \cdot Probability\ \left(\frac{\Delta P}{P}\right)]d\,\frac{\Delta P}{P} \qquad (6)$$

Risk-averse individuals are willing to pay more to limit the potential damage incurred by society. The willingness to pay of risk-averse individuals for avoiding a risky situation can be computed by comparing what would be the welfare change of a risk-neutral individual with that of a risk-averse one. The difference between the two welfare changes represents the risk premium:

Risk premium = Expected welfare loss with risk aversion – Expected welfare loss without risk aversion (7)

11.5.3 A tool to improve security of energy supply

The third step requires the assessment of the costs of any action that can counteract the damage to the welfare of society caused by a lack of security of supply. As previously discussed, different tools are available to prevent or mitigate the negative impacts of a sudden energy price rise. For a practical approach, we limit the analysis to hedge programmes designed to offer insurance-type coverage bought in the financial market, to provide protection against price spikes. In particular, we restrict the use of insurance tools to call options only.
For ease of calculation, we assume that the call options are European: by purchasing a call option we acquire the right to buy a given quantity of energy on a certain date (i.e. the maturity date) at a pre-determined price (i.e. the strike price), paying the so-called option premium. By guaranteeing that consumers will not pay more than the strike price, this hedge strategy can be described as "price cap" strategy, in which the strike price represents the maximum purchase price. Whether the call option is exercised or not depends on what the strike price is

with respect to the market price at the option's maturity date. If the strike price is lower than the market price, the call option is exercised – i.e. consumers can buy energy at the strike price avoiding the higher market price. As a consequence, the benefits of call options are measured by avoided loss of GDP, due to the price pegging, which appear only when the current energy price exceeds strike price. In this case the call option is said to be "in the money".

For a call option with strike price $\overline{P}_{t+1}$, we calculate the premium, C, using the Black-Scholes (1973) formula:

$$C = P_t N(d_1) - \overline{P}_{t+1}\ e^{-rT}\ N(d_2) \qquad (8)$$

where $d_1 = \dfrac{ln(P_t/\bar{P}_{t+1}) + (r+\sigma^2/2)T}{\sigma\sqrt{T}}$ and $d_2 = d_1 - \sigma\sqrt{T}$

The current spot market price is denoted by P_t, and the risk-free rate of interest by r; T is the date of expiration, σ^2 is the volatility of the spot market price and N(·) is the probability distribution function of a standard normal variable. According to the formula, choosing a strike price slightly above the initial spot market price allows us to limit changes in energy price to small increases implying a higher level of energy security at a cost; on the contrary, the higher the strike price, the lower the cost of coverage. These considerations enable us to plot a curve of the cost of insurance as a function of increasing energy strike prices ($\overline{P}_{t+1}$) with respect to the initial market price (P_t).

11.5.4 Acceptable level of security of supply, first method: Risk premium and willingness to pay of risk-averse individuals

We assess the level of the price risk people are willing to bear by calculating how much they are willing to pay to ensure it. Computing the difference between the total expected damage suffered by a risk-neutral individual and the total expected loss perceived by a risk-averse one it is possible to quantify how much money the latter is ready to pay to avoid the potential damage caused by a price shock (i.e. the Risk Premium). More precisely, we compute the premium per unit of imported energy that is the monetary surcharge that people are willing to pay on any GJ of imported gas to hedge against price increases, as:

$$\frac{RP}{NI(1-\varepsilon)} \qquad (9)$$

where:

- RP is the risk premium;
- NI is the gas net import (in GJ);
- ε is the gas demand elasticity to gas price (in absolute value).

Assuming that we rely only on call options as a hedge strategy, we can equalise the call option premium (C) – i.e. how much it costs society to restrict the extent of the price increase to an acceptable level – and the unitary risk premium – i.e. how much society is willing to pay to limit the price increase. This allows us to derive the maximum price increase that society is ready to accept, that is, the "optimal" strike price.

11.5.5 Acceptable level of security of supply, Second method: setting a cap on GDP loss

The basic idea of the second approach is that society is averse to the risk of suffering heavy losses and it is ready to pay in order to limit this potential damage. We suppose that countries may define, *ex ante*, the maximum annual loss of GDP they are willing to bear because of energy price shocks. Setting a cap on GDP losses allows us to calculate the maximum level of energy price increase consumers can accept and, consequently, how much they have to pay for eliminating further losses.

More precisely, once countries have to define a maximal threshold for the economic damage they are willing to accept ($\frac{\Delta \mathrm{GDP}^*}{\mathrm{GDP}}$), through equation (5) we can easily evaluate the level of price increase that restricts the extent of GDP decline to the desirable level (i.e. $\frac{\Delta P^*}{P}$):

$$\frac{\Delta P^*}{P} = \frac{\Delta \mathrm{GDP}^*}{\mathrm{GDP}} \times \left[(1-\varepsilon) \times \left(\frac{NI}{GDP} + \alpha \left(\frac{NI}{GDP}\right)^2 \right)\right]^{-1} \qquad (10)$$

The aim is to assess the cost to ensure that price does not exceed the tolerable level. In other words, we need to evaluate the cost of a call option characterised by a strike price ($\bar{P}_{t+1}$) such that:

$$\frac{\bar{P}_{t+1} - P_t}{P_t} = \frac{\Delta P^*}{P}$$

11.6 Conclusions

Our assessment leads us to two important conclusions. Firstly, security of supply is a specific rather than a general problem. Some EU Member States have already internalised the externalities,[47] to various degrees and at different costs, while others are not hedged against the possibility of a significant supply disruption or price spike. The cost for the full internalisation of the energy security externality depends to a great extent on a country's characteristics and may vary significantly between countries or projects.

Secondly, as regards fossil resources, we must differentiate those international energy markets where it is easy to change the origin or destination of trade of energy sources from those in which the link between supplier and buyer is more rigid. The coal market is the least developed in terms of international trade, and also raises less concern given the abundance of raw material and the limited role of states in the production and trade. As a result, the physical component of supply security can be considered negligible.

The oil market is a true interconnected international market, but raises concerns about the presence of political factors that may cause the disruption of non-negligible amounts of production in a short time. This explains why importing countries have established common policies to cope with supply disruptions for more than forty years. Looking at past experience (stocks have been used only three times and in no case was oil consumption rationed), it seems that the current stockholding policy has adequately internalised the risk of supply disruption.

Trade in gas is much more rigid (i.e. more contract-specific) when the exchanges are made through pipelines and the risk of disruption increases when there are transit countries. The fact that for gas the risk is contract-specific means that each project could increase or decrease the security of supply. The N-1 rule in this case has been introduced by the EU; in the evaluation of gas import projects we should take into account the costs associated with compliance with the N-1 rule. Our preliminary analysis shows that this cost may be quite high and in any case higher than in the case of coal and oil import. Therefore, among fossil resources, natural gas is the fuel that presents by far the highest costs of supply security.

[47] Either through government regulations or industry initiatives, or both.

12 The Value of Time in Transport

Diego Ferrer and Claus Eberhard

12.1 Introduction

The economic appraisal of transport projects is conducted through a cost-benefit analysis (CBA). One of the main benefits is often shorter travel times for goods and passengers. Travel time savings are measured in minutes or hours, which need to be monetised. In this context, the Value of Time (VOT) is a crucial CBA input parameter to derive the monetary expression of travel time savings.

Since the 90s, the Bank has launched several initiatives to define and update a set of guidelines to ensure a consistent approach to VOT. In 1996, the EIB chose a simplified methodology using average gross wages as the basis for calculating VOT.[48] In 2003, the Bank launched a second initiative based on GDP per capita and extending the analysis to more countries and transport modes.[49] The methodology based on GDP per capita is the one currently applied and is explained below.

In 2012, an initiative was launched to update and extend the VOT approach. It consists of a comprehensive meta-analysis on a substantial amount of VOT studies from across the EU and other relevant countries.

12.2 Basic theoretical considerations

The concept of VOT is based on economic theory. Numerous travel demand studies have been carried out over the past decades, many of which produce estimates of the VOT. These studies include a rich body of largely unpublished evidence, which can provide valuable insights into the impact of variables such as GDP per capita, transport mode, journey purpose and travel distance on VOT for transport modelling and appraisal. Most studies concentrate on in-vehicle travel time, but other relevant time parameters such as waiting time or walking time are also covered.

The Value of (travel) Time (VOT) denotes the exchange rate at which a traveller is indifferent to marginal changes in the time and cost involved in travel. The VOT therefore is an output of a traveller's decision-making process, not an input to this process.

In many countries, VOTs have been derived using ad hoc procedures. A commonly used methodology uses percentages of the gross wage rate as the value of travel time for business and other purposes. This is sometimes called the "resource value" method. The relationship between VOT and wage rate is based on microeconomic theory (both the microeconomic models for the goods-leisure trade-off and those for household production can be used to derive this result). In 1996, the EIB chose the average gross wage rate in a country as the VOT for business travel, 35% of the average gross wage rate for commuting and 25% for leisure. Real wage growth projections were used to give an increase in the VOT over time. Adjustment factors were used to give variation between transport modes. This approach was used until 2003.

Research has shown that many other factors, not just gross wage rates, may affect the value of time. Since the beginning of the 21st century, VOT studies have been trying to infer the value of time from models of consumer behaviour, acknowledging that VOT is the outcome of a consumer decision process. In many situations, consumers have to trade between time and money. These situations can be described by models. Common models are mode choice models, route choice models or alternative choice models within the same mode and route, but

[48] Pierre Vilain (1996) *Harmonising Parameter Values in Transport Project Appraisal: the Values of Time and Safety*. Internal PJ Paper.
[49] RAND Europe and CD Delft (2004) *Value of time and Safety Guidelines for Transport Projects*. Unpublished.

with different travel time and cost. Data used in model estimation can be classified as revealed preference (RP) data (actual choice data) or stated preference (SP) data (choices as stated by passengers in interviews prepared by researchers).

It is generally recognised that the best approach to estimating VOT is to carry out specific empirical research among travellers in that country. The preferred method is often to interview individuals using stated preference (SP) methods and to estimate discrete choice models on these data. The VOT can then be derived as the ratio of travel time to travel cost. Research has shown that these methods yield similar results to revealed preference (RP) methods using observed choices of travellers, but with a smaller variance (greater precision).

12.3 The EIB value of time dataset

The information is available in the document “European wide meta-analysis of values of travel time – Final report to the European Investment Bank” produced by the ITS (Institute for Transport Studies) of the University of Leeds in 2013.

12.4 The EIB modus operandi

EIB transport CBA models use different algorithms to devise the total time savings resulting from traffic absorbed or induced by the project relative to the reference “without project” situation. The resulting overall time savings are monetised using the values proposed in the 2013 EIB study, unless superior information is available and applicable to the specific project under evaluation.

The 2013 VOT values need to be adjusted for inflation and evolution of GDP per capita. In general, default VOT real growth rates are set to null, but the analyst may change those depending on the specifics of the project and available data. The journey purpose split is left to the discretion of the analyst.

The VOT dataset corresponds to in-vehicle travel time. Some CBA models provide for the possibility to define access/egress times, for which the same VOT values are used in a simplified approach.

If data are available in terms of travel time savings per vehicle, the average vehicle occupancy rates needs to be included in the algorithm. Time savings per vehicle are then multiplied by the vehicle occupancy rate, after which the reference VOTs values can be applied.

13 The Value of Transport Safety

Claus Eberhard and Diego Ferrer

13.1 Introduction

Benefits and costs resulting from changes in transport safety as result of an intervention (project) can be computed when attaching a monetary value to fatal and non-fatal accidents, and if information on traffic volumes and the accident probability are available.

Since the 90s, the Bank has launched several initiatives to define and update a set of guidelines to ensure a consistent approach to values in transport project appraisal, in particular the values of time and safety. A PJ Paper of 1996 defined the value of safety approach used by the EIB in subsequent years.[50] In 2003, the Bank launched an update study, produced by RAND Europe and CE Delft and finalised in October 2004, which has formed the basis of the Bank's valuation of safety to date.[51] And in 2012 the Bank launched a study to update the values.

13.2 Basic theoretical considerations

The EIB approach on the valuation of safety since 2004 is based on the willingness-to-pay (WTP) approach. It determines the value of safety risks by assessing people's willingness to pay for risk reduction. The results of the WTP method can be translated into a Value Of Statistical Life (VOSL), which can be used in cost-benefit analyses.

The VOSL is then complemented with the costs of net lost production,[52] emergency services and medical costs in order to obtain the full value of safety, since the latter costs are not taken into account in individual perceptions.

13.3 The EIB approach to value of safety

The information is available in the document "Update of the Value of Safety methodology and dataset" produced for the EIB by Significance in 2012.

[50] Pierre Vilain (1996) *Harmonising Parameter Values in Transport Project Appraisal: the Values of Time and Safety*. Internal PJ Paper.
[51] RAND Europe and CD Delft (2004) *Value of time and Safety Guidelines for Transport Projects*. Unpublished.
[52] Net lost production is the production minus the consumption. Using gross production would cause double counting, since lost consumption is assumed to be part of the WTP.

14 Road Vehicle Operating Costs

Pierre-Etienne Bouchaud

One of the main impacts of road projects, after time savings –in most developed countries–, is the reduction of Vehicle Operating Costs (VOCs). Reduction in VOCs is especially prominent in developing countries. This is due to a combination of two factors: (i) roads are usually less maintained and therefore in poorer condition than in more developed countries; and (ii) the value of time is lower, making time savings a secondary benefit.

Operating cost relationships for road vehicles are relatively generic and transferable within countries. A number of off-the-shelf models and computer software therefore exists for the calculation of such road VOCs. These models usually integrate a wide range of default data, although they also need to be populated with local data. The main components of VOCs are fuel (and/or electricity), lubricating oil, spare parts, maintenance (labour), tyres, depreciation, crew costs, and other costs and overheads.

VOCs are all distance-dependent. However, some VOCs vary linearly with distance travelled (e.g. fuel/electricity, lubricants and tire costs) while others vary by step (e.g. vehicle purchases, vehicle maintenance schedules, insurance costs). In fact, VOCs vary by vehicle type, type and condition of road surface, road geometry and vehicle speed. VOCs are therefore correlated with characteristics of the project area (climate, culture, etc.), proposed design standard (e.g. bitumen, concrete or gravel surface), road maintenance strategy, composition of traffic flows, and the level of road congestion.

Amongst the many types of computer software that estimate VOC savings, the HDM-4 program models, over time, the relationships between vehicle operation and road deterioration as part of evaluating the VOC impact of road infrastructure investments. This model can therefore be used to illustrate the needs in terms of inputs.

The HDM-4 requires input data to be defined for the following key modules, which will all affect the impact of the project in terms of VOCs:

- **Vehicle Fleet(s):** A number of vehicle types are identified to represent the vehicle fleet pertaining to the project area (various sizes of passenger cars, buses and trucks, as well as non-motorised vehicles if relevant). The information required by HDM-4 must be provided for each of the vehicle categories chosen. It relates to:
  - Basic vehicle characteristics (passenger car space equivalent, number of wheels, number of axles, curb weight, etc.);
  - Vehicle utilisation (annual km per year, average life, etc.);
  - Vehicle-related prices and costs (for new vehicles, replacement tyres, gas, etc.).
- **Road Network(s):** The road network interface provides the basic facilities for storing characteristics of the road sections. It will allow the road sections, which are the fundamental unit of analysis, to be defined. The following parameters are instrumental to determining the VOC impact of the project:
  - Speed flow types (to model the effects of traffic volumes on speeds. Speed flow types will depend mostly on the number and width of lanes);
  - Traffic flow patterns (inter-urban , commuter, urban or seasonal traffic);
  - Climate zones (in terms of moisture classification & temperature classification);
  - Surface classes (bituminous, concrete or unsealed);
  - Pavement type and thickness (asphalt mix or surface treatment over granular, asphalt, or stabilised base);
  - Geometry (rise & fall, average horizontal curvature, speed limit, altitude and drain type);
  - Road condition (ride quality/roughness, surface distress and surface texture);
  - Traffic volumes (as they have an impact on road deterioration);
  - Accident levels.
- **Works Standards,** comprising:

- Maintenance standards;
- Improvement standards;
- New construction sections (as relevant).

The basis for the calculation of VOCs is well-established within the model used by the Bank (Economic Road Infrastructure Appraisal Model, or ERIAM), which is based on HDM-4 outputs. The approach currently adopted in ERIAM is based on speed-VOC curves sourced from German guidance. Calculation of VOCs in the “with” and “without” project scenarios is performed using speed, gradient and road length variables, in combination with the share of gasoline and diesel cars.

Beside these parameters, the user specifies the roughness of the new and old roads. VOCs will vary depending upon the “baseline” condition of the road network, the change in quality of the road network, and the impact of the scheme on overall kilometres travelled. ERIAM caters for fuel cost growth, as well as for fuel efficiency gains over time.

15 Traffic Categories in Transport

J. Doramas Jorge-Calderón

15.1 Introduction

The main purposes of investments in transport infrastructure and operations include saving time (or time costs) to users, reducing the operating costs of transport, improving transport safety and reducing the external costs of transport. Also gaining prominence are factors such as comfort, reliability and punctuality, the last two being of increasing importance for logistic chains. Together, these factors are the key components of the generalised cost (GC) of transport. To the extent that these costs are borne by the transport user, the generalised cost becomes behavioural generalised cost (BGC), and any change on any of these costs arising from the project may elicit a response by the user.[53] This can vary from switching route, switching time of travel, switching mode of transport, travelling more – or less – or indeed not changing behaviour.

Each type of response is a consequence of how the project changes the relative value offered to the user by the different travel options available. That value, measured by consumer surplus (changes in non-monetised BGC), constitutes a key determinant of the economic viability of the project. Understanding both how users respond to the project and how much value the project offers therefore go hand in hand, and are central to measuring the economic viability of the investment.

Whereas the types of response are well understood, unfortunately the literature is at times ambiguous about how to measure the value implied by each type of user response. There is also some confusion about the terminology used for different types of response. This is due to a number of reasons. Firstly, the importance of each type of user response varies across transport modes. For example, for passenger railway or fluvial freight projects, modal diversion from road constitutes a large proportion of expected traffic; in urban road or air transport projects, diversion from alternative routings within the same mode tend to be more important.[54] Secondly, any modelling requires restrictive assumptions. The formulation of such assumptions depends on data availability and analyst judgement, and their validity may vary across types of traffic. Finally, the literature on transport project appraisal has generally focused on land transport modes, particularly road and rail. The circumstances and assumptions applied to such modes are not always directly transferable to other transport modes, requiring additional analyst judgement.

This chapter describes how traffic response is measured in EIB investment appraisals. It starts by addressing ambiguity in terminology, followed by a brief exposition of measures of benefits, and concludes with the treatment in EIB appraisals.

15.2 Types of traffic response

At a broad level, traffic types can be divided according to their behavioural response to a project as follows:

- Existing traffic; this is traffic that travels with the existing mode of transport or link, with and without the project. Such traffic may grow over the life of the project if the transport mode or link faces factors supporting demand growth.
- Diverted traffic, consisting of traffic that, as a consequence of the project, switches route, mode or time of travel.

[53] Differences between BGC and GC may be accounted for by factors such as externalities and subsidies.
[54] In addition, regardless of the transport mode, the type of project concerned – whether it is opening a much improved route, entering into competition with an existing operator, or opening up access to a new destination – determines the importance of each type of user response.

- Generated traffic, consisting of new trips as a result of the project, either by people who would not travel at all before the project, or by existing users travelling more often.

The academic literature and studies by practitioners varies in the terms used, and may group behavioural responses into traffic categories or "labels" differently. This is partly due to inconsistency in term use across authors, and partly because the nature of the project may affect the extent to which transport demand needs to be aggregated in the appraisal, which has probably contributed to blur the picture. Table 15.1 below summarises, non-exhaustively, frequent terminology and groupings used in both the literature and appraisal studies received by the EIB.

Whereas the table is self-explanatory, it is worth pointing out two things. First, deterred and generated traffic refers to the same traffic, depending on whether traffic is deterred by the absence of the project or is generated by the presence of the project. At the EIB the term used normally is "generated." Second, the "time of travel change" category may be modelled either as diversion in the presence of capacity rationing, or as the time cost resulting from congestion. The models at the EIB make a point of measuring "time of travel change" as diversion rather than congestion in airport projects, since some airport project types, particularly adding runways to an existing airport, are aimed primarily at avoiding such diversion.

15.3 Consumer surplus across traffic categories

The measure of benefits that a project yields to each traffic category may vary depending on project circumstances. Generally, there is no ambiguity regarding existing (or base) traffic and new trips (generated traffic). However, the treatment of diverted traffic, particularly when it consists of diversion to other modes of transport, may vary depending on project circumstances, including the extent to which the project is aimed at merely lowering generalised costs or whether there is a capacity expansion component in it. These cases are reviewed in turn.

15.3.1 Lowering generalised cost

Figure 15.1 (A) illustrates the case of a project consisting of lowering the generalised cost of travel between two destinations, and where there are no capacity constraints. An example may be adding bridges and tunnels to a road crossing mountainous area, so that travel time and vehicle operating costs fall. The project causes the generalised cost schedule to shift downwards from GC_1 to GC_2. It is not necessary to consider the GC of alternative modes, since there are no capacity constraints on the road. That is, the "without project" scenario consists of the road continuing to offer current travel conditions indefinitely. The analysis can therefore be made by looking only at the demand curve faced by the road.

The benefit of the project to existing traffic is measured by the area g_1adg_2. In addition, the project causes an increase in the number of trips in the road, from q_1 to q_2. This increase is made of (i) current travellers travelling more often; (ii) people who did not travel before at all travelling as a result of the project; and (iii) people who were travelling through an alternative mode, switching to the road. The total benefit for all such categories would be area abd, which within the rule of a half is calculated as follows: $(1/2)x(g_1\text{-}g_2)x(q_2\text{-}q_1)$.

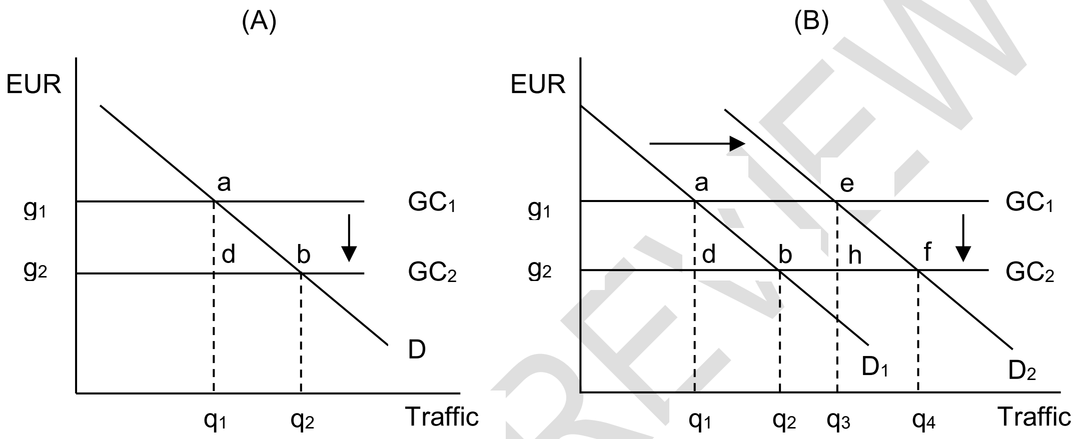
Table 15.1:
Common terminology and groupings for traffic categories

<table>
<tr><td></td><td colspan="3">Project evaluation approach</td><td rowspan="3">Terminology at the EIB</td></tr>
<tr><td></td><td>Demand of route or promoter</td><td>Demand of mode</td><td>Demand of transport system</td></tr>
<tr><td>Projects where approach may apply (non-exclusively)</td><td>Toll road, railway line, airline, shipping line.</td><td>Roads, urban rail, airports, seaports</td><td>Multi-modal schemes</td></tr>
<tr><td colspan="5">Behavioural response:</td></tr>
<tr><td>Same behaviour</td><td>Existing (or base) traffic</td><td>Existing (or base) traffic</td><td rowspan="4">Existing (or base) traffic</td><td>Existing traffic</td></tr>
<tr><td>Time of travel change</td><td>Diverted or reassigned traffic</td><td rowspan="3">Diverted traffic</td><td>Existing (except for airports, for which it is diverted in lieu of congestion)</td></tr>
<tr><td>Route change</td><td rowspan="4">Induced traffic</td><td rowspan="2">Diverted</td></tr>
<tr><td>Mode change</td></tr>
<tr><td>Additional trips by existing or diverted users</td><td rowspan="2">Induced or generated (or deterred)</td><td rowspan="2">Induced, generated (or deterred)</td><td rowspan="2">Generated</td></tr>
<tr><td>New users which did not travel previously</td></tr>
</table>

Source: adapted from World Bank (2005) “Treatment of Induced Traffic” Transport Note TRN-11. World Bank: Washington DC.

If demand does not grow over the life of the project, the benefits would be repeated every year as measured in Figure 15.1 (A). If, instead, demand grows, then benefits would increase every year, as depicted in Figure 15.1 (B). Since there are no capacity constraints either with or without the project, existing (or base) traffic is accommodated either way. The benefit to existing traffic on period 2 would be area g_1ehg_2, which is greater than the benefit with less demand (g_1adg_2). Benefits to generated and diverted traffic would be equal to area efh, assuming the value of time remains constant in real terms through time.

Figure 15.1:
Project aimed at improving generalised cost with no capacity constraint



15.3.2 Capacity expansion

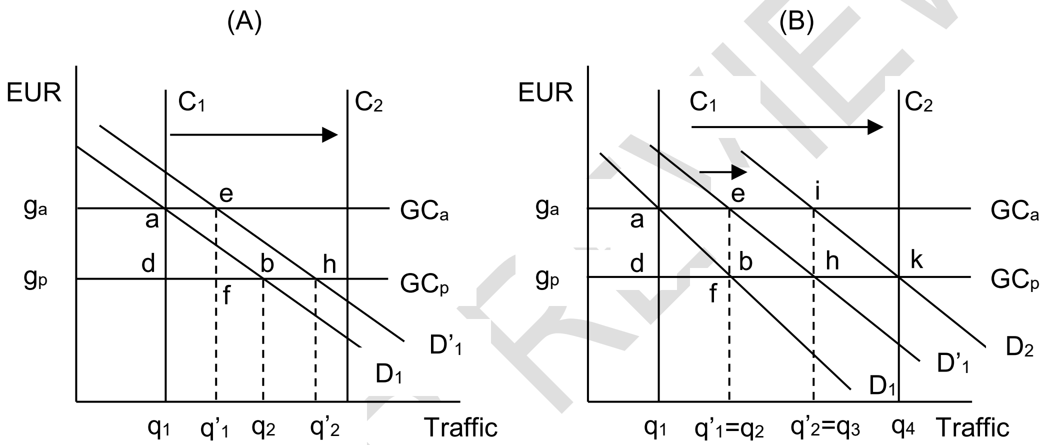
Figure 15.2 illustrates an alternative project, consisting of an increase in capacity, instead of a project as in Figure 15.1, aimed at lowering generalised cost without capacity constraints. An example could be a two-lane road operating at capacity, with a project consisting of widening the road to four lanes in order to alleviate the constraint. Assume for simplicity that capacity is represented by vertical (rather than diagonal or exponential) lines, C_1 representing the two-lane road, and C_2 representing the 4 lane road and that speeds do not change with the project.

Beginning with Figure 15.2 (A), schedule GC_p describes the generalised cost of travelling through the road, which has capacity C_1, enabling traffic q_1. The project would cause schedule C_2 to shift rightwards, enabling a greater amount of traffic at the same generalised cost. Because there are capacity constraints it is necessary for the analysis to make an assumption as to what would happen in the “without project” scenario if the project does not take place. In the current example, assume there is an alternative transport mode, for example, rail, that has a generalised cost of GC_a. The demand curve represents the segment of users for which the project mode (road) is the preferred choice, and for which the alternative mode (rail) is only accessible at an additional cost. Assuming demand does not grow and is at D_1, the effect of the project would be to generate traffic q_2-q_1, creating a benefit measured as area abd. Note that the project would not cause any traffic diversion from rail. Since there is no decrease in generalised cost in the road or any capacity constraint in rail, there is no reason why any traveller from rail should switch to the road as a result of the project.[55]

[55] The alternative mode (rail) would have its own demand curve, which is not shown in the graph. If instead the shown demand curve represented the entire road and rail market, no-one would travel by rail in the absence of capacity constraints on the road, since the GC of rail (GCa) in the figure is drawn to be higher than that of road (GCp) for all users. Users for whom rail is the preferred choice would not contemplate changing modes to road as a result of the project, since the relative GC between the modes at no point becomes more favourable to the road relative to the situation before capacity constraints (g_a-g_p). All those who switch from rail to road as a result of the project are passengers for whom road was the preferred choice in the first place but who were forced to take the less-preferred alternative (rail) because of the lack of road capacity.

If instead the demand curve in Figure 15.2 (A) was at D'_1 then, given the capacity constraint, traffic without the project would still be at q_1, and the project would cause traffic to grow to q'_2. This time, there would also be an inter-modal diversion of traffic (from rail to road, equal to q'_1-q_1), and newly generated traffic (q'_2-q'_1). The inter-modal diversion consists entirely of users for whom the road was the preferred mode, but who had been forced to divert to rail, the preferred alternative to the road, in view of the lack of road capacity without the project (we may call this diversion *back from* rail into the road). This being so, this time dividing diverted traffic by two (within the rule of a half) would underestimate the benefits to the user. Diverted traffic would have made the same modal choice as existing road traffic had there been sufficient road capacity, and therefore they are treated like existing traffic for purposes of calculating consumer surplus changes. For this it is necessary to treat all diverted traffic as a homogenous group, sharing an equal (which could also be understood as an average) access/egress time, operating cost saving, and comfort improvement, in addition to the normally assumed average value of time.

Figure 15.2:
Project aimed at increasing capacity with no generalised cost improvement



Note that if the analysis looked only at the observed demand by the road, the observed demand curve in the project would be a notional line linking points a and h in Figure 15.2 (A). However, dividing the welfare gain to the corresponding traffic increase (q'_2-q_1) by two would underestimate the benefits of the project, as it underestimates the generalised cost savings (reservation price) of users that had been forced to divert to rail.

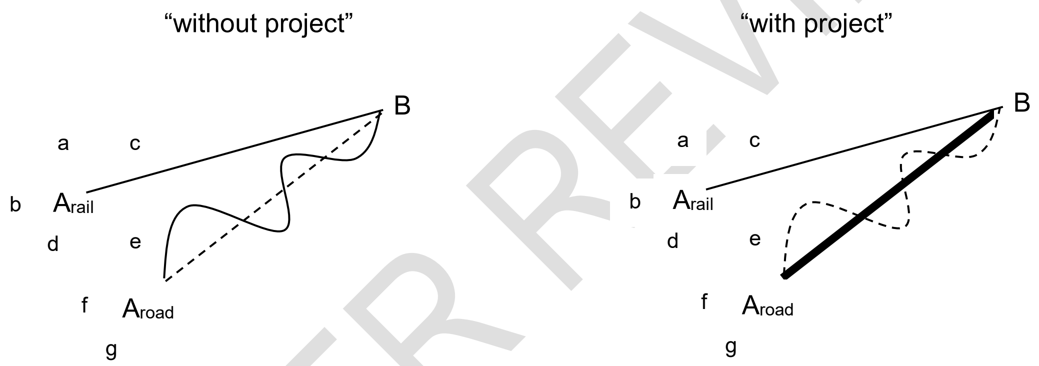
As was the case with the example in Figure 15.1, if traffic in the project does not grow throughout the life of the project, then the project would generate benefits as described in Figure 15.2 (A) every year during the life of the project. If, instead, demand grows, then the situation in some future period 2, would be as described in Figure 15.2 (B), which starts from the situation as in Figure 15.2 (A) (shifting the schedules slightly to unclutter the picture) and adding a new demand schedule D_2, representing a higher level of demand in period 2. Assuming that the initial demand is as described by D'_1, demand growth would result in higher diverted traffic from rail (q_3-q_1) than would have been the case with no demand growth (q'_1-q_1), and just as before, the welfare gain is not divided by two.

15.3.3 Traffic diversion with no capacity constraint

The presentation above may raise the concern that in the situation in Figure 15.1 perhaps none of the traffic gain would reflect diverted traffic. But the difference there is made by the decline in generalised cost in the case in Figure 15.1. As in any other sector of the economy, if demand schedules are not fully inelastic, a fall in real prices of a good or service will always bring about an element of substitution between goods or services, the extent of which would be reflected by the cross-elasticity of demand between them.

In the case at hand, the situation could be depicted as in Figure 15.3, below. The picture describes the railway and road links between A and B, and the location of passengers travelling from A to B at their trip origin. They are located at differing distances from the beginning of the inter-urban road and the rail station, and therefore face different access generalised costs. Starting with the situation "without project" on the left, passengers a, b, c, d, and e, travel by rail, whereas travellers f, and g travel by road. The tunnels and bridges built by the project make road travel faster (Figure 15.3 "with project"), lowering the generalised cost associated with it, as seen in Figure 15.1. Passengers f and g continue travelling by road, and with the project they have an equal fall in generalised cost (assuming their values of time are the same). However, in addition, traveller e, who was only marginally in favour of rail before the project, switches from rail to road, and has a large gain in generalised cost. Passenger d also decides to switch, but the gain in generalised cost is less than for passenger e. Even passenger b may now switch to road, even though the gain in generalised cost is marginal. Diverted passengers e, b, and d have declining gains from the project, and their consumer surpluses are therefore valued using the rule of a half.

Figure 15.3:
Diverted traffic with different generalised cost savings



The above analysis shows that whenever there is a fall in generalised cost, and there is no capacity constraint with and without the project, then the rule of a half should apply to inter-modal diverted traffic. Note that it is not correct to argue that the longer the A-B section of the trip, relative to the access and egress section, the lesser the error of not applying the route of a half to diverted traffic. Longer routes may simply widen the catchment area.[56] Also, note that Figure 15.3 would reflect poorly a situation with capacity constraints, as the preferred choice to any given traveller may not be available due to lack of capacity.

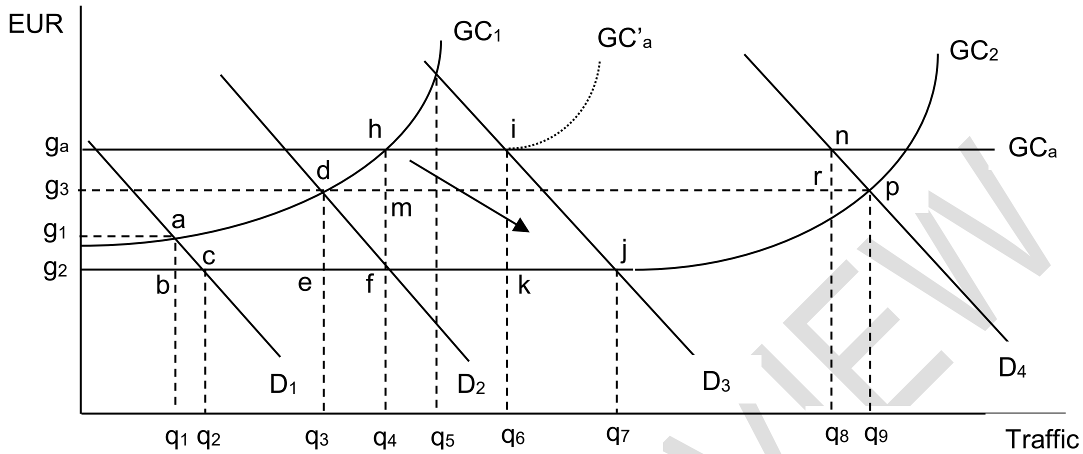
15.3.4 Capacity expansion and lowering generalised cost

In reality, projects may include a combination of lowering generalised cost and capacity increase. Moreover, such conditions may change throughout the life of the project. Figure 15.4 introduces such a situation. The project improves the generalised cost and expands capacity, represented by the shift from schedule GC_1 to GC_2. The supply schedules are curving upwards, depicting conditions of growing congestion, as traffic increases for a given amount of capacity. Schedule D_1 represents demand conditions during the first year of operation of the project. Traffic with the project (q_2) is higher than what would have been without the project (q_1). For existing or base traffic (those that would have travelled both with and without the project) the gain in consumer surplus is measured by the area g_1abg_2, representing a mixture of lower generalised cost from improved facilities and lower congestion costs. The unit cost of congestion is measured along the horizontal axis by the difference between g_1 and the

[56] For urban travel, the access and egress section may be done walking (implying short distance), for inter-urban travel access and egress may be done through another road (park and ride facilities, driving to the rail station, etc.); for continental trips, the access-egress section may involve hours of travel (short haul rail connecting to overnight rail) and for intercontinental trips, it may involve international travel (flying Naples to London to connect to Shanghai).

interception of the GC_1 curve with the vertical axis. The welfare gain to both diverted and generated traffic is measured by area acb, calculated through the rule of a half.

Figure 15.4:
Project that improves generalised cost and eases a capacity constraint



As demand grows to D_2, the situation is similar, but with larger magnitudes. Traffic (q_4) is higher than would have been the case without the project (q_3). The benefit to existing users would be area g_3deg_2, and to both diverted and generated traffic, area dfe. Again the welfare gain to all diverted traffic is divided by two.

When demand grows to D3, traffic with the project would be q_7, and without the project it would be q_4. By then, without the project, some traffic that would have normally travelled with the promoter will have switched to the alternative mode (q_6-q_4). The gain to such traffic from the project is measured by area hikf – the welfare gain to such diverted traffic would not be divided by two. The division by two would be applied only to traffic q_7-q_6, which consists of generated traffic, and may also include some additional diverted traffic from the alternative and third modes since the project has changed relative generalised costs in the transport market.[57] Note that despite the substantial difference of traffic with and without the project (q_7-q_4), and that all of traffic is diverted or generated, it would be incorrect to divide by two the welfare gain to all that traffic, as this would result in an estimated welfare gain of the area of triangle hjf, when the actual welfare gain is the area of trapezoid hijf.

By the time demand grows to D_4, congestion would have already set in the project, to the point of negating any of the lower generalised cost originally achieved. Existing or base traffic would have a welfare gain of g_ahmg_3. By then most of the traffic difference with and without the project (q_9-q_4) is attributable to the increase in capacity and, when valuing the gain in welfare the division by two is not applied throughout the category. Instead diverted traffic (q_8-q_4) is valued as existing traffic, accounting for a welfare gain of area hnrm. The division by two would be applied to traffic q_9-q_8 which includes generated traffic and may include diverted traffic from other modes.

15.3.5 Definition of counterfactual

The analysis above assumes that the alternative mode has no capacity constraint. If it did, the scenario would change. A constraint in the capacity of the alternative mode would be as described by the dotted schedule BC'_a in Figure 15.4, whereby after point i the mode would start experiencing congestion, to trend towards full capacity exponentially thereafter. Lack of alternative capacity would mean that the project would have much greater benefits than

[57] That is, diversion includes traffic *back from* the alternative mode, and may include also diversion *from* the alternative mode, as well as from a third mode.

estimated. Indeed, there would be added diversion from the alternative to the mode because relative generalised costs change in the transport market. The problem can be overcome by assuming that in both the “with project” and “without project” scenarios there will be sufficient investment to expand capacity at the alternative mode. Since the investment happens both with and without the project, it cancels out as far as the project appraisal is concerned.

There may be cases when assuming that alternative capacity can be expanded is not realistic. Since any capacity constraints in the alternative mode would work in favour of the project, the validity of the assumption becomes relevant only for a project that appears to have an insufficient return. However, projects the viability of which depends on insurmountable capacity constraints on an alternative mode of transport are exceptional.

15.3.6 Treatment of diverted traffic in the EIB

The analysis above has shown that there can be no hard and fast rule as to whether to divide by two BGC changes to diverted traffic within the rule of a half or not. The treatment of diverted traffic would depend on project circumstances, including whether there is an increase in capacity, the degree of congestion that can occur as the infrastructure approaches full capacity, and the availability of alternative modes with sufficient capacity to accommodate traffic that cannot be accommodated in the “without project” scenario by the project mode due to lack of capacity. Likewise, it was shown that the extent to which such circumstances apply may change throughout the life of the project. The key judgement to make is whether diverted traffic can be deemed sufficiently homogeneous as to regard their access/egress and other travel conditions as relatively homogeneous, and therefore whether the group can be treated through average magnitudes rather than marginal magnitudes.

Generally, projects financed by the EIB have a substantial component of capacity increase. Moreover, it is not always the case that it can be assumed that the sufficient capacity will be available to accommodate demand diverted by the project. In general, EIB appraisals do not divide by two BGC changes to diverted traffic within the rule of a half approximation, unless the project circumstances suggest otherwise.

15.4 Producer surplus and traffic categories

Economic appraisals address changes in welfare to society, whether to consumers, producers or to outsiders via externalities. Welfare changes to producers are measured through changes in producer surplus, or operating revenues minus operating costs (before depreciation). Changes in producer surplus in the project promoter must be made net of changes in the producer surplus in other modes experiencing traffic diversion as a result of the project. In addition, in measuring changes in surpluses the analyst must be careful to recognise that changes in ticket prices constitute surplus (or welfare) transfers between the producer and existing (or base) traffic.

16 Risk-Reduction Analysis in Water

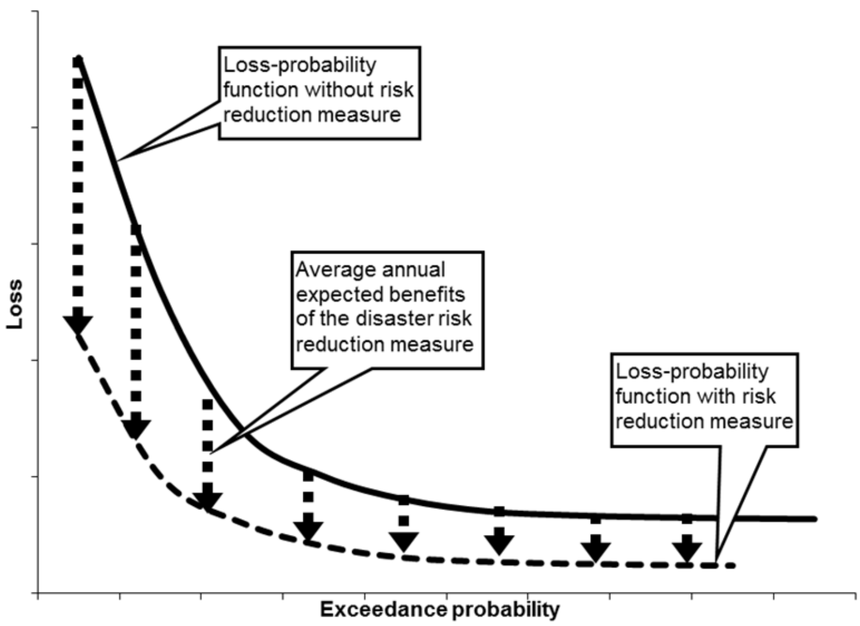
Thomas van Gilst

16.1 Introduction

Disaster prevention and post-disaster reconstruction operations follow probabilistic events, such as earthquakes, forest fires, floods, droughts, cyclones, tsunamis, landslides, volcanoes, industrial disasters, etc. Usually such operations include a large number of urgent and less urgent projects that have to be prioritised in function of available funds.

Most investments do not generate revenues, but rather produce economic benefits through the restoration of economic activities and the reduction of risks and related damage (avoided cost). The approach will be further detailed on the basis of flood protection examples, which are among the most representative risk-reduction projects for the EIB.

Figure 16.1:
Loss exceedance probability curve

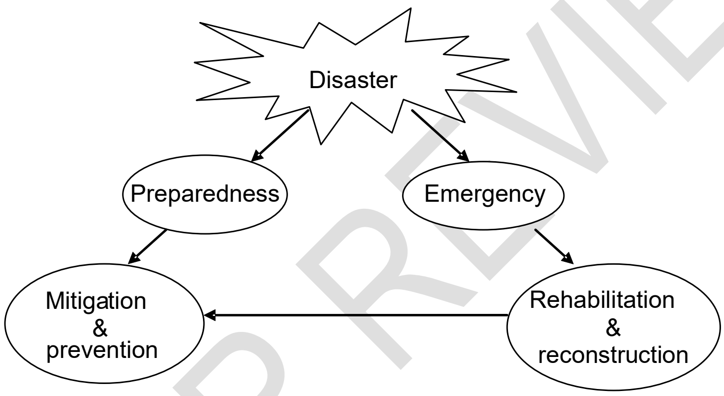


The typical approach to assessing the economic efficiency of risk reduction measures is based on the cost of average expected annual flood damage. In the graphical illustration above, this is given by the area under the loss-probability curve (above), which expresses losses as a function of exceedance probability: the higher the probability that annual peak flow exceeds a certain level (yearly small floods), the smaller the expected damage, and vice versa. The flow of incremental benefits (or avoided costs) expected from a measure is then given by the reduction in expected annual damages that it will generate, being the difference between the areas under the loss-probability curve for the baseline option (upper curve) and that for the "do something" option (lower curve) being considered.

16.2 Disaster management

Even before looking at a series of investment propositions, it is important to ascertain that there is a disaster management framework. A proper disaster management process encompasses all aspects of planning for and responding to disasters including both pre disaster (preparedness, mitigation and prevention) and post disaster activities (emergency, rehabilitation and reconstruction). The scope of each measure is heavily interdependent on the other measures. This extends even to the non-physical measures such as public policies and plans, which can either modify the causes of disasters or mitigate their effects on people, property and infrastructure. With all the key actions "informing" the *mitigation and prevention* activity (see picture below), it is clear that such a framework helps ascertain the effectiveness of investments and their prioritisation. In the EU for example, the floods "disaster management" framework is set out legally under the Floods Directive 2007/60/EC.

Figure 16.2:
Key actions should be geared to mitigation and prevention



16.3 The Floods Directive 2007/60/EC

The Directive's aim is to reduce and manage the risks that floods pose to human health, the environment, cultural heritage and economic activity. The Directive requires Member States to:

1. First carry out a preliminary assessment by 2011 to identify the river basins and coastal areas at risk of flooding;
2. For such zones they then need to draw up flood risk maps by 2013;
3. Establish flood risk management plans focused on prevention, protection and preparedness by 2015.

Flood risk analysis should combine the hydrological knowledge about the frequency of different types of flood events in an area, the hydraulic modelling information about inundation behaviour of flood water in its floodplains, and the economic evaluation of flood damage linked with different types of flood events, such as snowmelt, high tides, intense rainfall events and their joint probability.[58] The Directive applies to inland waters as well as all coastal waters across the whole territory of the EU.

The Directive is to be implemented in coordination with the Water Framework Directive, notably by flood risk management plans and river basin management plans being coordinated, and through coordination of the public participation procedures in the preparation of these plans.

[58] See for instance Messner, F. *et al*., 2006. *Guidelines for Socio-economic Flood Damage Evaluation*, FLOOD*site* Integrated Flood Risk Analysis and Management Methodologies, Report no.T9-06-01. Available at: www.floodsite.net

This Directive thus ensures that in all EU and, increasingly, candidate EU countries, the river basin authorities should be equipped to make informed decisions on how to prioritise actions including investments. Outside the EU, the EIB requires a similar approach to be taken.

16.4 CBA

As already mentioned, the main benefit of flood risk management is the avoidance or reduction of future damage or disruption from future floods. Measures that have this as their main aim may also have secondary impacts (e.g. ecological benefits and costs, or recreational opportunities), which should be reckoned in. Quantifying benefits requires a good knowledge and analysis of past floods, some system for modelling likely future floods, and a database of populations, properties and habitats at risk.

Though the broad approach of carrying out a CBA is clear, different methods can be used to assess both the costs and the benefits. European countries vary in their practice of flood risk management benefit assessment. Different methods have particular strengths and weaknesses and are appropriate for different circumstances.

16.4.1 Estimate of costs

Project costs are relatively straightforward to determine and not very different from any other type of project. Some such key principles as applied to the flood sector follow:

- *Land:* The cost of a project is the loss to the rest of society from using the resources for this purpose rather than for something else. The opportunity cost of land is its value in its best alternative use. In a freely functioning and undistorted market this is reflected in its market price. However, land is often treated as though it were free to the project and useless for anything else, whereas in reality it always has an alternative use.
- *Sunk costs:* Costs already incurred at the point of decision (e.g. a partially built project) should be disregarded for the purpose of the decision, and only *incremental costs* reckoned in. If a project causes a *loss of benefits*, this too is a cost (e.g. building a reservoir which destroys farmland and habitats).
- Costs can be either *tangible* (e.g. wages) or *intangible* (e.g. loss of amenity, destruction of wildlife habitat). Techniques are available for estimating *non-market* values, whether costs or benefits (*Willingness-to-pay*; *Defensive expenditure & avertive behaviour; Hedonic pricing; Travel cost; Replacement cost & shadow projects*)
- Costs include *internal* costs (to the promoter) and external costs, being those borne by the wider society. Indeed, the private sponsor would not normally factor externalities into the decision-making process,[59] but public bodies who would usually be involved in flood protection measures would. Furthermore, certain *financial costs* should be excluded from CBA, such as taxes (generally), financial transfers and depreciation allowances.
- *Contingencies* are of two main kinds. *Physical contingencies – assuming these are over and above the best possible estimate of the expected, base cost* – should be excluded from CBA. *Price contingencies* that are merely attempts to provide against general inflation should also be excluded as CBAs are carried out in constant values.

16.4.2 Estimate of benefits

The main benefit of flood risk management is the avoidance or reduction of damage or disruption from future floods – also referred to as the “contingent liability” for the public authority. This requires a good knowledge and analysis of past floods, some system for modelling likely future floods, and a database of populations, properties and habitats at risk. The main stages involved in benefit appraisal are as follows:[60]

- Define the maximum extent of future flooding and decide on the *benefit area* for the assessment. This determines the area and populations at risk. For the environmental

[59] Unless the government *internalises* the externality by imposing a tax, or requiring polluters to clean up their processes, etc.
[60] As presented in the *Multicoloured Handbook*, by Penning-Rowsell, et. al.

assessment (see below) this is important for the definition of the *benefits jurisdiction* – the population holding economic values for the environmental effects concerned.
- Assemble hydrologic/hydrographic and hydraulic data defining the flood problem. Projections of future flooding based on historical data should take into account climate change and its uncertainties. For instance, a 1 in 100 year flood event might become a 1 in 80 year flood in the future.
- Collect data on the land use and other characteristics of the benefit area. Assessing benefits relies on detailed information about properties, infrastructure and the socio-economic status of residents.
- Assemble depth/damage data for properties in the benefit area. Datasets are assembled relating damage costs from previous floods to flood depth, allowing standardised unit values to be produced for different kinds of properties. Some of these unit values can be downloaded from insurance company websites, though care should be taken about the inappropriate transfer of costs to non-comparable situations.
- Calculate annual average flood damages to be avoided by the selected scheme options and the present value of these damages. This then represents the project benefits. There is still some variety amongst EU countries in the detailed approach to this process[61] (e.g. some use replacement cost whilst others depreciated cost).

Once the costs and benefits have been determined and reduced to a common price and time basis it is possible to compare the two. The main decision criteria between project (and no project) options can be NPV, IRR, Benefit/Cost Ratio and the Least Cost (of attaining a given objective). In some cases these criteria will give divergent rankings of schemes.

It should be noted that designing a damage/exceedance probability function as described above is extremely laborious and difficult, and that infrastructure measures will be heavily affected by policy and other soft measures, and by human behaviour. Nonetheless, despite this note of caution, it provides for a good decision support system, particularly for ranking of options.

16.5 Economic appraisal with limited availability of information

The data requirements of appraisal methods described above are potentially considerable, calling for resources, time and budgets that may be unrealistic in some circumstances. In these cases alternative approaches would be required, such as the use of standardised datasets and the application of the benefit transfer method.

- The use of *standardised datasets* and *computerised modelling* is growing. Past flood events are analysed for data on areas at risk, and damage associated with different degrees of flood, and this data can be overlaid with current evidence of settlement, the distribution of economic activity, etc., derived from internet- based *geo-webs.* The latter are becoming increasingly powerful and versatile, and some leading webs are freely accessible.

- *Benefit and avoided cost transfer* is another method of economising on research and analytical resources, by selecting evidence from comparable situations elsewhere to give indications of the size and nature of impacts in the case in question. As noted above, this approach is gaining favour particularly for environmental economic estimation.

Such approaches may appear less scientific as they do not exhaustively enumerate all the “building blocks”, but the empirical nature based on observed floods can be very valid when comparable situations are being investigated. Either way, a preliminary analysis may indicate

[61] Meyer, Volker & Frank Messner: “National flood damage evaluation methods: a review of applied methods in England, the Netherlands, the Czech Republic and Germany”. UFZ Discussion Papers, Leipzig. Nov 2005; Cihak, Frantisek, Ladislav Satrapa & Pavel Fosumpaur: “Methodology for the assessment of flood prevention measures to be included in the 2nd stage of Flood Prevention Project (2007-2010)” Czech Technical University in Prague. 2006.

what the critical variables would be, if any, pointing to areas of investigation where attention should be focused if resources were scarce or time constraints were pressing.

PART 3:

SECTOR METHODS AND CASES

17 Education and Research

Heikki Kokkala

17.1 Methodology

17.1.1 Context/background

This chapter illustrates the economic appraisal methods applied in the education and basic research sectors in general through the example of a university project. University education in Europe is mainly provided by public institutions, or is at least firmly guided by the public authorities (Ministries of Education or Science and Research). The provision of university education has expended rapidly during recent years.

The Europe 2020 target is to have the tertiary attainment levels among the young adult population up to at least 40% by 2020. However, the current situation in the EU Member States varies. There are countries where the share of 30-34 year olds with tertiary attainment (in most cases university level education) is over 45% (Denmark, Luxembourg and Finland). On the other hand there are Member States where the same attainment is below 20% (Romania, Czech Republic, Slovakia and Italy).

The methodology applied by the Bank project appraisal takes into consideration context, both supply and demand factors, as well as social and private returns.

University sector is a regulated sector in all countries. In most cases, universities are not-for-profit entities and are not allowed by law to generate sizeable (e.g. more than 3%) surpluses. Individual universities can also incur deficit in some cases from year to year and the deficit is transferred to the overall public budget. The important role of the public sector requires that the economic appraisal not only looks at the individual university undertaking the project, but to some extent the whole university system in question. The universities are also an important provider of basic research, which is fairly remote from market exploitation and hence not undertaken by private sector business. Public sector R&D accounts for close to 1% of GDP in Europe, and a substantial part of this takes place in connection with universities. In other words, the indicators of the individual university need to be measured against the wider indicators of the academic and research environment. Hence MCA appears most appropriate for such cases.

17.1.2 Appraisal Methodology

The identification and appraisal of an education project has to integrate three consecutive but intertwined levels:[62] macro level (policy level: EU, macroeconomic and sector); meso level (the level of the education institution and/or the community); and micro level (project-specific analysis).

a) The macro level refers to the fact the project has to be considered in the overall framework for the country and the overall strategy for the sector. This first part of the identification and appraisal analysis will provide context-specific economic and social indicators by which system-wide changes in education are monitored and evaluated. It will also identify the extent of funding in education and the opportunity for the Bank to be directly involved in the provision of external funding.
b) The meso level analysis looks at the institutions – e.g., universities, ministries, local and regional government offices, etc. – that help structure the distribution of resources and activities at micro-level. It also explores the structure of decision-making at this level.
c) The micro level concerns the project-specific analysis. It may be based on cost-effectiveness or cost-benefit methodology, or international benchmarks, to take into consideration to the extent possible the various externalities or intangible effects of investment in education. The classical methodology for the appraisal of educational investment is the calculation of the rate of return, as periodically undertaken by the

[62] Sometimes the meso level is not applicable.

OECD. Educational projects generate tangible and intangible costs and benefits and the usual wage-based rate of return analysis fails to grasp in an appropriate way the whole set of costs and benefits associated to the investment. Whether or not we are able to estimate an Economic Rate of Return (ERR), education investment still generates monetary and non-monetary benefits and costs that will not be captured. Further, in many instances the lack of data on education, especially at the regional and local level, will reduce the scope of the appraisal analysis.

17.1.3 Costs and revenues

Direct or market costs, costs that can be measured in monetary terms can be costs to the provider of universities (in many cases government, foundation or corporate) or costs to the "user" (student or household). The trends of direct costs have been very important items to assess: e.g. in the recent university projects in the UK, where the tuition fees have been increased substantially. For the purpose of project appraisal most of these values have been drawn from the annual budgets and financial reports. National, Eurostat and OECD statistics serve as important wider regional and global references.

Cost breakdown between education and research is an important parameter as far as universities are concerned. On the revenue side, the income profiles, trends in public vs. private funding in education and research are basic parameters.

In countries where tuition fees are collected, their trends as well as their basis (undergraduate vs. postgraduate, home or foreign students) are analysed.

Indirect or opportunity costs are forgone earnings either for the individual or for society. These are analysed in the context of each university system. Labour market situation, taxation, social transfers and their impact on the costs are analysed.

Given the diffuse nature of the outputs of education, costs analysis has often turned to inputs to educational production as units of analysis, i.e. students enrolled and teachers recruited. The type of indicator is related to the objectives assigned to the educational project.

Cost indicators are normally measurements such as: unit cost per student, degree, programme, classroom, laboratory etc. Cost efficiency can be measured by student/teacher, student/programme, student/laboratory ratio, teaching or other use of the facilities, completion rate, actual vs. planned years of studies before graduation etc.

Educational/non-educational costs: depending on the country and legal context universities have in addition to their mission on education and research also other responsibilities such as policy implementation or national project assignments. Pension schemes, study loans and student housing are examples of these. In cases where these are included in the university's balance sheet, these are included in the appraisal. In cases they are not, they are not necessary subject to the appraisal.

17.1.4 Efficiency/value for money/outputs

Dropout and repetition rates are used for assessing the internal efficiency of universities. Data on years of studies is compared against the Bologna structure (three plus two plus three years). These are connected to funding formulas and incentives that, again, are highly policy related.

Employment situation, both wage and employment premia, is the key numeric indicator for external efficiency. This is supported by qualitative estimates, like employer perceptions, research and other cooperation between the university and the relevant business.

Numbers of graduates and the ratio of the enrolled to the graduated are used as benchmarks in the appraisals. The definition of output seems to be complex, even within countries. The reasoning is that universities vary in their composition of faculties (scientific fields), which causes different kind of outputs, since the output "teaching" and "research" can have very heterogeneous characteristics depending on the department.

17.1.5 Benefits

The benefits from a university project are manifold. There are benefits at the local level to the university promoting the project. In some cases, especially when promoted as private business, these can be clearly identified. However, there are generally wider benefits beyond the project, in particular for individuals attending the university and the impact of education on economic performance of a country..

Private benefits: The private internal rate of return on education is equal to the discount rate that equalises the real costs of education during the period of study to the real gains from education thereafter. In its most comprehensive form, the costs equal tuition fees, forgone earnings net of taxes adjusted for the probability of being in employment minus the resources made available to students in the form of grants and loans. This IRR is closely linked to market and demand context. In appraisals of individual universities in some cases, and as mentioned above, the Bank has conducted a CBA on the projects, or else national level estimates are used as proxy. In the case of some specialised universities, such as business or medical schools, a private rate of return, either in full or at least some elements thereof, is calculated. Wage premium and employment prospects are examples of variables that are analysed.

Social benefits: The social rate of return refers to the costs and benefits to society of investment in education, which includes the opportunity cost of having people not participating in the production of output and the full cost of the provision of education, rather than only the cost borne by the individual. In appraisals of individual universities national values are used as proxy. In most cases the rates of return from other studies is used.

Other variables commonly taken into account are: revenues brought by the university to the local/regional economy, employment offers and opportunities, increased employability, improved supply of studies and research to meet the demand etc.

17.1.6 Multi-criteria Analysis

The use of multi-criteria analysis in education and basic research projects is currently being considered and evaluated, and the development of appropriate benefit criteria and methodologies is work in progress. The selection of variables and the deployment of respective weighting criteria depend on the nature of the project and the preferred scenarios. This involves relying on the informed professional judgement of its sector experts in respect of the value of education benefits compared to total project costs. These judgements are supported by the analysis of key project variables and informed by the knowledge and experience of the Bank's education specialists/economists. The quantitative/qualitative analysis could take into account the criteria and weights as listed in Table 17.6. This is developed further in the example below.

17.2 University case study

17.2.1 Project description and outcome

The project concerns the campus extension programme of a university. Specifically, the project covers the construction of new buildings for the departments, and a learning hub with auditoria and meeting rooms. Also included in the project are site clearance, development and landscaping works, archaeological surveys and the construction of access roads and a car park.

The appraisal concludes in favour of financing this project because the new campus will enable the university to increase its attractiveness to both students and staff, thus helping it in competing for able students and researchers. The project will contribute to improving the quality, efficiency and effectiveness of educational programmes, increasing the available floor space for housing new university departments and research and teaching personnel, and improving energy efficiency. The new buildings will be rated "very good" according to the Building Research Establishment Environmental Assessment Method (BREEAM) classification.

The risks and mitigants of the project are as follows:

- *Market demand risk:* The demographic forecast for the country for the population aged 18-23 years shows a slight increase initially. In the medium term scenario the student-age population is expected to decline by 10% by 2030. The competition for able students among higher education institutions is therefore expected to intensify. *Mitigant:* The campus extension, the development of new programmes, the university's brand and the attractiveness of host city as a university town should help the institution in competing for both native and foreign-born students.
- *Operating cost risk:* The new campus will be more costly to operate than is the case at present because of the chosen architectural solutions and the substantial increase in gross floor area. *Mitigant:* Possible new sources of income include fees charged to additional students and levies charged on third-party funded research projects.
- *Affordability risk:* The university has adopted an ambitious expansion plan. Besides the Bank's project, the university also intends to modernise the old, including the rehabilitation of the existing library, refurbishment of buildings vacated by departments decanting to the new site and remodelling of a part of the science park, as well as further developments on the new site, such as other college buildings, offices and a sports complex. It is foreseen that much of the additional investment cost will be financed through new debt. Debt servicing in future will to a significant extent depend on revenues from student fees. *Mitigant:* According to the financial model the university should succeed in growing by up to 5,000 extra students by 2015.

17.2.2 Appraised items

17.2.2.1 Tariffs and operating costs

In 2009/10 the tuition fees amount to £3,225 per annum for a new undergraduate student from the UK or EU and £11,300 per annum for an undergraduate overseas student. Tuition fees for new postgraduate students ranged from £3,250 per annum for a UK/EU student to as much as £14,850 for a new overseas student enrolled in a laboratory programme.

The university managed a portfolio of 52 patents in 2008/09 and has launched about 20 active spin-off companies every year since 2002/03. Income from third-party funded research activities was close to £10 million.

Table 17.1:
University revenues and expenditures for year ended 31 July 2009

Income	***2009 (£000)***	***2008 (£000)***
Funding council grants	62,759	58,805
Tuition fees and education contracts	52,368	46,515
Research grants and contracts	55,288	50,552
Other income	52,931	50,468
Donations		6,119
Endowment and investment income	2,622	4,494
Total income	***225,968***	***216,953***
Expenditures		
Staff costs	131,929	117,574
Depreciation	14,029	14,259
Other operating expenses	71,259	69,104
Interest and other finance costs	3,403	3,692
Total expenditure	***220,620***	***204,629***
Surplus for the year retained within general reserves	**6,669**	**16,504**

The total investment cost for the new campus development (Phases I and II) is £200-250 m, about half of which will be financed with borrowed money. This means that by project completion the university is expected to have gross debt of about £140m. Operating Cash Flow (OCF) was about £7m in 2009.

The decision to continue to grow had, and still has, significant financial and operational implications for the university. Critical to the plans for execution of the growth strategy was the identification and development of additional and stable sources of recurrent income.

Additional loans bring additional costs both in the terms of interest and capital costs. Funding of the university is comprised mainly of student fees and education and research contracts. If the additional funds needed for the investment are to be collected entirely from student fees, then the university would need to recruit about 5,000 additional students annually. However, a substantial increase in the number of students will also call for more teaching staff if quality is to be maintained and improved. It is not obvious that the required new qualified personnel will be immediately available. Furthermore, because the university will be operating two campuses instead of one, operational costs are also expected to increase.

The overall annual cost of current staff is about £130 million. Hence the unit cost per student is roughly £10,000. Although the relationship between staff costs and student numbers is not necessarily linear, the additional student population will in any case increase the staff-related costs accordingly. The planned increase of students (at least 1000 new students by 2015) will mean a minimum increase of £10 million in the annual running costs of the university. An increase by 5,000 students would mean an additional operational cost for teaching staff of up to £ 50 million. If this additional cost were to be borne by student fees only, the university should either enrol extra students (up to another 1,600) or increase the fees demanded of the current and future students.

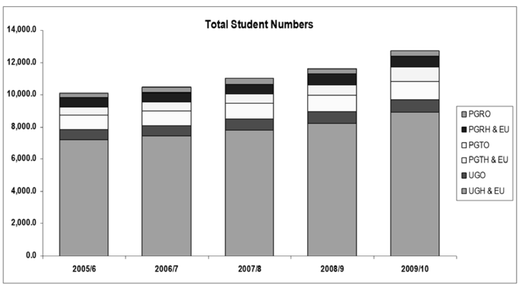
Compared with other, similar universities, the university does not have an exceptionally high proportion of income derived from student fees (see Table 17.3). Whether there is scope, realistically, for further increasing the fees demanded of students is unclear, partly because of a cap imposed by the current government, and partly also because of the market conditions in which the university competes for students with other universities in the UK and elsewhere.

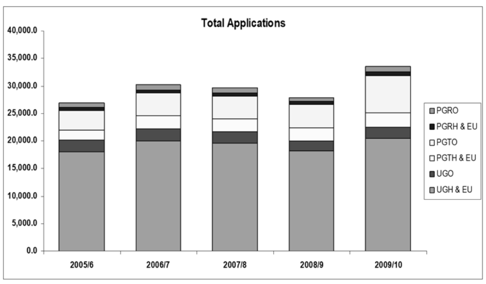
Table 17.2:
Income (%) in comparison with other same-size universities in the UK, 2008.

	X	a	b	c
Grants	27.8	32.0	26.0	31.5
Fees and teaching contracts	23.1	28.0	27.0	25.0
Research contracts	24.6	20.0	27.0	22.5
Other income	24.5	20.0	20.0	21.0

17.2.2.2 Market and demand

Figure 17.1:
Applications and enrolments at the university by department, 2008/09





The size of the student-age population in the UK is expected to increase by up to 10% during the next decade. In addition, the flows of international students to the UK, both from EU and from non-EU countries, seem to be increasing. The numbers of applicants have been, and still are, steadily increasing as well.

The total project investment costs are estimated at £132.47 m.

Table 17.3:
Cost benchmark report, Turner & Townsend, February 2010

Academics	Total Capital Cost (£)	Total Build Cost (£)	Square metres	Cost / sqm	Benchmark Average	Start date	End date
Dept a	23,685,499	16,367,081	6,105	2,343	2,422	02/02/2009	August 2010
Dept b	20,510,081	14,683,103	3,575	2,136	2,422	06/04/2009	July 2010
Dept c	20,294,033	15,108,400	6,287	2,403	2,440	11/05/2009	August 2010
Dept d	20,343,647	14,834,063	6,315	2,349	2,322	20/04/2009	October 2010
Total	**84,833,260**	**60,992,647**	**22,282**				

Table 17.4:
Summary of the project investment costs

	Cost Item	Value (£)	Estimated End date of the Works
A	Land purchase	9,904,496	completed
B	Clearance, project development, preparations	10,104,288	July 2010
C	Utilities, supply, public connections	9,117,389	July 2010
D	Buildings	84,833,260	October 2010
E	Landscaping	13,597,755	May 2011
F	Equipment	4,913,560	January 2011
	TOTAL COST	**132,470,748**	

17.2.3 Economic profitability

The benefits of the project should comprise a stable supply of university graduates and expanded research capacity. The returns should also include gains in labour productivity, income premiums for graduates, increased lifetime earnings, and economic benefits associated with a well-educated labour force. The university is the major provider of tertiary education, and hence supplier of human capital, in the region.

Recent OECD studies show that the private internal rate of return to one additional year of schooling or tertiary education in the United Kingdom in excess of 10%. The university has provided the Bank's services with the financial models that underlie the campus development project. Based on this assumption the estimated Internal Rates of Return (IRR) are as follows:

Table 17.5: IRR of the sub-projects

	IRR (%)
Dept a	6.3
Dept b	7.4
Dept c	5.5
Dept d	8.0

The total IRR for the Bank's investment project is estimated at 7%. This can also be seen as a lower bound estimate of the economic rate of return.

17.2.4 MCA

Table 17.6 below shows the MCA analysis that can be undertaken by analysing the scenarios entailing the different options of refurbishing and that of moving to a new site.

Table 17.6:
Example of possible criteria (MCA)

		option scores			weighted option scores		
Benefit criteria groups	Criteria weights	Renovation of the existing buildings Base Scenario	Renovation and construction Scenario 1	New campus	Renovation of the existing buildings	Renovation and construction of new space	New campus
Services quality	10	3	8	9	30	80	90
Services synergies	15	3	6	10	45	90	150
Services accessibility	15	4	6	9	60	90	135
Ease and implementation time	10	8	3	5	80	30	50
Urban improvements: upgrading of derelict areas, de-congestion of other areas	15	0	5	9	0	75	135
Socio-economic and environnemental externalities	10	0	6	8	0	60	80
Efficiency of services (including energy efficiency)	15	1	3	5	15	45	75
Third party cooperation	10	1	3	5	10	30	50
Total scores (B)	100	20	40	60	200	400	600
Rank		3	2	1	3	2	1
Advantage from base scenario (% increase in B)		0	100%	200%	0	100%	200%
Ratio C/B							
Advantage from base scenario (% decrease in Ratio C/B)							
Advantage from scenario 1 (% decrease in Ratio C/B)							

18 Renewable Energy

David Kerins and Juan Alario

18.1 Methodology

18.1.1 Introduction

Renewable energy projects can be either to produce power, heat (or both), or biofuels for transport use. This chapter will cover the economic appraisal of renewable power and heat production, as this captures the majority of the renewable energy projects seen by the Bank. The methodology described is used by the PJ/ENERGY Department of the EIB, and is very similar to the one applied by the energy sector specialists of JASPERS.

18.1.2 Renewables

This section covers only commercial technologies and thus does not include technologies in the RDI stage. Renewable power projects can involve the full range of technologies from hydropower to concentrated solar power. Given the different development stages that these technologies are at, the Bank has chosen to divide them into mature and emerging technologies, with a separate economic rationale for each. The costs of mature technologies are expected to decline modestly in the future. Examples include onshore wind farms, hydropower, geothermal, and solid biomass.

On the other hand, there are a number of technologies that are in an early implementation phase; not only have costs been declining rapidly, but an engineering analysis of the components suggests there is the potential for this to continue. The expected decline might be substantial (say, 30 to 50% within the next 5 to 10 years), and the expectation is that they can become competitive with alternatives in a reasonable timeframe. This includes a wide range of options such as photovoltaics or solar thermal. Each of these groups, mature versus emerging technologies, must be considered separately.

18.1.3 Mature renewables

The Bank's approach to assessing the viability of mature renewable is based on the cost of the next best alternative, which is normally a fossil fuel alternative, including the costs of environmental externalities associated with CO2 and other pollutants and security of supply.[63] The analysis takes also accounts for the costs related to the intermittence of many of the renewable energy sources, in particular the cost of back up capacity.

The first step is to identify the alternative to the project, the marginal plant, and this will vary depending on the market/system. The LCOE calculation involves a discounted cash-flow analysis over the alternative's economic life. In the case of electricity, a CCGT operating in base load (capacity factor of 70%) is the typical alternative for the continental Europe electricity system. In other regions, coal or oil power stations, are usually the appropriate alternative. Fuel costs are usually the largest cost in the electricity cost of the alternative. This is determined on the basis of energy price scenarios.

The alternative of a fossil fuel power plant cannot be directly compared with an intermittent renewable energy plants, such as wind or solar plants. This is related in particular to the fact that intermittent renewables do not provide firm capacity as fossil fuel plants do and thus their contribution to cover electricity demand is rather limited. In addition, the value of electricity replaced by renewable energy can vary depending on the output profile of the plant during year and whether it replaces peak or off-peak generation. The analysis of the value of renewable energy generation for an electricity system is very well developed for hydropower, but it is less common for other renewable technologies, such as wind or solar.

The cost of connecting the RE project to the electricity network is included in the assessment of the economic cost of the project. Other costs generated in the network to integrate RE need to be assessed on a case by case basis. These additional costs are generally limited for low

[63] See chapters: "Incorporating Environmental Externalities" and "Security of Energy Supply".

penetrations of intermittent renewables in the electricity system. They increase as this penetration expands. If networks are not upgraded, RE curtailment will increase as RE penetration increases. The economic analysis integrates the cost of curtailment to reflect this.

To sum up, three costs are considered in the economic analysis of intermittent RE: a capacity penalty to reflect their limited contribution to cover demand, a penalty due to the additional balancing costs and a penalty or benefit related to the output profile during the year (replacement of peak or off-peak generation). On the other hand, RE generate environmental and security of supply benefits, which are integrated in the analysis of the cost of the alternative fossil fuel generation (see previous chapter).

For the mature renewable power plant to be deemed economically viable it must have an LCOE equal to or lower than the alternative, taking into account the cost of intermittence. The LCOE calculation for the renewable plant will be determined by its technical characteristics as detailed in the engineering analysis, the investment and annual O&M costs, and includes grid costs.

A similar approach is adopted for the economic analysis of heat, whereby the levelised production cost for the renewable technology and its fossil fuel alternative are calculated. This analysis also takes into account the costs related to intermittence, when relevant (back up fossil fuel capacity). However, the costs of intermittence are generally rather low for heat. The alternative is usually based on the cost of an individual gas boiler.

18.1.4 Emerging renewables

Supporting emerging technologies has a dual purpose: to generate cost reductions mainly via learning by doing in the longer term and to produce electricity in the short-term. Technologies with significant promise to be competitive in a reasonable time frame fall into this category. PV, CSP and offshore wind projects are technology examples.

Emerging renewable technologies are not currently competitive with the fossil fuel alternative. However, the costs of some of these renewable technologies are on a rapidly declining trajectory. Consider the case of photovoltaics: since early commercial production in the mid-1970s, average PV module costs have decreased from EUR60/Wp to below EUR1/Wp today.

18.2 Onshore wind case study

The example concerns an investment in the construction and operation of a small onshore wind farm located in northern Europe. The new plant will have a total capacity of 120 MW. The economic life of the plant is estimated at 15 years and annual O&M costs are at the typical level associated with this kind of project. The project's unit investment cost is around the European average, and includes transmission system connection costs. The system where the plant will be located is well interconnected and the reserve margin is around 20%. Demand is growing slowly, less than 1% annually. The plant will make a limited contribution to capacity, and due to the volume of wind that is expected on the system, some output will be curtailed.

The project enjoys a high load factor due to its good location and site/turbine optimisation. A long-term wind resource assessment conducted by reputable international consultants using 3 years of onsite measurements at hub height, with long-term correlations to a nearby weather station suggest a 30% net load factor[64] at the metre point under average (P50) conditions. While this level is high, it is not unusual for this region. Output at the meter point is thus expected to be 315 GWh per annum on average. An analysis of the system demand and the wind farm's output show a reasonable correlation exists between these factors with roughly 50% of output produced during peak periods. The project's output is expected to be in the range of 315 GWh/annum to 306 GWh/annum.

[64] Net of electrical losses, icing, turbine availability, etc.

Table 18.1: Calculation of economic returns and LCOE for an onshore wind project.

		Units		PV*	-1	0	1	5	10	15
	Econom ic Assupm tion									
(1)	Installed capacity	MW	120							
(2)	No. of turbines	-	40							
(3)	unit capacity	MW	3							
(4)	Project Cost	MEUR	180							
(5)	Construction Start Year	-	2011							
(6)=(1)*(12)*8.76	Net power production	GWh/year	315.4							
(7)	Load factor	%	30%							
(8)	Turbine availability	%	97%							
(9)	Economic Value of Power	EUR/MWh	90.0							
(10)	Curtailment		Low							
(11)	O&M		2.0%							
	Captial Expenditures									
(12)	Investment cost				50.4	129.6	180.0			
	Physical output									
(13)=(6)	Production	GWh		3403.4	0.0	315.4	315.4	315.4	315.4	283.8
(14)	Curtailment	GWh		62.0	0.0	0.0	3.2	9.5	9.5	5.7
(15)=(13)-(14)	Net Sales	GWh		3341.3	0.0	315.4	312.2	305.9	305.9	278.1
	Expenditures									
(16)=(12)	Capex	M EUR		173.8	50.4	129.6	0.0	0.0	0.0	0.0
(17)=(16)*(11)	O&M	M EUR		38.9	0.0	3.6	3.6	3.6	3.6	3.2
(18)=(16)+(17)	Total cost	M EUR		212.7	50.4	133.2	3.6	3.6	3.6	3.2
	Revenues									
(19)=(9)*(15)	Economic Value of Electricity	M EUR		300.7	0.0	28.4	28.1	27.5	27.5	25.0
(20)=(19)	Total revenues	M EUR		300.7	0.0	28.4	28.1	27.5	27.5	25.0
(21)=(20)-(18)	**Econom ic Cash flow**	**M EUR**		**88.0**	**-50.4**	**-104.8**	**24.5**	**23.9**	**23.9**	**21.8**
(22)	**Econom ic Rate of return**	**%**		**12%**						
	LCOE (5%, 15y)	EUR/MWh		64						
	Unit cost	EUR/kW		1500						

Note: PV* is the present value at year 0 discounted at 5%

The marginal plant on the system the project is being connected to is a CCGT whose output has an economic cost estimated at EUR90/MWh. This number includes environmental externalities and a security of supply value of EUR10/MWh$_{\text{-output}}$. A balancing cost and capacity penalty have also been included, reflecting the cost associated with the rising level of wind penetration on the system. The LCOE of the project (NPV total cost/NPV net sales*100) is substantially lower than this. The calculation is illustrated in Table 18.1. The project is deemed competitive with the alternative and therefore economically justified.

19 Electricity Network Infrastructure

Jochen Hierl

19.1 Methodology

19.1.1 Project types

The projects concerned are individual investment schemes or multi-scheme pluri-annual investment programmes concerning:

- Electricity transmission networks (and/or associated transformer stations);
- Electricity distribution networks (and/or associated transformer stations);
- Electricity interconnectors.

This chapter describes the methodology used for EIB loan operations, which is very similar to that used by JASPERS.

19.1.2 Project identification

The projects need to be correctly defined in terms of cost, objectives and technical characteristics:

- Location, scale and dimension, accompanied by an analysis of the market;
- Investment and operating costs;
- Basic functional data:
  - Voltage (kV) and capacity (MW);
  - Route and length (km);
  - Number and capacity (MVA) of transformer equipment;
  - SCADA and/or smart grid equipment;
- Objectives/benefits of the investment:
  - Supply of incremental electricity demand (capacity extension) or maintaining the ability to supply (capacity refurbishment);
  - Improvement or maintenance of the quality of supply (avoidance of power interruptions);
  - Reduction in losses;
  - Connection of new generation with load centres or reinforcements thereof (high voltage transmission);
  - Enabling the exchange in power between different electricity systems/markets and associated benefits (interconnectors).

Generally conservative estimates and projections are applied. The typical average economic life considered for investments of this type is 25 years.

19.1.3 Economic profitability analysis

The methodology applied varies slightly depending on the project's nature.

<u>Multi-scheme investment programmes in electricity distribution networks</u> implemented over a number of years (+/-3) consist of a large number (several thousands) of independent and geographically dispersed components, and concern both reinforcements (new assets, capacity extensions) and refurbishments. For this, the standard economic profitability analysis applied is a cost benefit analysis which considers in a cash flow calculation the investments and estimated life-long annual O&M cost (Costs) on the one side, and on the other side the economic benefits (Revenues) accruing during operation over the investment's economic life as far as they can be quantified. The economic benefits identified are generally in terms of:

a) supply of incremental electricity demand (capacity extension) or maintaining the ability to supply (capacity refurbishment);

b) improvement or preservation of the security of supply (avoidance of power interruptions);
c) integration of renewable energy; and
d) reduction in network losses.

Benefit (a) concerns the incremental consumption realised (or the share of electricity currently supplied which the promoter would not be able to deliver anymore as a result of network deterioration – often <1% of current supply), valued at the difference between the price of grid-supplied electricity (including upstream network charges) and the estimated maximum price the consumers would be willing to pay for it, which is assumed to be the cost of self-generated electricity (currently valued at the generation cost of a micro turbine running on gas which is estimated at EUR170-190/MWh).

Benefit (b) is evaluated on the planned reduction of the CML (Customer Minutes Lost) and the resulting reduction of the unserved energy enabled by the investments, valued at the estimated social cost of power cuts (energy not served – estimated at the ratio of GDP and electricity consumption in the given area).

Benefit (c) concerns enabling the integration of renewable electricity generation capacity through network extensions or smart grids, which can be valued at the estimated cost of curtailment of the planned renewable electricity generation capacity (a 20% reduction in load factor of wind power capacity could cost around EUR15/MWh), plus any cost of counter trading that may have to be undertaken by the TSO to avoid overloading of saturated transmission lines.

Benefit (d) is evaluated on the basis of the planned reduction of network losses enabled by the investments, valued at the saved average cost in power generation (plus transmission cost if applicable).

An investment in a single high voltage transmission line can have clearly identifiable purposes which are comparable to the above, e.g. avoidance of costs associated with shortage management, emergency measures, integration of renewable power generation and network losses. In this case, these avoided costs are established in similar manner and treated as revenues in a cash flow calculation as above. The analysis is often complemented by a review of the TSO's planning studies and of load flow results in both N and N-1 in different time horizons to check that the capacity of the planned investments are proportionate to the expected flows. It can also be checked whether the discounted cost of the investment and related O&M expenditure over the economic lifetime of the invested assets, divided by the incremental flows to be expected (specific discounted cost of transmission), are within the normal range for the cost of transmission.

The economic profitability of an electricity interconnector is assessed on the basis of economic benefits accruing from its operation over its economic lifetime. Such benefits consist mainly of:

- Alignment effect of market prices in the interconnected electricity markets. The benefits arise from the lower market outcome (lower wholesale electricity price – a consumer surplus) in a given market compared to the higher prices that would have occurred without the project (e.g. the marginal cost of generation); and the producer surplus (higher prices formed due to extra demand from the importing market). These benefits are difficult to quantify as this requires long-term market projections based on a range of economic and technical (overall grid development) assumptions. Therefore simulations with system models applied by the relevant TSOs are often relied upon. Alternatively, these benefits are estimated and quantified on the basis of long-term base case market assumptions regarding plant decommissioning and the implementation of new generating capacities (nuclear, thermal and renewable) in both markets. The market price differentials are then approximated on the basis of the differences in O&M and fuel costs and considering the external cost of CO_2 emissions (the EIB uses its own scenario for CO_2 emission allowances and other non-greenhouse gas pollutants).

- Gains in terms of increased reliability for both transmission network systems (reductions in loss of load expectancy and probability), which allows reduction of energy interruptions (not served) by several GWh p.a.
- Avoided costs from the integration of planned renewable electricity generation capacity.
- Reduced costs of ancillary services in terms of reduced needs for reserve capacities and counter trade and reduced forced outages.

In addition, for all project types, a cost check is performed on the planned investments, combined with a soundness check of procurement procedures and process. In particular, it is checked whether the average specific investment costs of the programme's components (EUR/km of overhead line or cable; EUR/MVA of transformer capacity) are within the normal range known from similar investment programmes. If not, the higher cost will have to be properly justified.

19.2 Case study of a regional electricity distribution network

The project consists of a 3-year investment programme (2009-2011), to reinforce and extend the transmission and distribution electricity networks of a large regional transmission and distribution company in a Member State in the EU. The main purpose of the project is to cater for a projected annual load growth and to enable the connection of about 70,000 new system users per year, including 400 MW/year of new generation capacity from renewable resources. The project will also enable to reduce network losses by 13% and to improve the reliability of electricity supply by 4%.

The investments are geographically dispersed throughout the Member State. The promoter's network infrastructure extends across several large communities, covering a surface of 81,000 km^2 and 3.5 million customers in total. The asset base includes 220, 132, 66 and 45 kV assets (HV), 20 and 15 kV assets (MV), and <1 kV assets (LV).

The overall project capacities compare as follows with the 2008 asset base of the promoter:

Voltage	Network		Transformers	
	[km]	% asset base	[MVA]	% asset base
VHV (220 kV)	229	189 %	2,210	20 %
HV (132, 66, 45 kV)	622	7.7 %	1,815	14 %
MV (15-20 kV)	2,712	6.6 %	1,799	15 %
LV (< 1kV)	3,804	5.1 %	-	-

The project sets out a considerable development of HV assets to fulfil new and stricter reliability requirements for the HV grids supplying large urban areas. In addition, the project comprises new and refurbished equipment including power transformers, other substation equipment, overhead lines and underground cables. The technologies applied are mature, reliable and widely used in the power sector. Once in operation, the project components will become an integral part of the promoter's electricity infrastructure.

The 220-132-66 kV networks are planned to supply peak demand in compliance with the N-1 security criterion. By virtue of this, the typical load factor of these assets falls in the range 20%-80% depending on load conditions (peak, off-peak) and on type and location of the asset involved. The 45-20 kV networks are operated in radial configuration to supply peak demand, and have a typical load factor in the range of 30%-60% depending on load conditions (peak, off-peak) and on type and location of the asset involved. The LV distribution network has a typical load factor of 40%-90%.

The investments have been accepted by the regulator and will enter the regulated asset base.

19.2.1 Economic profitability

The investments will mainly serve to maintain and improve quality of supply and to cater for growing demand. The economic benefits of the project include (a) consumer access to /

provision of electricity to meet the growth in demand, (b) improved reliability of supply, and (c) reduction of losses.

Benefit (a) is a fraction of the increase in consumer surplus over the investment period. This is calculated by associating the incremental demand with the difference between the price of electricity (including network charges) and the maximum price the customers are willing to pay for it (assumed to match the cost of self-generated electricity). Benefit (b) is evaluated on the basis of the projected power interruptions that can be avoided with the investments, valued at the estimated social cost of power cuts (energy not served). Benefit (c) is valued at the saved cost in power generation.

Those economic benefits would result in an economic internal rate of return of around 13%, as illustrated on Table 19.1. This result has been obtained by assuming the promoter's demand growth scenario and a conservatively low cost value for self-generated electricity (EUR170/MWh). A sensitivity case, based on a 33% lower demand growth scenario brings the ERR to 7% which is still justified under an economic perspective. In the case of a significantly lower demand growth, the promoter is likely to downsize the investment programme, which is likely to maintain acceptable ERR values.

The project is therefore acceptable from an economic profitability perspective.

Table 19.1:
Economic profitability calculation for an electricity distribution network

		Units		**-2**	**-1**	**0**	**1**	**10**	**15**	**25**
	Electricity Demand									
(1)	Annual growth of distributed energy	%		2,0%	2,4%	2,6%	1,0%			
(2)	Distributed Energy	TWh		40	41	42	42			
(3)	Losses in % of energy delivered to UFD system	%		6,10%	5,85%	5,65%	5,65%	5,65%	5,65%	5,65%
(4)=(2)*(3)/(1-(3))	Losses	TWh		2,57	2,52	2,49				
(5)=(2) - value 2008	Incremental Energy Demand (vs. 2008)	TWh		1	2	3	3	3	3	3
(6)=(4) - value 2008	Incremental saving in energy losses (vs. 2008)	TWh		0,14	0,19	0,22	0,22	0,22	0,22	0,22
	Energy Prices									
(7)	Price of electricity to final users	EUR/MWh	*65*	65	65	65	65	65	65	65
(8)	Cost of self generated electricity	EUR/MWh	*190*	190	190	190	190	190	190	190
	Benefit calculation									
(9)=(6)*(17)	Losses Benefit	MEUR		5	8	9	9	9	9	9
(10)=((22)-(23))/60/ 8760 *(2)x(21)	Reliability benefit	MEUR		0	1	1	1	1	1	1
(11)=0.45*(5)*((8)-(7))	Benefit of supplying incremental demand	MEUR		44	97	156	156	156	156	156
(12)=(9)+(10)+(11)	Total Benefits	MEUR		49	105	166	166	166	166	166
	Actual costs									
(13)	Capex	MEUR		326	435	330				
(14)	Opex	MEUR	*1%*	3	8	11	11	11	11	11
(15)=(13)+(14)	Total cost	MEUR		329	443	341	11	11	11	11
(16)=(12)-(15)	**Economic cash flow**			**-280**	**-337**	**-175**	**155**	**155**	**155**	**155**
	EIRR		**16%**							
(17)	Average generation cost (assuming average 10% price-cost mark-up)			EUR/MWh	*41*					
(18)	Average energy price (net of network charges and taxes)			EUR/MWh	*45*					
(19)	GDP country (2007)			1 054	*bEUR*					
(20)	Energy demand Country (2008)			263,90	*TWh*					
(21)	Cost of Energy Not Served			3 994	*EUR/MWh*					
(22)	Minutes of interruption 2008			80						
(23)	Minutes of interruption 2011 (target)			77						

Sensitivity Analysis		Demand growth scenarios 2009-2011	
	ERR	Low scenario	Promoter's scenario
		0.5%, 1.5%, 2.6%	2%, 2.4%, 2.6%
Price of self generated electricity	170 EUR/MWh	7%	13%
Price of self generated electricity	190 EUR/MWh	9%	16%

20 Energy Efficiency and District Heating

David Kerins and Juan Alario

20.1 Methodology

20.1.1 Objectives definition

Projects in the sector of energy efficiency (EE) and district heating (DH) include measures leading to energy savings or to improve energy systems efficiency in the following sub-sectors:

- Buildings, with measures such as insulation, boiler replacement, rehabilitation of heat transmission and energy management systems;
- Industry, e.g. waste gas or heat recovery;
- District heating and cooling, including networks;
- Cogeneration.

The methodology described is used by the PJ/ENERGY Department of the EIB, and is very similar to the one applied by the energy sector specialists of JASPERS.

20.1.2 Project identification

Basic data might vary significantly from one sub-sector to another. The following examples illustrate the data requirements for different types of projects:

Rehabilitation of residential buildings: the main information focuses on the number of apartments and total surface to be renovated, the baseline consumption and expected consumption per m^2, the type of heating system and fuel used and the types of individual measures (insulation, heating/cooling systems, etc.).

Rehabilitation of a district heating system: the required information concerns the characteristics of the existing system (capacity, fuel types, generation efficiency, heat production and distribution losses), the planned network investments and the capacity and heat production of retrofitted system.

Industry: the key data for this sector includes the baseline consumption and expected savings confirmed by in-depth audits, the type of processes/buildings to be renovated, fuel(s) used, heat production if any and the type of energy efficiency measures.

The economic life depends on the type of project and can vary from less than 15 years for many EE investments up to 25 years for some investments concerning the building envelope.

20.1.3 Economic profitability analysis

The economic profitability analysis is based on the energy savings derived from the project. The common information needed for assessing these projects is related to the cost of the investment, the energy savings to be achieved (in relation to the without project situation or baseline), the impact of the investment in operating costs.

The main economic benefits of energy efficiency projects are related to the economic cost of the energy saved, including environmental externality costs. Some Investments in energy efficiency can carry further economic benefits, e.g. when they concern building renovations which have wider benefits such as reducing noise, improving comfort or the living environment, etc. Such additional benefits can be substantial in some cases, but are usually difficult to quantify.

The analysis for district heating systems is based on their overall competitiveness after all renovations compared to alternative individual heat systems. A long term analysis of heat demand is the starting point to ensure that a DH system is sized correctly and will be sustainable over the life of its assets. This is particularly important given the focus on and expected investment in energy efficiency in the EU in coming years. The economic analysis is normally based on a comparison of the discounted heat costs of the project to the costs of the best alternative, taking into account investment costs, net of financial and fiscal transfers, fuel, operating and maintenance costs, network rehabilitation, heat losses and environmental externality costs, assuming an economic life of 15 to 20 years depending on the assets in question.

Individual boilers can be used in all cases to assess the viability of DH. The fuel would usually be either natural gas or gas-oil. If the price of heat from the district heating is significantly higher than this option, it is likely that the DH is not sustainable in the medium to long run or is dependent on regulatory measures that restrict consumer options.

Heat generation is one of the most important elements for the viability of DH systems. Cheap heat is essential to overcome the inherent losses and to compensate for the high capital costs of the distribution network. The key factors in determining whether a fuel source is cheap are investment cost for generation, fuel cost, environmental cost, and unit efficiency. Renewable sources of heat such as biomass (for heat only) are regularly the most competitive with decentralised heat supply options due to their limited environmental impacts. One also needs to consider the effectiveness of the DH network, including heat losses, the cost of rehabilitation, and operation and maintenance.

20.2 Case study of the thermal rehabilitation of multi-storey building in a Member State

The project concerns the refurbishment of 365 buildings with nearly 20,000 apartments in a district of the capital city. The proposed investment is to be realised within 4 years. The investment will focus on thermal energy efficiency improvements of the building envelope (wall insulation, windows, roof and cellar insulation). The main source of energy used for heating in these blocks is heat from the district heating network with only a limited share of owners having switched to individual gas boilers. In addition, the renovation of the district heating system (production, pipes and sub-stations) could result in substantial energy savings, but this is not included in the project.

According to the National Energy Efficiency Action Plan, the residential sector accounts for a substantial part of the total energy efficiency gains (41.5%). The average specific energy demand in multi-family residential buildings is some 190 kWh/m² per year in the region according to EU studies and in situ estimates and taking into consideration the building construction period, losses due to thermal bridges, the lack of maintenance and factors related to occupants' behaviour. Based on existing studies and the preliminary results of the refurbishments carried out previously, the average potential energy savings with the planned investment scope are estimated to 50% of the present consumption. Therefore, the estimated energy consumption in the refurbished buildings can be expected to reach 95 kWh/m².

The economic cost of heat supply is estimated at around EUR62/MWhth, including CO_2 and other external environmental costs (SO_2, NOx and dust). The calculation of economic profitability is illustrated on Table 20.1. On the basis of this economic cost of the energy saved, including environmental external costs, the energy savings generated by the project over its life represent 104% of the investment cost in NPV terms (20 years, 5%) in the baseline scenario and 119% in a high CO_2 scenario.

The project also generates significant additional economic benefits due to the improvement of the living environment, because of the positive image provided by newly coated and painted buildings in an area where most buildings are constructed with concrete panels. It has positive consequences in terms of affordability of heat for lower income households. These additional benefits are difficult to quantify.

Table 20.1:

Calculation of economic profitability of the thermal rehabilitation of a multi-story building

		Units	PV*	-3	-2	-1	1	15	20
	Base Case Scenario								
(1)	Baseline consumption	MWh/y	358,590						
(2)	Reduction	%	50%						
(3)	Economic value of heat	EUR/MWh	62						
			NPV(5%,20yr)						
(4)	Capex	EUR	130,525,196	45,647,590	45,647,590	45,647,590			
(5)=(1)	Baseline energy cons	MWh	5,078,706	358,590	358,590	358,590	358,590	358,590	358,590
(6)=(1)*1/3*(1-(2))+(1)*2/3	Energy cons w . measures	MWh	2,886,695	358,590	298,824.72	239,060	179,295	179,295	179,295
(7)=(1)-(6)	Delta	MWh	2,192,012	-	59,765	119,530	179,295	179,295	179,295
(8)=(6)*(3)	Energy cost	EUR	178,975,060	22,232,559	18,527,132	14,821,706	11,116,279	11,116,279	11,116,279
(9)=(7)*(3)	Energy savings	EUR	135,904,729	-	3,705,426	7,410,853	11,116,279	11,116,279	11,116,279
(12)	**% of savings in NPV of cost**		**104%**						

Note. *PV is the present value at year 0 discounted at 5%

21 Health

Christine Blades

21.1 Methodology

21.1.1 Introduction

The EIB has been lending to the health sector since 1997, following the Resolution on Growth and Employment adopted by the European Council in Amsterdam, which urged the Bank to intervene in new areas, such as health and education. Since that time, a range of health projects have benefited from EIB funding support in EU countries and beyond, a good proportion of which have been investments in hospital infrastructure. EU policy on health is complex and evolving and responsibilities continue to be divided between the EU and Member States, with Member States taking the lead on healthcare delivery. Reflecting subsidiarity, the policies and objectives of Member States normally underpin healthcare investment decisions – and, hence, the projects submitted to the Bank for funding.

The methodology described in this chapter is not designed to prioritise projects across different countries or investments across sectors but, rather, focuses on the evaluation of the appropriateness and robustness of health projects within the strategic context in which they are developed – see the introductory chapter to this guide. A different methodology would be needed were the Bank to seek to prioritise projects across settings and sectors explicitly and on the grounds of comparative economic return.

21.1.2 Economic appraisal of health projects

The Bank adopts a three-stage economic appraisal to all health projects:

- **Stage 1:** evaluation of the strategic context and rationale for investment;
- **Stage 2:** economic evaluation of the project in comparison with the alternative(s);
- **Stage 3:** assessment of the deliverability of the project.

The context for, and nature of, health projects the Bank appraises varies in a number of respects:

- Country/regional context, including:
  - o The relative development of health systems and the availability of resources to deliver healthcare;
  - o National policies, strategies and plans for health improvement;
- The nature of projects for which EIB funding is sought (specialist centres, university and general hospitals, primary care centres, health technologies, research and development, etc.);
- Promoters of health projects:
  - o Mainly public sector entities, increasingly PPP companies, but also private sector providers;
  - o Differential development of healthcare planning and investment appraisal techniques and the availability of relevant and reliable data, information and analysis.

As a consequence of this variability and material differences in the availability of appropriate information from promoters, the Bank is unable to use a single analytical framework or appraisal methodology for all its health sector appraisals. Most particularly, the approaches adopted by the Bank vary with respect to the assessment and evaluation of investment benefits. It is rarely possible to calculate an ENPV or ERR for health projects, given the significant difficulties of measuring and valuing health benefits expected to arise from investments in health and investments in healthcare infrastructure specifically. Where standard cost-effectiveness analysis is relevant and feasible, the Bank seeks to use this method. On the rare occasions in which outcomes are not expected to be materially different following the delivery of a project, least cost-analysis is used. In most cases, however, the Bank uses multi-criteria analysis (MCA) to appraise its health projects undertaken to different levels of sophistication, quantification and qualification. This involves relying on the informed professional judgement of sector experts in respect of the value of healthcare benefits compared to total project costs. These judgements are supported by the analysis of key project variables and informed by the collective knowledge and experience of the Bank's health economists.

Building on the principles of MCA set out in chapter 9 of this guide, the current chapter outlines a systematic approach to the use of MCA in the assessment of project benefits, thereby facilitating robustness, consistency, and transparency in the Bank's appraisal of healthcare investment without a requirement for full cost benefit analysis. The method builds on the Bank's current practice and experience in respect, primarily, of the appraisal of public sector health projects in EU countries and is illustrated in the accompanying case study.[65] The chapter also highlights some specific issues that face the EIB in undertaking the economic evaluation of health projects.

21.1.3 Strategic context and investment rationale

In the absence of effective healthcare markets, market forces cannot be relied upon to deliver solutions that are allocatively efficient for the country/region or sector/sub-sector as a whole. As a result, it is critically important for the EIB to appraise health projects within the context in which the investment and subsequent healthcare operation will function. Hence, the strategic context and rationale for the project is evaluated by the EIB prior to, and as a precursor to, more detailed examination of the project. In the case of "new" countries (i.e. countries where the Bank has not previously lent to the health sector) or new/innovative healthcare concepts, this typically involves a full sector study, and in others, a full evaluation of the investment context and project rationale.

Key assessments include:

- Independent, critical examination of the strategic context:
    - EU (if any) and/or other relevant regional, national and local health and healthcare policy context;
    - Health and healthcare strategies and plans that provide the framework for delivering health improvements;
    - The current position from a system-wide perspective, including healthcare capacity, distribution, utilisation and performance, as well as human, infrastructure, financial and information resources;
    - Future healthcare needs (health needs, healthcare demands, service workloads and capacities) and anticipated resources available to meet these needs;
    - Key issues arising from the above, including strategic responses to national and local pressures for change that require health infrastructure investment;
- Assessment of the project's consistency with and support to the delivery of:
    - Relevant EU policy and actions in relation to health and healthcare delivery;
    - National and local policies, strategies, trends and plans;
    - Internationally recognised/best practice;
- The robustness of the rationale for the investment, expressed in policy, strategic, service and resource terms.

Until and unless a robust strategic context and underlying project rationale provides the context for an investment (a proxy for allocative efficiency), the Bank will not proceed to the full appraisal of the infrastructure investment project.

21.1.4 Demand analysis

A rational, appropriate and well planned healthcare investment project is underpinned by assessments of future need, demand, resource availability and service capacity. These are also key cost drivers and represent healthcare inputs/outputs that generate health benefits – and, hence, facilitate the assessment of relative costs and benefits. The Bank's promoters examine these factors to varying degrees of rigour and precision, with no common approach. Given this variability and in order to come to a judgement on the robustness of healthcare and infrastructure planning for the project, the Bank assesses the forecasting methodologies used

[65] Though most of these principles apply also to economic evaluation of private sector health projects and projects outside the EU.

by promoters' (if any) and examines the related planning processes and their outcomes with reference to internationally accepted/best practice.

21.1.5 Evaluation of alternatives

The Bank also examines the process by which promoters have identified the investment project within the strategic healthcare context, including with respect to developing and evaluating strategic and other alternatives and selecting the project submitted to the Bank for funding. It also seeks to ascertain the specific health, healthcare and related objectives of the project and the constraints facing the promoter in seeking to meet these. Projects are evaluated against either a single "counterfactual" or a range of options for delivering the objectives of healthcare promoters (see Chapter 3 on counterfactuals). At a minimum, comparison should always be made against a "do nothing"[66] or a realistic "do minimum"[67] option – not simply the static situation before and after the project, which assumes implicitly that "before" is a realistic and continuous state, neither deteriorating nor improving. The total discounted costs (typically, Net Present Costs, NPC) of no/minimum change and any other options are compared with the benefits each is expected to deliver.

21.1.6 Benefits appraisal using MCA

The Bank uses different forms of MCA to assess the benefits of health projects. The systematic approach outlined below and illustrated by a simple case study, enables a comparison of the project with alternatives and facilitates the ranking of multiple options from best to worst. The purpose of MCA is to compare the benefits of the project and other options for meeting the investment objectives. When combined with the total discounted costs of options, it enables an assessment of the comparative economic value of the project. In this case, therefore, the economic decision-criterion is based on the incremental "cost benefit/effectiveness" of the project and other options, as represented by the incremental discounted-cost-per-benefit-point.[68] This indicator is useful where two or more options for delivering the project objectives have been analysed in the Bank's project appraisal.

Depending on circumstances, the Bank's health appraisals involve the examination and evaluation of analyses undertaken by promoters, its own analysis of key economic parameters or, more commonly, a combination of both. For MCA, this involves:

- Drawing from the healthcare policy and strategic objectives and, within this context, the specific objectives of the investment[69] to establish:
  - The benefit criteria to be examined and evaluated in the MCA;
  - The relative importance (weight) of each benefit criterion;
- As far as possible based on quantified indicators, examining the extent to which each option (at a minimum do nothing/minimum and the project) delivers the expected benefit, criterion by criterion;
- Calculation of the total weighted scores for each investment option;
- Where required (i.e. depending on variations across options) undertaking sensitivity testing with respect to criteria weights and option scores.

Without valuation, it is not possible to discount project benefits for easy comparison with discounted costs. Nevertheless, the timing of benefits may be an important factor in a promoter's investment decision-making and hence should be reflected in the MCA. Where this is the case, the timing of benefits can be taken into account within the benefit scores (are "soft" time-weighted) or, more commonly, a time related criterion is included explicitly within the benefits appraisal.

[66] A full understanding of the implications of no change at all to the current situation, which in some circumstances could have important consequences for the continuation and quality of healthcare.

[67] The minimum change and investment required if the Project is not implemented, incorporating the costs of maintaining the current service over the lifetime of the proposed Project. This may include significant costs just to maintain the status quo – buildings and plant may have come to the end of their useful life and may need replacing or upgrading and where patient workloads are increasing, maintaining the service may require additional staff, energy and other operating expenses.

[68] The implicit assumption is that all "benefit points" are of equal value. Where there is a concern this might not be the case the scaling or weighting of the attributes may need modifying and different weights/scores tested through sensitivity analysis.

[69] Typical criteria might include, for example, improvements in clinical quality, access, scope and level of service, and performance (not already reflected in costs) and ease of staffing, ease and/or timing of implementation, etc.

21.1.7 Wider ("displacement") impacts

Strategic changes to healthcare delivery, including those facilitated by major capital investment, frequently have "knock-on" implications for other parts of the health sector. For example: a relocation of a hospital will improve access for some of the population but may worsen it for others, who therefore attend a different hospital; successful delivery of changes to the function of a hospital will often require the support of complementary services outside the project; and so on. Drawing from the strategic context and project definition, and where material to the appraisal, these wider implications are incorporated into the economic evaluation – whatever form that takes – to enable an appropriate like-for-like comparison of alternatives (e.g. on the cost side, by incorporating the costs/savings that accrue elsewhere in the healthcare system).

21.1.8 Equity/inequalities

Given wide variations in health status and differential healthcare access within countries, across the EU and beyond, the Bank endeavours to assess the contribution of investment projects to reducing healthcare inequities and health inequalities in accordance with EU health policy. In particular, whether, to what extent and for whom healthcare access is improved and/or worsened as a result of the project's implementation is an important factor in the Bank's appraisal of health projects. This issue is examined at different stages of the appraisal, including on the basis of evidence presented in the strategic context, the rationale for the investment, the objectives set and the constraints upon them, the options examined, the overall design of the project and its anticipated outcome. Whenever equity concerns are an important consideration, an appropriate benefit criterion is included explicitly within an MCA exercise.

21.2 Health sector case study

21.2.1 The hospital project

At a total initial investment cost of almost EUR211 million, the project is a new build replacement acute hospital of 295 beds, which will facilitate and support the transformation of local healthcare services. The two existing acute hospitals will be merged into a single service and relocated to a new, purpose-built, greenfield site acute hospital that is complementary to and networked with other local health and social care services in the area.

21.2.2 Strategic context and project rationale

The Bank's services' review of publicly available documents and material provided by the promoter shows the strategic context to involve a national and local policy context of "modernisation" for safe, accessible, sustainable, equitable, affordable and high quality health services. This is reflected in a range of strategies for the transformation and development of health and social care, including standards for service access, new models of service delivery, effective networks with other acute services in the area and integration with other forms of care (primary, community and tertiary healthcare, social care). Within this context, the current hospital configuration does not and, increasingly will not, meet the healthcare needs of the population adequately or the expectations of the public; faces challenges in terms of clinical risks/safety, adequacy of human resources, service cost and value for money; and has an infrastructure that is inappropriate for modern healthcare delivery and is not easily accessible to the local population.

21.2.3 Market analysis

In the context of demographic change, the implications of the new service delivery model and national assumptions about the redistribution of some services across the area, the promoter developed a number of workload scenarios for the local area and for the hospital project in particular – and concluded that a 12% higher hospital inpatient caseload is expected by 2020. Combined with improvements in hospital throughputs, this workload generates a total requirement for 337 beds across the area. These comprise 295 acute beds delivered by the new hospital and 42 intermediate care beds provided in different settings. Based on its examination of the methodology adopted by the promoter, the Bank considers this approach to represent a reasonable basis for planning infrastructure investment and, given the uncertainties of the future, provides some flexibility for future changes to service levels and mix (by varying throughputs).

21.2.4 Option evaluation

The promoter's option identification and evaluation process involved a three stage process: development of models for the delivery of acute hospital services; identification of site options for a new acute hospital; and evaluation of the costs and benefits of shortlisted options. From a long-list of eight service configurations and three site variants, three options were selected for full appraisal – the do-minimum option, refurbishment and extension of an existing acute hospital and construction of a new build hospital on a (specific) new site. In this example, the minimum option represents a realistic baseline for comparison, involving investment in existing hospital facilities to meet statutory/health & safety standards, ongoing maintenance and equipment replacement (i.e. minimum investment to maintain the status quo), but without an ability to deliver the service improvements generated by the new service model and hospital reconfiguration. As another comparator and potential solution, the refurbishment/extension alternative to new build was designed to deliver the service strategy by utilising and adapting one of the existing hospitals.

21.2.5 Wider ("displacement") impacts

The current configuration of acute hospital services (and the minimum option) comprises two small acute hospitals, which together offer 365 hospital beds. As a result of the transformation of local healthcare services, a proportion of the workload currently undertaken in the acute hospitals will be re-provided as intermediate care (i.e. "displaced"). To ensure a like-for-like comparison, the discounted costs of new build and refurbishment/extension options were supplemented by the Bank's services to include an estimate of the cost of workloads that will be delivered in alternative local settings.

21.2.6 Equity/inequalities

The key equity considerations for the project focus on access to healthcare services and by different groups of the local population. Drivers for change reflected in local healthcare policies and strategies primarily concern equity of access to: an appropriate range and good quality of clinical services and healthcare facilities, helping to reduce inequalities in health outcomes; improved access to services, especially for rural populations and for the disabled; the availability of alternatives to acute inpatient care (ambulatory, intermediate care, etc.); and integrated models of care delivered by multi-disciplinary/multi-professional teams across the local healthcare system and within the new hospital. The healthcare transformation plan and the future model of care for hospital services are designed to address these considerations. In addition, the relative accessibility of appropriate services is also appraised explicitly in the MCA summarised below.

21.2.7 Economic evaluation – NPC and MCA

The costs of the three options evaluated are set out in Table 21.1 below.

Table 21.1:
Total option costs, EUR Million

Costs & Benefits	Minimum	Refurbish/Extend Existing Hospital	New Build Hospital (the Project)
Initial investment costs	47.6	206.8	210.7
Life-cycle investment costs*	13.2	34.1	38.4
Annual operational cost (once complete)	43.9	44.3	44.2
Net Present Cost (at 4%[7], 30 years)	**885**	**993**	**1 015**
Rank	1	2	3
Advantage over minimum option	-	+12%	+15%

* The investment costs incurred throughout the life of the Project (excludes annual maintenance)

Drawing from the strategic context, drivers for change and investment objectives, the promoter defined seven benefit criteria and weighted them for their relative importance. Wherever possible, with the advantage of supporting data and analyses, each option was evaluated for its ability to deliver the project benefits. The total weighted benefit scores were calculated for each of the three options, as outlined in Table 21.2 below. Given the relatively large magnitude of differences in benefits expected to be delivered by the three options, the Bank’s limited sensitivity testing demonstrated the outcome of the MCA to be insensitive to the weights assigned appraisal criteria, as well as to individual option scores.

Table 21.2:
Weighted benefit scores (MCA)

Benefit Criteria	Criteria Weights (%)	Option Scores			Weighted Option Scores		
		Minimum	Refurbish/Extend Existing Hospital	New Build Hospital (the Project)	Minimum	Refurbish/Extend Existing Hospital	New Build Hospital (the Project)
High quality care	20	5	8	9	100	160	180
Service synergies	17	3	7	10	51	119	170
Accessibility	17	6	7	9	102	119	153
Patient/staff environment	15	3	7	10	45	105	150
Statutory requirements	10	8	9	10	80	90	100
Ease/timing of implementation	8	6	8	1	48	64	8
Future flexibility	13	2	5	8	26	65	104
Total Weighted Scores	**100**	**-**	**-**	**-**	**452**	**722**	**865**
Rank					3	2	1
Advantage over minimum	-	-	-	-	0	+60%	+91%

Table 21.3:
Cost and benefit comparison of options

	Minimum	Refurbish/ Extend Existing Hospital	New Build Hospital (the Project)
Costs and benefits:			
NPC at 4% TDR*, 30 years (EUR m)	885	993	1 015
Cost rank	1	2	3
Total Weighted Score	452	722	862
Benefits rank	3	2	1
Average NPC/benefit point (EUR m)	1.96	1.38	1.18
Rank	3	2	1
Incremental costs and benefits:			
NPC minimum	885		
NPC refurbishment vs. minimum.		+108	
NPC new build vs. refurbishment			+22
TWS minimum	452		
TWS refurbishment vs. minimum		+270	
TWS new build vs. refurbishment			+140
NPC/TWS minimum	1.98		
NPC/TWS refurbishment/min		0.4	
NPC/TWS build/refurbishment			0.16
Overall preference rank	3	2	

* Cost/benefit points at the alternative social discount rate of 5.5% for a Convergence Region: EUR 1.66m for the minimum option, EUR 1.18m for refurbish/extend and EUR 1.02m for new build, retaining the original ranking and broad relativities across options

Table 21.3 compares costs and benefits. At a 4% discount rate (the test discount rate for the country) and a 30-year discount period, the new build hospital project is assessed to generate an average cost (NPC) per benefit point that is 30% lower than the minimum option and almost 15% lower costs than the refurbishment alternative. The incremental cost per benefit point is lower for the refurbishment/extension than the minimum option (0.4), and even lower for the new build solution compared with refurbishment/extension of an existing hospital (0.16). This shows that the refurbishment option is more “cost-beneficial” than minimum change and the new build replacement hospital (the project selected by the promoter) even more “cost-beneficial” in circumstances where major investment is both desirable and affordable.

22 Private Sector Research, Development and Innovation (RDI)

Antonello Locci and Tom Andersen

22.1 Methodology

22.1.1 Purpose of RDI projects

The EIB's financing of Research, Development and Innovation (RDI) of private promoters concerns both investments in tangible assets (e.g. the construction of a new research centre) and investments in intangible assets (e.g. the development of a new drug or a new powertrain technology). Financing of RDI is not sector-restricted (with the exception of EIB excluded activities)[70] and, in recent years, the majority of projects financed have been in the automotive, pharmaceutical, med-tech, industrial engineering (e.g. industrial machinery and equipment, construction and logistics machines, etc.), ICT, heating and water heating as well as chemical sectors (this list is not exhaustive).

The Bank's financing for RDI covers various eligible costs such as salaries of researchers and technical staff, RDI consumables and materials, RDI equipment, outsourced RDI, costs for prototypes, investments in RDI facilities. Typically the Bank limits its financing to activities up to the pre-commercial stage.[71] Projects supports the creation of promoter knowledge and know-how and thus of intangible assets expected to generate benefits, for the promoter and society, in the medium to long term. This new private knowledge will generate spillovers, contribute to the diffusion of knowledge and, in line with the EU Policy objectives, is finally expected to create incentives for further private-sector RDI investments in Europe.

22.1.2 Market

R&D, technology and product innovation are often at the base of a promoter's market and technological leadership. In many instances, the RDI projects play a strategic role for a promoter, as they help to stay ahead of competition, anticipate trends and regulation, withstand price pressure, and support long-term growth and profitability. Investments in RDI certainly contribute to the creation of private and public knowledge as well as to the advance of science; however, and particularly for private-sector promoters, the results of RDI projects are intended to find a viable commercial application and yield returns for the promoter on the investments undertaken.

RDI projects typically help promoters address the demand and requirements of their customers: demand for mobility from private or commercial/industrial customers, demand for drugs and medical technology from patients and/or healthcare providers, demand for industrial tools, machinery or technology components for industrial or service processes, etc.

RDI projects therefore help promoters to accelerate the introduction of innovative, enhanced, more efficient (e.g. in terms of energy or productivity) and higher-value-added products, and to meet the demand of customers as well as the requests of society and governments, not only by complying with regulation, but frequently by exceeding regulation, setting the standard in the industry and creating further incentives for investments in RDI.

22.1.3 The costs and benefits of RDI projects

The cost and benefits of RDI projects are assessed at the EIB in relation to two different agents: the promoter and society (at the EU level). In the first case, the Bank typically refers to the project's financial profitability, whereas in the second case, the Bank refers to the project's economic profitability. The calculation of the project's economic profitability for RDI projects

[70] Military projects, projects resulting in limitation of people's individual rights and freedom, ethically or morally controversial projects, projects unacceptable in environmental and social terms, projects prohibited by national legislation.

[71] The EIB is, however, currently considering, in some sectors, the possibility of extending its financing to the technology deployment stage, particularly for projects aiming at the deployment of breakthrough and key enabling technologies.

normally follows a two-step approach, starting from the assessment of the project's financial profitability and then enlarging the scope of the analysis from the promoter to society.

22.1.4 Financial profitability

The assessment of a project's financial profitability has the objective to evaluate ex ante the soundness of the project and the rational allocation of resources from the promoter's standpoint. The financial profitability provides an indication of the project's capability to generate future cash flows, therefore allowing repayment of the investment undertaken by the promoter and compensating for the cost of the capital invested.

The approach followed by the EIB to calculate the project financial rate of return (FRR) for RDI projects in the industrial sector is not generally differentiated by specific subsector. It rather depends on (i) the size of the promoter and its specific RDI management processes, (ii) the size of the specific RDI project financed vis-à-vis the total RDI investment of the promoter, (iii) the importance of the RDI project and its potential impact on the promoter's business, (iv) the data and information made available by the promoter during the EIB appraisal.

Typically the FRR is calculated by assessing the expected incremental discounted cash flows from the commercial application of the RDI project's results. The project's internal rate of return (IRR, FRR in EIB's terms) is then compared with the opportunity cost of capital of the promoter (WACC or specific hurdle rate). Alternatively, the project's financial profitability may be assessed by considering the promoter's entire portfolio of RDI projects. In this case, it is assumed that the RDI projects, <u>on a portfolio basis</u>, through the commercial application of their results will yield a rate of return that is at least equal to the hurdle rate used by the promoter in the selection process. The project's rate of return could also be assessed by considering the expected impact of the RDI project on the firm as a whole in the medium term. This typically happens with a large portfolio of RDI projects, representing the majority of the promoter's RDI investments, which will be carried out over a number of years. The firm's future ROIC (Return on Invested Capital), in a with project scenario, is therefore firstly estimated over a sufficiently long period for the R&D to unfold its potential; it is then compared with a "without project" scenario (estimated) ROIC in which the promoter would not invest in RDI and with the promoter's (firm-level) WACC.

22.1.5 Economic profitability

The assessment of the economic profitability of a project considers the benefits of that project for society. For RDI projects in the industrial sector, it is normally calculated using a two-step approach, starting with the project's financial profitability and then enlarging the scope of the analysis from the promoter to a different economic agent, "society" at the EU level. Therefore the project's costs and benefits for a different agent are taken into account.

The financial soundness of a project *per se*, although not a necessary or sufficient condition, is however already a first indicator of a positive economic impact; a project for which the resources are properly allocated and expected to yield a positive return is generally likely to contribute to the promoter's long-term competitiveness and sustained profitability and thus to support the wider economic growth and welfare. There could however be projects not financially viable for the promoter in the medium term but still expected to show positive developments in the long-term (e.g. "option" value) and with a positive economic profitability due to their expected socio-economic benefits (e.g. environment, introduction of breakthrough technologies).

The RDI project's costs and benefits for society are therefore explicitly assessed by considering the project's externalities (positive or negative) as well as its other spillovers and wider socio-economic benefits.

The project's externalities therefore represent positive or negative effects on third parties (costs or benefits), which do not have monetary compensation, are not reflected in the financial accounts and are not included in the project's financial profitability calculation. Typical externalities of industrial sectors' RDI projects include their impact on the environment (emissions of CO_2 or other harmful pollutants), energy consumption/efficiency, human health, employment, consumer/final user time, and consumer surplus.

The project's spillovers and wider socio-economic effects represent uncompensated benefits of the project provided to society. In the case of RDI projects in industrial sectors, they could include dissemination and generation of knowledge (inter-industry, intra-industry, geographic), due to the promoter's collaboration with other industry participants, academia and research institutes, which normally drive incentives for further private RDI investments. Other socio-economic effects frequently considered by the Bank include the project's impact on the advance of the EU industry technology leadership and competitiveness and therefore its support to long-term EU economic growth.

Indicators of likely spillovers effects could be: the patenting and publications expected to result from the RDI project implementation; the promoter's involvement in collaborative projects with inter- or intra-industry partners and academia; or other indicators of RDI input (RDI intensity, quality of RDI management, track record of invention disclosures and patent applications). Empirical evidence supports knowledge spillovers and enhanced competitiveness of the industry stemming from increased private and public RDI investments.

The approach followed to assess the economic profitability of a project finally depends on (i) the data and information made available by the promoter, (ii) the possibility to define in monetary or quantitative terms the project's externalities, (iii) the importance and number of the project's spillovers and other socio-economic benefits.

When the project's externalities can be translated into monetary terms and priced through a market or shadow price, their net monetary value can be added to the project's incremental financial cash flows, netted of subsidies and other public transfers, and an Economic Rate of Return (ERR) is explicitly calculated.

As an example, the CO_2 and NO_x emissions that a new powertrain technology reduce when it is introduced in new vehicles replacing existing ones, can be appropriately translated in monetary terms through market or shadow prices. Another example is represented by the energy savings that the development of a new technology may drive, when applied to new products or improved industrial processes. They can easily be translated into monetary terms through a market price. The analysis also lists the main non-quantifiable spillovers and other socio-economic effects.

Otherwise, the analysis develops qualitative considerations to take into account the project's externalities, other spillovers and socio-economic effects in qualitative terms and the project's economic profitability is assessed in qualitative terms.

The analysis, which concerns projects in competitive markets, will state the alternatives that the promoter may have taken into consideration or the most appropriate counterfactual defined by the Bank's economist, and highlight whether the project represents, on the basis of the industrial sector knowledge, the most efficient allocation of resources vis-à-vis other alternatives.

22.2 Case study (1): Portfolio approach

The promoter is a provider of industrial solutions ranging from compressed air and gas equipment to generators, construction and mining equipment, industrial tools and assembly systems. The promoter is a technology leader and a standard setter in all segments where it has activities. In light of this, substantial investments in R&D and Innovation are of critical importance to the promoter, allowing to continuously enhancing productivity, product quality and product range by investing in "first mover" technological developments.

The project considered for financing by the Bank concerns the promoter's investments for advanced research and development of technologies, new innovative products in the areas of compressor technology, and construction and mining machinery technology. The promoter's RDI activities are essentially driven by the need to develop enhanced product solutions, which allow its clients to increase the levels of productivity, energy efficiency and energy recovery, safety and ergonomics as well as to reduce the environmental impact of their production processes, where the promoter's product solutions will find application. R&D, technology and product innovation as well as market introduction of new, more energy-efficient and productive equipment are the basis of the promoter's market and technological leadership. This project therefore has a strategic role, as it is expected to help the promoter stay ahead of competition, anticipate trends and regulation and finally support its long-term growth and profitability.

The selected project cost includes operating expenditures (primarily salaries for internal staff and consultants, materials and other R&D costs) and capital expenditures (pre-commercial-stage, including prototyping and tooling investments) to be incurred over a period of 4 years.

22.2.1 Financial profitability

The promoter's RDI project includes expenditures for RDI initiatives at different stages of development, many still at an early stage and many concerning technology concepts still far from market launch stage. For RDI initiatives with a longer-term perspective, the promoter follows a rigorous qualitative screening and selection approach, assessing the level of innovation (for the promoter and the market), the strategic attractiveness and strategic fit, the consistency with the promoter's core competences and the ease of implementation. This process leads to defining a long-term technology roadmap consistent with the promoter's strategy and its customer needs. For RDI initiatives closer to market stage, in addition to verifying the strategic fit and potential benefits for the final customer, and therefore market attractiveness, the selection and investment decision is carried out on the basis of the expected profitability. The investments submitted for approval with a business case need to have a positive NPV, with cash flows discounted at the promoter's opportunity cost of capital, with is set at 10% (pre-tax). It can therefore be assumed that the promoter's RDI project, at portfolio level, will have a profitability exceeding its average cost of capital and yield a rate of return (FRR) of at least 10%.

In addition, the quality of the RDI management and project selection procedures, the stringent budget accounting, project progress evaluation and monitoring, patent portfolio and the track record of invention disclosures and patent applications, as well as the promoter's attention to its customers' needs, all give reassurance that the project's resources are properly allocated. This is further confirmed by the level of the promoter's sales from new products, between 20% and 40% depending on the business area, confirming that RDI has a long-term strategic importance for the promoter.

22.2.2 Economic profitability

In terms of economic contribution, the benefits of this project for society are identified by considering: (i) the positive environmental effects (energy efficiency) and the contribution to increased levels of productivity, safety and ergonomics arising from the application of the promoter's RDI results to its customers' industrial processes; (ii) the knowledge spillover from joint RDI collaboration with universities, research institutes and customers, as well as from patenting, and therefore the contribution to increasing the public stock of knowledge and creating an incentive for further R&D and innovation. As a quantification of one of the project's positive environmental benefits, it may be mentioned that the promoter is targeting the development of compressors featuring some 3-4% improvement in energy efficiency with each new product generation (about every 3 years). The project's ERR is therefore expected to exceed the FRR (higher than 10%).

22.3 Case study (2): Discounted cash flow approach

The promoter, a car manufacturer, intends to maintain its competitive position in the premium car market segment and is consistently investing in R&D whilst applying a long-term view. The continuous search for efficient solutions to reducing the emissions of its fleet is an essential driving force of the promoter's research and development activities. The promoter focuses its efforts on projects that support its premium product strategy, i.e. remaining the world's leading company in vehicle engine technology, performance and fuel efficiency. Its strategy includes the continued optimisation of the internal combustion engine and intelligent lightweight construction, as well as the development of alternative drive systems and innovative mobility concepts, including the development of electrically powered vehicles and hybrid and plug-in hybrid vehicles.

The promoter's project considered for financing by the Bank has the objective to create a hybrid and plug-in hybrid technology offer in every class of its vehicles. It specifically concerns the promoter's investments for: (i) the development of a complete system of components for the hybridisation of passenger vehicles' powertrains and the development of the promoter's new-generation full-hybrid and plug-in hybrid architecture; (ii) the adaptation and integration of the hybrid components and technologies to a selected number of the promoter's future fleet of vehicles, to be launched in the market in the next 4-6 years.

The promoter's investment includes the R&D activities to be carried out in a period of 5 years and is composed of R&D-related operational expenditures, including mainly salaries and materials as well as capital expenditures, including mainly pre-production costs for the electrification components (e.g. tools and prototypes).

22.3.1 Financial profitability

PJ estimated the project's expected rate of return on the basis of the data made available by the promoter and of further estimates based on industry information. Under these assumptions the project is expected to yield a financial rate of return of 13.4% (FRR), in line with the promoter's weighted average cost of capital.

The project's profitability is highly sensitive to the level of market acceptance of hybrid electric vehicles (HEVs) and plugged-in HEVs (PHEVs) and the level of sales volume that the promoter will be able to achieve. The project's rate of return might, however, be higher if the promoter succeeds in reducing the level of costs thanks to economies of scale achieved through specific partnerships with other carmakers. It should however be considered that the promoter's decision to undertake the project mainly responds to a strategic objective. The promoter intends to develop technology, know-how and a market position in the field of hybrid and plug-in hybrid vehicles in order to build strategic flexibility; this would allow the promoter to be able to quickly go to the market with a satisfactory offer of vehicles, not only to comply with worldwide regulations in terms of fuel efficiency and emissions, but also to fulfil the likely increasing customer demand for hybrid and plug-in hybrid vehicles in the next few years.

22.3.2 Economic profitability

The ERR has been calculated taking into account the project's positive environmental externalities, expected as a result of the reduced emissions of CO_2 that the hybrid and plug-in hybrid vehicles would lead to vis-à-vis conventional ICE (internal combustion engine) vehicles. The project's ERR - estimated at 13.6% - is therefore expected to be slightly higher than the FRR. In addition to this, it is important to highlight that this project is expected to bring about additional benefits for society, namely: (i) the knowledge spillover from patenting and joint R&D collaboration between the promoter and its suppliers; (ii) its contribution to the further development of the competitiveness of European industry in the field of sustainable vehicle technologies.

Table 22.1 summarises the approach followed; for the purpose of profitability calculation, the promoter's entire investment (including production phase) has been considered, not only the R&D investment cost, retained as eligible for EIB financing. The numbers have been altered for confidentiality reasons.

22.4 Case study (3): Proxy of project profitability approach and quantitative non-monetary benefits

The project concerns the EU-based part of the promoter's corporate RDI programme in the period 2010-2011, related to the discovery and development of innovative enzymes, novel proteins and micro-organisms to enhance product quality and process/energy efficiency in industries such as detergents, agro-food, pharmaceuticals, fibre and textiles.

The promoter is a research-based biotechnological company with a world leading position in the production and sales of industrial enzymes. The company moreover targets the segments of micro-organisms, biofuels and bio-pharmaceutical ingredients.

22.4.1 Financial profitability

PJ has evaluated and accepted the promoter's internal RDI investment evaluation and approval procedures, which aim at ensuring that the company continuously optimises the use of its resources. This project groups together and includes a large number of R&D projects with different duration times and objectives, with an uncertain outcome in terms of deliverables and timing. The sub-projects are pursued as part of the promoter's ongoing RDI expenditures, and are indispensable investments to a biotechnology-based research company like the promoter. They will aim at safeguarding and expanding the company's future position by strengthening the company's future knowledge base and ensuring future competitiveness, growth and eventually revenues.

This promoter is particularly setting high standards within project performance evaluation and measurement in terms of both past project performance indicators and future individual project return indicators (e.g. NPV / IRRs). As an example, it is possible to observe an annual product portfolio-value increase of above 20% in recent years, measured by the "probability adjusted NPV of new products entering the portfolio",[72] which indicates the success of the promoter's RDI efforts. The probability-adjusted NPV of the entire portfolio has exhibited annual growth of close to 14-15% from 2005-2009.

Alternatively, bearing in mind that the investments under the project at hand group together a large number of RDI projects with different duration and objectives, one may look at the overall performance of this research-based company. To do so, one may use the return on invested capital ROIC as an estimate of the success of past RDI expenditure and a proxy for the expected impact of the project.[73] The promoter's ROIC increased steadily from 8% in 1998 to 20% in 2009 (19% in 2008),[74] and by comparing the company's ROIC with its WACC at 8%, it is clear that the company has been creating significant value. Taking into account the consistency between the company's product pipeline and its current strategy, as well as the company's historical performance, it appears likely that the company will be in a position to defend its market shares in the important mature enzyme segments, as well as in the important growth segments (bio-pharmaceuticals, micro-organisms and biofuels). As such, maintaining a financial profitability (e.g. 20% profit margin, >18% ROIC) on a par with the average of the last three years for the next four-year period is expected to be achievable.

22.4.2 Economic profitability

Enzyme-assisted products and processes enjoy increasing demand because they typically replace more environmentally-intrusive conventional chemicals, or more energy-intensive processes. For example, a household can save around 30% of electricity per wash by using enzymes at a lower temperature. Furthermore, the increased use of enzyme-driven industrial processes has been calculated to facilitate large savings of CO_2 emissions, i.e. 1 kg enzyme product will cause CO_2 emissions of 10kg, replacing CO_2 emissions of 3,800 kg in the bakery industry, 1,800 kg in the pulp industry, 1,400 kg in the oil industry, 500 kg in the bio-ethanol industry, 176kg in the detergent industry and 120 kg in the textile industry, and as such will contribute to the *Tackling Climate Change* initiative by making the processes more efficient.

In terms of economic return, it seems reasonable to assume that for a project of this type (i.e. likely to improve food quality and safety, minimising losses in the logistics chains, increase material and energy efficiency while also minimising the environmental impact of industrial processes), the net economic returns to society of the company's activity should be at the same level as the financial rate of return, or higher.

[72] NPV (Net Present Value) is calculated based on future probability-adjusted discounted cash flows (the financial discount rate used is 15%). The probability is differentiated based for the different segment according to market prospects, competition, degree of uncertainty etc.

[73] ROIC (Return On Invested Capital) is defined as operating profit, before or after tax, as a percentage of average invested capital. Operating profit is adjusted for net foreign exchange gain/loss.

[74] The later years strict investment controls has been a major contributor to this development as investment capital in percentage of sales has decreased from 74% to 70%, and is forecasted to stay around this level.

Table 22.1: Calculation of project ERR for a private sector RDI project

	M EUR		**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**TOTAL**
(1)	HEV / PHEV sales (000 units)			12	30	66	82	107	117	144	197	227	983
(2)	Contribution profit (cash contribution)			32	80	176	218	284	312	384	525	605	
(3)	Project investment cost		(250)	(400)	(450)	(250)	(100)						1,506
(4)=(2)+(3)	Net Incremental Cash Flow		(250)	(368)	(370)	(74)	118	284	312	384	525	605	
	IRR	**13.4%**											
(5)	HEV/PHEV cumulated CO2 reduced (kt)			5.1	17.2	37.6	55.8	69.1	80.2	91.9	118.9	147.0	
(6)	Environmental benefits cumulated (EUR m)			0.1	0.5	1.1	1.7	2.1	2.5	3.0	3.9	4.8	
(7)=(4)+(6)	Net Incremental Cash Flow for ERR		(250)	(368)	(370)	(73)	120	286	314	387	528	610	
	ERR	**13.6%**											

Assumptions

Operating cash flow per vehicle estimated by the EIB

CO_2 reduction benefits estimated vs. most fuel-efficient comparable ICE vehicle

Includes emissions for electricity production (avg EU mix)

Environmental benefits (CO_2) valued on the basis of EIB CO_2 price scenarios 2008

23 Software RDI

Anders Bohlin

23.1 Methodology

23.1.1 Introduction

Software Research, Development, Innovation (RDI) projects are assessed in two stages: firstly the financial return of the activities of the promoter is calculated, and secondly the economic return is estimated.

The economic return is based on both the promoter's RDI activities and their effects on the economy, as well as from its enabling effects that arise from the usage of the software products that are being used in the market as a result of the software RDI activities.

Software projects that the Bank has assessed mainly cover the RDI activities of Enterprise Resource Planning (ERP) products, which normally include human resources (HR) systems, financial reporting systems and customer relationship management. Other software RDI projects that the Bank may appraise could include simulation software for manufacturing or other business support applications.

23.1.2 Financial Outcome from Software RDI Projects

It is very difficult to assess the financial outcome of a specific Software RDI project, as these types of projects are not always completely ring–fenced to one product only. The assumption taken is that the promoter would not consider any RDI activity that, on average, would not generate at least the promoter's weighted average cost of capital (WACC). This approach supports the idea that any company in the software business must invest heavily in RDI activities in order to remain competitive and by remaining competitive, the return on these RDI activities must reach at least the WACC of the company.

23.1.3 Economic benefits arising from promoter Activities

Software RDI activities attract highly educated employees to the promoter's facilities, which normally creates a ground for intellectual "stock" in a geographic area. There is also a tendency for these software RDI companies to establish themselves near a university in order to have access to a "talent pool" but also to cooperate with the nearby university with regards to RDI activities. This normally leads to several software development companies with similar activities becoming established in a limited geographical area, as it is easier to find competent co-workers there, and so-called clusters are formed.

A cluster, also known as an industry cluster, competitive cluster, or Porterian cluster, was mentioned by Michael Porter in *The Competitive Advantage of Nations* (1990). The importance of economic geography, or more correctly geographical economics, was also mentioned by Paul Krugman in *Geography and Trade* (1991). Since then Cluster development has been included in many government programs.

Michael Porter states that clusters can have an impact on competition in three ways: through increasing the productivity of the companies in the cluster; by driving innovation in the sector; and by stimulating new entrants into the sector. According to Porter, in today's global economy, comparative advantage, such as certain locations having special natural advantages (i.e., harbour, cheap labour) to overcome heavy input costs, is less relevant. Now, competitive advantage, how companies make productive use of inputs, requiring continual innovation, is of greater importance.

Put in another way, a business cluster is a geographical location where enough resources and competences gather together and reach a critical mass, giving it a leading position in a given sector, i.e. Silicon Valley.

All this is expected to lead to positive economic externalities for the area where the promoter is active.

23.1.4 Economic benefits arising from Enabling Impact

By using the commercialised outcome of the Software RDI projects, companies of SME size, can get access to software solutions traditionally only available to large corporates for cost and organisational reasons. Utilising these ERP solutions, SMEs can improve their productivity and their competitiveness in the market. Software solutions may also enable companies to integrate their existing software solutions from several suppliers into one common interface, thereby improving user friendliness. These types of solutions avoid expensive software upgrades that could lead to cumbersome installation procedures and even result in business interruption.

Furthermore, the new generation of software products are more energy efficient through the use of so-called Cloud computing, leading to savings in energy consumption. Therefore software RDI projects in the ERP segment are expected to have positive environmental effects as well as positive economic effects.

23.2 Software RDI case study

23.2.1 Introduction

The promoter is a leading player in enterprise application software, is present in 120 countries and has 109,000 customers. At the end of 2010, the promoter held about 2,900 patents. Current customers to the promoter mainly use the “Gold” software product of the promoter and belong to the large corporate segment, with the lion's share amongst them included in the Fortune 2000 list of companies, which is a relatively mature market with regards to enterprise application software.[75]

The project is aligned with the strategy of the promoter to grow its business beyond its current customer base into the market for small and medium-sized companies (SMEs) by providing an integrated on-demand ERP suite for this market segment.[76] The launch of the on-demand application “Project X” should attract the SME market for which the traditional products of the promoter have been too complex and too expensive. By offering an on-demand product, such as “Project X”, the promoter enables smaller companies to become clients without the typical high up-front investment required both in time and money for the traditional ERP products.

“Project X” is a business management suite aimed primarily at companies with 100-500 employees and is delivered on-demand through a web portal over the Internet, by subscription, and is hosted, managed, monitored and maintained by the promoter in the Cloud environment, through large data centres, therefore reducing the need for a small company to have large and costly in-house IT resources deployed.

The project’s economic life can be estimated on average at 7 years.

It is expected that increasingly over the next decade, business customers will want to choose how their software is delivered to them. In this context, one major technology trend currently in the market is the increasing availability of software as a service (SAAS), or what are often referred to as hosted, on-demand or “Cloud” offerings (and often lumped under the catch-all term “Cloud computing”). With Cloud computing, application software does not have to be loaded on to desktop computers or local servers but can be hosted remotely, managed remotely, accessed anywhere, and just as importantly, rented (as opposed to purchased or licensed, which is the current standard) for use. Another key trend in the software industry driven by customers is the desire to achieve nearly universal availability of wired and wireless high-speed-data connections and virtualisation. This requires the development of technologies that permit more efficient use of servers and data centres. Therefore, unifying software solutions, which promise to better integrate corporate communications and data systems, will gain traction.

[75] The “Gold” brand name is fictitious.

[76] ERP integrates internal and external management information across an entire organisation, embracing finance/accounting, manufacturing, sales and service, CRM, etc. ERP systems automate this activity with an integrated software application. Its purpose is to facilitate the flow of information between all business functions inside the boundaries of the organisation and manage the connections to outside stakeholders.

23.2.2 Financial rate of return of the RDI project

Typically software RDI projects run over relatively short cycles and are managed under stringent cost controls; in the case of the promoter, project overrun costs cannot exceed 3% and they require a short pay-back period. Furthermore, the financial internal rate of return (FRR) of a single RDI project must generally at least be aligned with the WACC of the promoter in order for the project to be pursued. The WACC of the promoter was 8% in 2010.

23.2.3 Other external effects of project with economic impact

Information and communications technology (ICT) represents around 2% of global CO_2 emissions through its direct impact on energy consumption during production and operation of ICT equipment. There is scope for improved energy efficiency through more energy efficient equipment. However, the far greater potential for ICT in improving energy efficiency is on the remaining 98% of total CO_2 emissions caused by other sectors, especially, by utilising ICT in innovative and efficient ways in sectors other than ICT. This indirect impact on the environment, induced by appropriately used ICT, could actually be positive, leading to a significant reduction in CO_2 emissions when compared to companies who continue to carry out business as usual.

The new software application developed by the promoter, called “Project X”, will be such an example, as it will help to lower the power consumption of computer hardware for companies using the product by allowing a deployment over the Internet instead of an installation at the local premises of the company. As the software application will, to a large extent, suit the needs of small and medium-sized companies, the power saving potential will be even bigger, because such small installations can less easily exploit the economies of scale in today’s IT hardware.

Over the recent years, initial IT outsourcing concepts, mainly of interest to large corporations, have been refined in order to make them more flexible and also widen the type of potential beneficiaries. Today, with latest technologies, standard software applications are offered over the Internet without lengthy and costly adaptations. The customer does not need to buy the entire hardware and software setup in the data centre, but can purchase licences as the need arises when its business grows. This flexibility is particularly important for smaller companies, such as SMEs.

23.2.4 Key technologies / concepts that enable SAAS

Public Cloud Computing is an emerging style of computing in which software applications, data, and IT resources are provided to users by external companies as services over the Internet, rather than being stored locally on the end user's machine or local IT centre. Also, the Cloud is expected to be flexible, in order to adapt to the different capacity needs of companies with volatile businesses or temporary peak load demand.

Computer hardware virtualisation means that the physical characteristics of a computing platform are hidden from users. showing a logical rather than physical computing platform, also called a “virtual machine”. This concept is used, for example, in the case of server consolidation, where many small physical servers are replaced by one larger physical server to increase the utilisation rate of costly hardware resources.

23.2.5 Cost advantages for SME customers

SAAS solutions are considered as well tailored to the needs of small companies as they can avoid large up-front investment costs through the provisioning of software applications over the Internet. At the same time, the company only needs to pay for the number of users actually employing the software service. If the small company needed the same application to be provided by a dedicated own installation, it would require buying and installing the entire software package on their own in-house IT hardware, tailored to meet the peak-load demand of the business. On the contrary, SAAS enables companies to temporarily increase their IT capacity over short periods in time on a pay-per-use basis depending on their business needs. Companies using SAAS will reduce the time to become operational – traditional software installations could take 3-4 months, while the use of SAAS can shorten this time to weeks.

23.2.6 Energy-efficiency increases

The CO_2 saving when comparing a SAAS application with an on-premise installation have been studied by Microsoft, Accenture and also by Salesforce.com, a direct competitor to the promoter’s “Project X” product and well comparable. All studies have shown that at least 50%

of CO_2 emissions can be saved when moving to the SAAS/cloud computing concept. The smaller the companies get, the more these savings will increase due to lower economies of scale that SMEs can utilise in their own local installations.

To double-check these results, the Bank's services have developed a basic model regarding power consumption to compare the two main deployment scenarios. This model uses typical industry hardware deployed by SMEs and also in data centres. It compares the power consumption of client PCs and servers for small to medium-sized companies in deployment scenarios where the application is either installed by dedicated local hardware or deployed with a SAAS / cloud based solution over the Internet.

The potential savings when moving from the installation in their own premises to the promoter's product (which is supported through the EIB operation) could potentially reduce the power consumption per user and per year from 611 KWh (50 employee case) respectively 513 KWh (250 employee case) down to 275 KWh for a SAAS solution. This would represent savings in the order of 47 – 55 %.

The total savings of a company in power consumption per year would range from 16.7 MWh for the 50 employee case to 59.3 MWh for the 250 employee case. One of the main reasons for the power saving is that servers in data centres are typically running at 60 – 80% utilisation load while SME servers at their own premises run at only 10 – 25% utilisation load, which is used as an assumption in the comparison.

23.2.7 Economic rate of return of the RDI project

In order to arrive at the economic rate of return for the project, externalities such as energy efficiency have been included. Average price per kWh electricity in June 2011, was EUR0.11. This would imply an economic impact of ranging from EUR1,837 to EUR6,523 per company. The promoter aims for 1000 customers in 2011 which would give total annual savings in energy costs ranging from EUR1.8 – 6.5 million. For the project, this would lead to an economic rate of return of the RDI project in the range of 11-19%, as shown in Table 23.1 below.

The project's EUR480m cost is split evenly over three years. The monetary savings of an SME for the different scenarios are based on the average price in June 2011 per kWh for industrial consumers, according to Europe's Energy Portal (http://www.energy.eu). The assumed cash flows for the project are based on the required yield of the project, which is also the WACC of the promoter.

Part of the economic return of the project is obtained by adding the savings in energy costs to the financial cash flows. Further positive economic externalities could be added to the RDI project, which would lead to a higher ERR, such as consumer surplus, value of time to market (TTM) for the end users and the positive impact of enabling a software cluster in the region. These externalities have however been left out due to difficulties in estimating the values.

Table 23.1:
Calculation of ERR of a software RDI project

		2011	2012	2013	2014	2015	2016	2017
(1)	R&D Costs (EUR m)	160	160	160				
(2)	Annual Energy Savings per small SME Customer MWh (I)	16.7	16.7	16.7	16.7	16.7	16.7	16.7
(3)	Number of small SME Customers	500	1500	2000	2500	3000	3500	3500
(4)	Annual Energy Savings per large SME Customer MWh (II)	59.3	59.3	59.3	59.3	59.3	59.3	59.3
(5)	Number of large SME Customers	500	1500	2000	2500	3000	3500	3500
(6)	Average cost per kWh (EUR)	0.11	0.11	0.11	0.11	0.11	0.11	0.11
(7)=(2)*(3)*(6) / 1000	Energy Savings I (EUR m)	0.92	2.76	3.67	4.59	5.51	6.43	6.43
(8)=(4)*(5)*(6) / 1000	Energy Savings II (EUR m)	3.26	9.78	13.05	16.31	19.57	22.83	22.83
	Cash flows Project (EUR m)							
(9) = -(1)	RDI Costs	-160	-160	-160				
(10)	Revenues	79	79	79	79	79	79	79
(11)=(9)+(10)	Net Cash Flow	-81	-81	-81	79	79	79	79
	FIRR	8%						
	wacc	8%						
(12)=(11)+(7)	Cash flows Adjusted for Energy I (EUR m)	-80	-78	-77	84	85	86	86
(13)=(11)+(8)	Cash flows Adjusted for Energy II (EUR m)	-77	-71	-68	96	99	102	102
	ERR I	11%						
	ERR II	19%						

24 Research Infrastructure

Jacques Van Der Meer

24.1 Methodology

24.1.1 Introduction

The economic assessment of Research Infrastructures (RIs) is often complicated, not at least because the outcomes of R&D are difficult to assess ex ante. Although many research infrastructures have difficulties to demonstrate a financial return, they often have an economic return, because they play an important role in the advancement of fundamental and applied knowledge and technology. They have a direct influence on technological innovation and socio-economic competitiveness and the progress of the European Knowledge-Based Economy. A vast multitude of methods and indicators are used to capture their economic value added in singular assessments, unfortunately lacking a common ground. Only recently, the research community has been working towards a coherent, methodological framework with a clear procedure, instructions, recommendations and instruments to conduct such an assessment for RI projects: FenRIAM – Foresight enriched Research Infrastructure Impact Assessment – Methodology. The development of this methodology was financed under the Framework Programme (FP) 7: http://proiecte.uefiscsu.ro/rifi/methods.html. However, the methodology used by the Bank is much more restrictive and aligned to DG Regio's *"Guide to Cost Benefit Analysis of Investment Projects"* and concentrates on the additional direct benefits from the infrastructure. For instance, the use of IO-tables to measure the benefits of the RI accumulates the direct and (non eligible) indirect effects of the construction and equipment of the RI, without an assessment of the benefits of the scientific work in and the technological merits of the infrastructure. A fuller quantification of the results from investments in research infrastructures will be part of an EIBURSE-programme on the Cost-Benefit Analysis of Research, Development and Innovation, that has been recently started.

24.1.2 Measuring direct incremental benefits

It is important to reflect on the costs and benefits with and without project scenarios, i.e. measuring the increase in scientific productivity (publications, number of doctorates) that results from the project. ESO's Very Large Telescope (VLT) has been highly instrumental to Europe's excellence in astronomy and associated sciences. Since 1997, the number of European publication in leading scientific journals has raised from 390 before the project to 730 annual publications today, based on data from the world's most advanced optical and near-infrared telescope. Direct incremental benefits that can be identified are:

- Increased number of graduates (also avoiding brain drain to, for example, the USA);
- Savings in terms of avoided costs to use other RI (outside Europe);
- Income from research contracts and grants specifically related to the unique technical features of the infrastructure;
- The "value" of the created scientific jobs (adjusted for shadow prices);
- Increase in publications (articles and books);
- Health benefits and QALYs (for clinical RI).

With respect to job creation, personnel charges are an operating cost. However, it is difficult to value the correct "economic" costs of the highly specific work by a potential Nobel-prize winner, or a specialist in the "dark matter" in astrophysics. Therefore, it may be necessary to apply corrections. JASPERS, together with the Czech Ministry of Youth and Sports, has proposed monetised values to some of these parameters in a methodology for preparing Feasibility- and Cost-Benefit Analyses for R&D infrastructures projects in the Czech Republic.

24.1.3 Cost comparison

Although RI are unique, it is recommended to compare the costs of the investments and the operations with benchmarked infrastructures, especially those related to the building (compared by m^2, costs per researchers/staff, or m^2 per researcher). The investment costs of the new E-ELT large telescope to be built by ESO with a diameter of 42 meters, estimated at EUR1 billion, compares favourably to competing infrastructures like the Hubble Space

Telescope (EUR12 billion and an additional USD700-800 million for the repair mission) or its successor, the James Webb Space Telescope (6 meter telescope costing USD5 billion). Most of the component for the E-ELT will be built based upon tendered contracts at fixed costs, to reduce cost overruns.

24.1.4 The value of spin-offs

The spin-off of companies from public research institutes is an important contribution to the transfer of knowledge and technology. Spin-offs carry knowledge, methods and specific technologies from the scientific arena into industry, and create commercial applications for the results of research. However, spin-offs size, growth rates, revenues, and product generation tend to be modest, at least in the first decade of existence. Their economic impact needs to be studied over a longer period of time. The propensity and the success of spin-offs also depend on the institutional framework, like the availability of Venture Capital, incubating facilities and the country's business climate. For the purpose of a CBA, it can be assumed that 5 jobs are created per spin-off. These jobs should be valued at the average income (I_{ms}) in each member state. Assuming an average life (treat this income as stream of revenues) of 15 years the Present Value (PV) for each EURO generated at the social discount rate of 5.5% is about 10. Assuming a probability / success-rate of 50% for the average newly created firm, the equation is: Average value per spin-off created = 5 * 10 * 50% * (I_{ms}).

24.1.5 The value of technology transfer

The OECD Report: *Turning Science into Business* gives an insight on the value of Technology Transfer practice and illustrates that revenues per license vary widely. Taking Germany as a reference, the average income per license is EUR55,000. However, also within that country, the variation is considerable. In their annual report the Max Planck Institute reports that their average value per license in EUR200,000. It is recommended to refer to these values when conducting a CBA.

24.1.6 Valuation of open access

By allowing users to access the facility free of charge or at a fairly low fee, RIs promote mobility of researchers in the EU, one of the key aspects of the European Commission's policy in the field of research. How to value the use of RI by visiting researchers? Starting from the publication *Developing World-class Research Infrastructures* for the European Research Area (ERA), different sort of fees can be applied for charging the access to a potential user:

- Marginal costs – based on the incremental expenditures caused by access;
- Average costs – based on the user's share of full operating costs, depreciation excluded;
- Full costs – based on the user's share of full costs of operation, depreciation included.

Within LASERLAB, a European laser research infrastructure consortium, researchers from a partner laboratory do not pay for the access to another partner facility, the EU (through LASERLAB) does. Access is granted on merit, as measured by the ambition of the proposed experiments and the track record of the applicant team. The fees paid by LASERLAB to research facilities is based on maintenance costs, utilities, consumables and access-related work of the hosting facility's scientific staff.

Yet, those rates are based on costs, and can therefore be distorted by operational inefficiencies and do not provide an answer to the real economic value of the access. Another way to measure this value, in absence of a market of access time, could be the willingness-to-pay by the user. This willingness-to-pay (WTP) of researchers from the institution ***I*** for the access the facility ***F*** should be evaluated by taking into consideration:

- The full costs researchers from the institution ***I*** pay for the access to their own infrastructure;
- The quality of equipment and services in their own facility ***Qi***;
- The quality of equipment and services in the facility considered ***Qf***.

Also here, the valuation may introduce operational inefficiencies (comparatively high costs at the researcher's institution) and benchmarking the operational efficiency before determining the WTP is necessary.

24.1.7 The value of patents

In the PatVal-EU survey (2005), funded by the European Commission, inventors at a number of academic institutes were invited to estimate the minimum price at which the owner of the patent (whether the firm, other organisations, or the inventor himself) would have sold the patent rights on the very day in which the patent was granted. The average estimate was a value between EUR300,000 and 1 million. This is however, in sharp contrast with the market value of patents reported by Patent brokers like Ocean Tomo, which underlines the difference in perception by the researcher about the value of his work and that of the market. Ocean Tomo values the average monetised value of marketable, individual patents at USD75,000 (EUR57,500) and at about USD115,000 (EUR85,000) for patents that are effectively used in industrial applications (the top 10%, industrially viable patents). The EPO has developed its valuation model of intellectual property (IP), “IPscore”.

24.1.8 Reference period

An important element to include in the CBA is the technological obsolescence of the RI. Keeping the IP at the State of the Art and boundaries of science often requires substantial investments in upgrades and maintenance. Without these investments, the economic life of the RI is reduced significantly and as such the potential stream of benefits.

24.2 Research Infrastructure case study

JASPERS assists the 12 Central and Eastern EU Member States in the preparation of major projects to be submitted for grant financing under the Structural and Cohesion Funds. Major projects are projects of value greater than EUR50m typically.

The application procedure of the project was prepared with technical assistance provided by JASPERS and was approved by the European Commission, the project is to be funded through ERDF funding with an estimated cost of the project is of EUR153.26 million.

24.2.1 Project background

The Research Centre (“the promoter”) is a company which promotes innovation, interdisciplinary research and knowledge management in the fields of biotechnology, medicine, nanotechnology, material sciences, telecoms and climate change through collaboration with government, academia and private businesses. The company’s constituent shareholders consist of the municipality, its largest universities and the region. The project encompasses the construction of a new campus of 20,000m^2 with specialised laboratories equipped with superior equipment, which will ensure that R&D support and infrastructure management meet world class standards. The different departments constructed will cover; site operations, business development, life sciences, nanotechnology and a Tele-Information Technology Research Centre. The project also has for a plan to construct a Climate Change Energy Park and a Science Park on the premises in the future.

The group’s primary operational objective is the commercialisation of proprietary research or done either in cooperation or through commission with industrial partners. Through the sale and licensing of IP and technology and seed capital investment in companies that might spin-off from the facility.

24.2.2 Demand analysis

The approach taken to the evaluation of the project CBA was deemed to be in accordance with Commission guidance It was assumed that the revenues generated from cooperation with industry, commercialisation of research results as well as on technology and transfer will start to be generated in 2015 and will generate approximately 115 million in local currency units which will constitute roughly 41% of total income. It was also assumed that the amount spent on research activities would have a multiplier effect on the increased efficiency of industry represented by limited costs of processes. It was also assumed that revenues generated from the commercialisation of IP would have a threefold benefit to society or industry.

24.2.3 Economic analysis

With the assumption of a reference period of 15 years and a (real) discount rate of 5.5%, the economic analysis generated:

- an ERR of about 16%;
- a NPV of EUR112 million; and
- a B/C ratio of 1.3.

These values were derived from:

- The reduced cost of technological methods due to operation of new technologies and innovations developed at the centre. This represented 30% of the costs of research activities;
- The societal benefits of the commercialisation of IP developed at the centre were represented by its commercialisation activities.

Table 24.1: Project output measures

lp.	Indicator	Unit of measure	2015	2023
1	Number of research projects using the infrastructure	%	10-20	30-40
2	Number of innovation (product and process) introduced in companies through cooperation with the infrastructure	%	15-30	50-70
3	Number of patent applications resulting in projects benefiting from the infrastructure project (including applications in the European Patent Office – EPO)	%	30-40	60-80 (6-8)
4	Number of patents obtained in the framework of the projects using the research infrastructure (including patents obtained abroad)	%.	0	15-25 (2-5)
5	Number of young national scientists (up to 30 years of age) employed in the research projects carried out in the infrastructure	%.	60-80	150-200
6	The number of professors and doctors with foreign research centres working in research projects carried out in the infrastructure	%.	8-15	30-60
7	Number of projects ongoing development and implementation of infrastructure using the infrastructure	%.	0-6	15-20
8	Number of companies benefiting from services built and modernised in the infrastructure laboratories	%.	10-20	30-50-
9	Number of publications from the projects benefiting from the infrastructure project	%.	35-60	100-200

The Beneficiary had identified benefits derived from the fiscal corrections and economic / shadow prices. Due to their limited impact on the economic evaluation of the project, these were not included in the application form. These included:

- Increased competitiveness of the region and the country;
- Increased entrepreneurship in the region;
- Increased innovation in the region's economy;
- An increase in technology and knowledge transfer due to the increased number of spin-offs.

24.2.4 Project benefits

It was foreseen that whilst difficult to quantify, there was a possibility of cost reduction of technological processes for society resulting from the commercialisation of any IP produced by the project. The beneficiary made these assumptions and outcomes calculated, were deemed based on past JASPERS' experience, as a reasonable proxy of benefits such as:

- Increased competitiveness;
- Technology transfer;
- Patents produced;
- Increased capacity of Polish science;
- Increased number of PhD graduates;
- Health/environmental benefits;
- Increased efficiency in the industry;
- Sustainable development;
- Regional development;
- Competitiveness of the industry.

JASPERS determined that the Centre of Biotechnology was likely to achieve its goals and to significantly contribute to the societal wealth and increased quality of life due to its commitment to IP commercialisation and technology transfer, supported by a comprehensible strategy and well thought-out organisation, including links to international research organisations and industry.

In the event of a significant reduction of the benefits as calculated, for example 50%, the project will still achieve an economic rate of return of around 5.7% and a positive ENPV of close to EUR2 million. The beneficiary appropriately identified several non-quantified benefits and rightly disregarded any additional fiscal and economic price corrections which were marginal. Taking the above into account, the analysis and CBA calculations provided suitable evidence for the project's results and thus it was deemed likely that an adequate economic rate of return would be achieved.

25 Manufacturing Capacity

Tom Andersen

25.1 Methodology

The economic analysis of the project proposal is undertaken to ascertain that the project is in line with the Bank´s financing rules (eligibility check) and that the project is an efficient rational allocation of resources. The Bank not only carries out a systematic project appraisal, but will also be monitoring and evaluating the project afterwards.

The project appraisal considers feasibility and options analysis. Feasibility of the project encompasses rationale for the Bank´s financing (value added), technical description and capacity, investment costs, implementation, market and sector analysis, implementation, operation, environmental impact and financial return from the investment, and economic benefits arising from the project. In this analysis, the alternative options are duly considered.

For all types of projects three alternatives could be considered: 1) the “do nothing” alternative; 2) the “do minimum” alternative; and 3) the “do something (else)” alternative (alternative technology or concept). Depending on the nature of the project, the EIB typically defines the counterfactual as the “do nothing” alternative or the “do minimum” alternative (see chapter 3 on defining the counterfactual scenario) to compare the situation with and without the project. The calculation of the financial and subsequently economic performance indicators must therefore be performed on the basis of the difference between the situation with the project (that is a “do something” alternative) and the counterfactual (usually “do nothing” or “do minimum”) alternative.

As such the economic justification of the project would encompass: 1) economic appraisal of value added of the project; 2) calculation of the project’s economic rate of return; 3) estimation of external costs/benefits, such as environmental impact, regional development, employment creation, etc.; and 4) a sensitivity analysis.

The usual outcome of a manufacturing industry project would be: 1) the end-product produced; 2) the impact on employment, 3) social surplus (producer’s and consumer’s surplus); 4) support of regional livelihoods; and 5) generation of fiscal revenues to local community, regional authorities and state.

25.1.1 Market analysis

The market addressed by the project will, as a rule, need to be analysed, even for environmental projects which do not lead to a capacity expansion. The investment will still have to be economically justified and financially viable as the loan will have to be paid back. When considering a capacity expansion, the project may have import-substitution or export-oriented rationale. The impact of the project on the local, regional and global market (if relevant) will be taken into account, when assessing potential market demand, market supply, growth forecasts, prices and development, competitors and potential new capacity on the horizon. All this information will feed into the financial and economic analysis.

25.1.2 Financial profitability

The purpose is to use the financial variables coming out of the project appraisal to analyse the project’s cash flow in order to establish financial internal project rate of return (FRR) which can be benchmarked vis-à-vis other projects financed by the Bank. This analysis provides the Bank with most of the information on inputs and outputs, prices and timing (data on costs and benefits) needed to do a cost-benefit analysis (CBA).

The analysis is usually performed as a differential cash flow analysis (with and without the project). The time horizon of the analysis is determined by the economic life and would usually be 8-15 years for productive investments. This may be limited by length of concession rights, need for large reinvestments, product substitution risks, etc. Real or constant prices are used. It will a priori be expected that the financial internal return is higher than the sector specific hurdle-rate would usually be for a productive investment. For an environmental investment without an inherent capacity expansion the financial internal rate of return could be negative.

25.1.3 Economic profitability

The economic analysis appraises the contribution of the project to the economic welfare of society at large. As such the analysis is made on behalf of the whole society and not just the project promoter. This means that all input or output variables in the financial analysis would have to be adjusted to reflect this approach. As such there will benefits and social costs (externalities) not considered in the financial analysis, which by their inclusion will allow a transformation of the financial analysis into an economic analysis, which yields the economic rate of return (ERR).

If there are subsidies or other transfers involved, they will have to be netted out. That implies that input and output prices should be net of VAT and other indirect taxes. If there are significant market distortions for example, then the prices will need to be adjusted to reflect opportunity costs. Within the EU this is however not the case in most productive industries as markets are liberalised and prices are little or not distorted. There might be a situation however, where a promoter for some reason has acquired land below market prices, or at too low a rent not properly reflecting the opportunity cost of this specific project input. An essential production input which often should be adjusted to reflect its social opportunity cost is labour cost (wages), as labour markets are imperfect. Here a so-called shadow wage should be applied to take into account that under conditions of high unemployment actual wages are higher than the opportunity cost of labour.

The environmental impact of a project will also be considered. As an example a capacity expansion would usually lead to an increase in CO_2 emissions, which should be considered in their own right, but also in the context of the alternative investment, which may have higher emissions etc. The economic value of this negative externality needs to be factored in and will ceteris paribus lead to an ERR below the FRR. On the other hand a project may have an environmental purpose, such as a significant energy-saving or emission-lowering component, which leads to net environmental benefits not already included in the financial rate of return analysis. In developing countries market prices for products considered as strategic are often regulated by the government. Such prices will have to be adjusted to reflect the internationally prevailing price if it exists. This depends on the sector. If there is no international market price for the product, the import parity price (or border price) may be calculated and used instead.

Other benefits with social impact could be training, provision of education, building of schools, water wells, provision of energy for the households, medical checks, vaccinations and health facilities provided by the promoter in the context of the project for local community.

In general all significant social and economic spillovers, even when not quantifiable, should be taken into account. It is recommended that the analysis lists the main unquantifiable externalities vis-à-vis the ones encompassed in the calculation of the economic rate of return. Also, potential project impacts in terms of relocation of economic activity, in addition to the creation of new activity, should be considered in the analysis when relevant, at least qualitatively. As a result of this exercise, the ERR is generally higher than the FRR.

25.2 Manufacturing capacity case study

The project consists of the construction and operation of a greenfield integrated cement plant, dedicated to supplying cement to the local market. The plant will be centrally located close to essential raw materials, but still well placed to supply the main economic centre in and around the country’s capital.

Unmet demand of cement prevails in the country. A local entrepreneur wants to build a greenfield cement plant to produce cement locally instead of importing cement over long distances from nearby countries at high prices. The project rationale therefore is import-substitution, and the right timing should allow the promoter to build a strong market share in a growing cement market generating local jobs in a region suffering from high unemployment and general underemployment.

25.2.1 Impact of the project

The plant will address an unmet, growing demand for cement, while partially substituting cement imports. Thus, the project should help to ensure lower cement prices, while facilitating infrastructure development and meeting general housing demand. At the same time the project will support the Government's Industry and Urban Infrastructure development goals (e.g. public and private housing, bridges, dams, schools and enterprises) as outlined in the planning programmes. The project will have an impact on economic activity in the area around the site, in particular on employment. It will thus underpin the livelihood of a large number of inhabitants in the local community, which currently suffers from unemployment. Indirect employment creation will also be the result from the social and economic impact of the project.

25.2.2 Market context

Cement is being imported and transported over long distances, incurring high costs in the process. In some cases there are additional surcharges which will make imports even more expensive. However, even if the government alleviates the restrictions on imports and fully liberalises the market, selling prices to direct customers of imported cement would not fall lower than the import parity prices. The project company would nevertheless retain its competitive advantage given its advantageous location vis-à-vis the country's capital.

Growth in cement usually tracks GDP growth in low-income countries, and is generally driven by housing demand, development within the construction sector and public infrastructure projects. Cement is heavy and bulky, and is thus expensive to transport over long distances. This makes cement a largely local/regional business. As cement is a uniform product, price is an important sales parameter. The cement industry has all the characteristics of a mature industry: low profit margins; cyclical capacity build-up; limited innovation; a constant struggle with overcapacity and regular consolidation waves.

Cement demand in the country has been growing faster than GDP at an average of 15% pa for the last years and is expected to continue at this rate the next 5 years. The country has a significant unmet demand prevailing on top of planned infrastructure projects and large-scale housing construction plans.

In sum, the company should be able to command an average sales price well above its average production costs and below the costs of the cheapest landed cement in the region. Due to the timing of the project and its favourable location, it will be well placed to address the growing cement demand and should thus be able to secure a significant market share for the promoter vis-à-vis the other important projects currently in the pipeline, while remaining viable even under moderately adverse market conditions.

As other projects are on the drawing board and there is a substitution risk of smaller quantities of lower quality cement in the future, price competition may increase in the future. Hence, a sales price lower than the present import parity price has been assumed for the economic return calculation. Even then the estimated average sales price, being significantly below the present import parity price, is well above average production costs.

Table 25.1 summarises the results of the project economic appraisal. This plant has an economic life of at least 15 years. All monetary figures are expressed in constant prices.

Table 25.1:
Calculation of industrial project return

	Greenfield project	year	**-2**	**-1**	**0**	**1**	**2**	**3**	**4**	**5**	**10**	**15**
	Production/sales											
(1)	Cement production	000 ton				1400	1950	2150	2150	2200	2200	2200
(2)	Cement Net Sales	MEUR				67	93	101	101	102	102	102
	Production cost											
(3)	Variable costs	MEUR				33	46	51	51	52	53	53
(4)	Fixed costs	MEUR				4	5	5	5	5	5	5
(5)=(3)+(4)	Total production cash costs	MEUR				37	51	56	56	57	58	58
(6)=(2)-(5)	**Operational profits**	**MEUR**				**30**	**42**	**45**	**45**	**45**	**44**	**44**
(7)	Investment cost	MEUR	50	90	70	35						
(8)	Working capital	MEUR				15						
(9)	Replacement investments	MEUR								5	5	5
(10)=(6)-(5)	**Operating cash flow**	**MEUR**	**-50**	**-90**	**-70**	**-20**	**42**	**45**	**45**	**40**	**39**	**39**
	IRR	**11%**										
(11)	Net economic benefits		-3	-6	-3	6	8	8	8	8	10	10
(12)	**Economic cash flow**		**-53**	**-96**	**-73**	**-14**	**50**	**53**	**53**	**48**	**49**	**49**
	ERR	**14%**										

The economic rate of return is based on an estimate of the social opportunity cost for labour, the net exchange rate savings, and the economic price for cement (refer to line 11). Under these assumptions the economic rate of return (ERR) is 14%, significantly higher than the FRR. This indicates that this is a project where the promoter will not appropriate the full economic benefits of the project.

This ERR should be regarded as the lower boundary of the true ERR, since no further quantitative adjustments have been made for the important beneficial spill-over effects to other sectors of the economy such as on infrastructure and housing, when more cement becomes available and at lower prices. Also, it is worth mentioning that there will be significant indirect employment effects in the area close to the plant when there is unemployment, although these effects will to an extent be counterbalanced by negative externalities in the form of increased traffic and associated emissions.

The project has received a technical assistance in form of a grant to further explore using encroacher bush woodchips as an alternative way of meeting the plant's energy demand. This would provide the plant with a renewable source of energy at the same time as rehabilitating the land for farming.

26 Telecommunications

Jussi Hätönen

26.1 Methodology

Telecommunications refer to infrastructures needed for the provision of telecommunications (e.g. telephony and Internet) and other media (e.g. television) services over fixed or mobile infrastructures. Such infrastructures also include satellites, which are sometimes used in addition to basic telecommunications services for research or observation purposes, for instance. Telecommunications infrastructures are a subset of what is typically referred to as information and communications technologies (ICTs), which also include areas such as electronics manufacturing and software development which are discussed separately in this document.

While the economic benefits of telecommunications networks have been widely reported, problems in creating a single methodology to assess the economic benefits of telecommunications projects derive from the complexity of the industry. As some type of telecommunications networks have been already deployed in almost every part of the world, the projects which we increasingly deal with no longer relate simply to enabling (broadband) Internet or voice service availability (as opposed to not having any availability), on which majority of the academic research has focused on, but more and more it is about increasing capacity and quality of service – which carry different types of economic returns. The existing technological and market environment imposes added complexity to the analysis. For instance, in developing the methodology for each individual project several questions need to be addressed regarding the existing telecommunications infrastructure and competition environment such as: What is the service and its quality enabled by the project? Are there existing technologies that can provide similar service in the project area? Or is the low quality or lack of infrastructure-based competition maintaining high consumer prices?

Therefore from the economic perspective it is not sufficient to classify projects based on the technology or simply the service they enable, but on the basis of what is the value-added of the project and the service it enables to the market. Based on this approach telecommunications projects can be classified based on their ability and nature of generating economic value added into the following categories: (i) network/service coverage expansions, (ii) network/service quality improvements, and (iii) network modernisations (leading to operational efficiency gains). The methodology to assess the economic returns in these project categories is discussed below.

26.1.1 Network/service coverage extensions

In respect to network/service coverage expansions (i) typical mobile projects include expansions of GSM and 3G, and going to the future LTE (Long-Term Evolution) and 4G, access network coverage in previously uncovered areas to enable voice and/or broadband data services. In fixed line the projects include deployment of fibre or cable access networks and related support infrastructures (e.g. backbone). Projects in this category include also satellites enabling mobile, broadband and/or television services. Assessing the economic return of network coverage expansions is a relatively straightforward task when a similar service is not provisioned before. For instance several academic studies have outlined the economic returns of telecommunications by investigating the correlation between economic growth (GDP) and mobile or broadband penetration, clustering the different economic benefits of telecommunications such as employment generation, market efficiencies and productivity gains to a single measure of economic gains – i.e. additional increase in GDP. In the mobile arena, studies have concluded that a 10% increase in mobile penetration contributes on average 0.6 to 0.8 percentage points of additional GDP growth, while a 10% increase in broadband penetration contributes 0.9 to 1.5 percentage points to GDP growth.[77] However, while these

[77] E.g. Nina Czernich & Oliver Falck & Tobias Kretschmer & Ludger Woessmann, 2011. "Broadband Infrastructure and Economic Growth," *Economic Journal, Royal Economic Society*, vol. 121(552), pages 505-532, 05

results are based on static models, often comparative between developed nations (OECD), they do not provide sufficient basis for investigating the impact of deployment projects. To avoid excess complexity in the analysis, the calculation of economic return in coverage expansion projects is based on the finding that broadband contributes 1 percentage point additional GDP growth in developed economies. Given earlier studies, mobile voice can be expected to have a slightly lesser effect than this.[78] Advanced economies are estimated to have a broadband penetration of 70% of households (which is in EU-15). The GDP effect can be expected to linearly decrease in lower penetration levels.

So in simplified terms the methodology of calculating the economic return of a coverage expansion entails estimating the additional penetration achieved through the coverage expansion over the economic life of the infrastructure, and calculating the effect on GDP growth, i.e. as follows:

[(coverage expansion (% of population) x estimated uptake rate (% of population covered) x growth effect (per additional penetration) x country's/area's nominal GDP] x n years (n= the economic life)

In this calculation a coefficient can be used to adjust the growth effect. This is due to the characteristics of the telecommunications industry and its network effects. Prior research has shown that in respect to the growth effect there are increasing returns to scale, meaning that the higher the penetration the higher the growth effect. Koutroumpis (2009) suggested that a critical mass effect can be achieved when 50% of the population in a country have access to broadband services, and similarly this can be applied to mobile voice communications. Therefore for population coverage, i.e. availability of the service, the following coefficients can be used for the growth effect:

Coverage	0%-10%	10%-20%	20%-30%	30%-40%	40-50%	>50%
Coefficient	0.5	0.6	0.7	0.8	0.9	1.0

Also the effect can be adjusted by a technology coefficient. This is due to the fact that while for instance mobile 3G and fibre-to-the-home (FTTH) technologies can both enable broadband services, the service quality with fibre-to-the home is much higher, indicating much higher economic benefits than the mobile technology.

26.1.2 Network/service quality improvements

In respect to projects improving network/service quality (ii), typical project examples are deployment of backbones such as submarine cables to replace satellites, for instance for providing backhaul traffic, or deployment of fibre based fixed lines or LTE/4G access networks to improve DSL or 3G based broadband access networks. In respect to assessing the economic return while the service to be enabled exists on some level, the economic assessment needs to be corresponded to the increased quality and the economic externalities it can provide. For instance, in a case of FTTH deployment in areas with existing copper (DSL) network, the inhabitants have already access to basic broadband, yet the FTTH deployment enable much higher broadband access speeds that unlock additional economic benefits. In this respect two questions need to be addressed. Firstly what is the likely increase in service penetration due to the increased quality? If the existing service quality is poor and therefore impeding service uptake, the deployment of higher quality network is likely to increase the uptake in the area. For this estimated net addition the uptake effect on GDP growth, as discussed above in more detail, can be used. Secondly, for the existing subscribers of the lower quality service, what level of productivity gains are enabled by the better quality networks? This calls for more qualitative service-based approach, that is, to investigate the additional possibilities (services) enabled by the higher quality networks and their potential

Qiang, C.Z-W. and Rossotto, C.M. (2009). "Economic Impacts of Broadband Information and Communications for Development 2009: Extending Reach and Increasing Impact". The World Bank.

[78] Harald Gruber & Pantelis Koutroumpis (2011) "Mobile telecommunications and the impact on economic development", *Economic Policy*, July 2011, 387-426

further productivity gains. Productivity gains may derive from lower consumer costs, which is often the case in replacing expensive satellite backhaul transmission links with high capacity submarine cables. So, in sum, addressing the economic benefits calls for a two-staged approach:

1. Benefits for the existing service customers:

[Number of existing customers x estimated productivity gain per customer (annual cost saving)] x n years (n= the economic life)

2. Service uptake increase:

[Estimated net uptake increase (% of population covered) x growth effect (per additional penetration) x country's nominal GDP] x n years (n= the economic life)

Similar approach can be applied also to projects which do not deploy advanced technologies to improve service quality, but that introduce competition to the market and through that lead to productivity gains and improved service quality. Also the competition is likely to result in lower consumer prices, and with elastic demand this will also increase the uptake of the service in the area and contribute to dead weight loss. However, in case of parallel deployment of similar technology, the direct environmental effects need to be assessed as a negative consequence.

26.1.3 Network modernisations

In respect to final category of projects, network modernisations, while these projects may lead to some quality improvements, the basic rationale typically lie in reducing operation and maintenance (O&M) costs of the promoter. A typical example is the modernisation of GSM and 3G networks, where the trend is to move from having separate network equipment for GSM and 3G networks to a single radio access network design, whereby these same services are provisioned by much less active equipment resulting in lower O&M costs. Therefore the economic return is in line with the financial return. However, often part of the operation and maintenance savings, often even significant part, derive from savings from electricity consumption thereby having an economic effect in respect to CO_2 emissions. The price of carbon is currently set at EUR25 per ton of CO_2. Therefore, the basic methodology of assessing the economic return of network modernisation projects is as follows:

Financial Cash flow (FCF) + [yearly electricity savings converted to CO_2 savings x price of carbon x n years (n= the economic life)

Table 26.1: summarises the quantifiable economic benefits of the three different telecommunications project categories. In respect to energy consumption and CO_2 emissions, apart from parallel network deployments, telecommunications infrastructures are expected to have a neutral or positive direct impact. This is due to the fact that although telecom networks consume energy, it will significantly reduce travelling, for instance, therefore offsetting the consumption at minimum. This has been shown in a broad range of academic research. Furthermore, telecommunications have a well reported indirect effect on reducing CO_2 emissions, but these are not included in the assessment. However, the Bank is currently working with other institutions to identify the total effect of telecommunications on the environment (through life cycle assessment).

Table 26.1:
Sources of quantifiable economic benefits by project category

	Economic growth effect (GDP)			
	Employment	Efficiencies	Productivity	CO_2 impact
Network/service coverage expansions	+	+	+	0
Network/service quality improvements	0 / +	+	0	0 / -
Network modernisations	0	0	+	+

It is widely acknowledged that telecommunications networks in fact have limited negative externalities, and therefore argued that in the CBA the economic return (ERR) is typically greater than the financial return (FRR) of a project. Furthermore, there exists a vast number of reported more qualitative positive socio-economic externalities from telecommunications network deployments, namely increased access to education and healthcare services, increased social inclusion, supporting regional development, positive effects in improving safety, contribution to freedom of speech and democracy, and so on. If the project allows it, such externalities, to a certain extent, can be factored into the analysis on a case-by-case basis. However, the general conclusion is that by only including the quantifiable variables in calculating the ERR, the outcome is deemed to be on a conservative side.

In general, the high level of complexity involved in assessing the ERR of telecommunications projects calls for a case-by-case judgment on the approach and methodology applied. For instance, whether to use standard conversion, and to what extent, of the project cost depends on the type of project, technologies used, and deployment method. In following sections, an illustrative case of each telecommunications project type is shown.

26.2 Case study (1): Network/service coverage expansion – Case of mobile broadband

The project involves the expansion of a mobile broadband (HSPA+ 3G) network in a European country to increase the current coverage from 91% to 98%, enabling mobile broadband services to 7% of the country's population. The areas included in the project are currently not served by any type of fixed or wireless broadband networks. These areas are mainly rural and remote areas of the country, and therefore there exists a high deployment cost per population covered.

Due to this high unit cost of deployment, the estimated 6% financial rate of return (FRR) for the project is relatively low in general for telecommunications projects. Furthermore the FRR estimate already includes national subsidies, 4% of the total investment, which were awarded to the company for providing broadband services in uncovered areas. The economic life for the project was estimated to be 7 years after the implementation.

To assess the economic rate of return (ERR) of the project, the impact of the project on GDP was used. The ERR calculation did not build on the business case as including the service revenues could lead to double counting effect. Although the coverage expansion areas, totalling to 7% coverage increase in the country, were scattered around the nation, for calculation purposes the approach considered the expansion area as a single area. This leads to a conservative approach to the calculation for reasons explained below in more detail.

The basic methodology in assessing the ERR was to project the uptake rate of broadband services in the coverage area and estimate the GDP growth impact of this. As a baseline estimate it was assumed, based on earlier academic studies, that broadband contributes an additional 1 percentage point to GDP growth in developed countries. This one percent was used as a growth impact cap, growing linearly as the uptake increases. We estimated that as the broadband penetration in the EU-15 averages close to 70% of households, this would enable the 1 percent additionality, while with a lower penetration the impact would be lower (linear decline calculated: coverage in a given year (%)/70% x 1).

The following adjustments and related coefficients were used to adjust the GDP impact:

- A 0.5 (50%) technology adjustment was used to scale down the effect due to application of mobile broadband. Although mobile solutions, HSPA+ in this case, are efficient to provide basic broadband solutions in rural and remote areas in particular, they lack in respect to access speed, consistency and reliability in comparison to the most recent fixed line infrastructures (e.g. FTTx). Therefore it is plausible to expect that as the total GDP impact is based on an aggregate level, mobile technologies do not allow certain services and in turn the GDP effect is lower than the average.
- The GDP impact was further adjusted with penetration. This due to the fact that telecommunications has increasing returns to scale, meaning that the higher the

penetration the higher the impact. Therefore, although the adjustment of the total impact was based on the penetration, the further penetration adjustment will break the linearity of the impact. As a threshold 50% household penetration is used, this would yield the full GDP effect. Below 50% the impact is down modulated by 10pp for every 10% decrease in the penetration rate (e.g. a penetration of 40-50% yields a coefficient of 90%). By this logic the lowest possible coefficient in penetration range of 0-10% of households would be 50%.
- Due to the fact that the coverage expansion in the country is in the most rural and remote parts, it was assumed that the GDP in the area is lower than the proportion of population living in the area. This is due to the fact that it can be estimated that businesses, for instance, are not present to a wide extent in these areas. It is estimated that the GDP generation in the coverage area is 50% of the relative share of the population living in the area.

The GDP effect was calculated without the direct revenues accumulating from the project, as this would lead to double counting of benefits.

With these assumptions an economic rate of return (ERR) of 32% is derived for the economic life of 7-years as illustrated in Table . However, to assess the sensitivity of the ERR it was also calculated for a 5-year period. The resulting ERR is 23%.

26.3 Case study (2): Network/service quality improvements – Case of a submarine cable deployment

The project consists of the deployment of a fibre optic submarine cable to connect a remote island to the rest of the world. The cable would enable transmission of voice and data traffic to and from the island, which is currently reliant on highly expensive satellite links. The project would be ready for service two years after the beginning of building works.

With the cash flow estimates the project would result in a financial net present value (FNPV) of USD-5.5 million with a discount rate of 10%. This value is for an estimated economic life of 15 years and excludes any residual value for the investment at the end of the life. With residual value the FNPV was USD-2.4 million. In the estimation of the economic return of the project, the costs were firstly converted by using simple conversion factors. For calculating the economic return (ENPV/ERR) of the project, the following conversions were made:

- Operational costs were converted with a conversion factor (CF) of 0.8. This is justified by the fact that the operational costs of the submarine cable entail to large extent labour, for which salaries do not reflect opportunity costs..
- Capital expenditures were converted with a CF of 0.96, mostly related to labour costs.

In addition, some positive externalities were estimated to calculate the economic effect of the project. Firstly, it is quite plausible that the project would result in lower consumer Internet connection prices given that proper regulatory / ownership conditions are applied. Only effects to broadband Internet prices were considered in our approach. The decreases in broadband prices were estimated based on current price of international capacity, consumer prices, connection speeds and contention ratios. It was identified that approximately 45% of the current Internet prices derive from the cost of international capacity. It was further estimated that due to the sevenfold initial decrease in international connectivity, consumer prices will decrease by 35% after the introduction of the cable.

Table 26.2: Calculation on network/service coverage expansion returns

		Units	Year -2	Year -1	Year 0	Year 1	Year 4	Year 7
	FINANCIAL RETURN OF THE PROJECT							
(1)	3G Network Coverage increase	%	93%	96%	98%	98%	98%	98%
(2)	Mobile revenues	EUR	5,806,330	28,160,700	57,363,347	74,189,928	118,494,503	154,495,334
(3)	Mobile broadband revenues	EUR	4,000,198	19,425,420	39,886,862	52,118,834	85,844,201	115,422,679
(4)	Fixed revenues	EUR	4,492,111	21,337,526	42,568,364	53,919,928	80,901,797	99,090,255
(5) = (2)+(3)+(4)	Total revenues	EUR	14,298,638	68,923,646	139,818,573	180,228,690	285,240,501	369,008,267
(6)	EBITDA margin	%	47.0%	46.5%	46.0%	45.5%	44.0%	42.5%
(7) = (5)*(6)	Total EBITDA	EUR	6,720,360	32,049,496	64,316,544	82,004,054	125,505,820	156,828,514
(8)	Total 3G expansion capex	EUR	246,000,000	264,000,000	251,000,000	0	0	0
(9) = (7)-(8)	Cash flow	EUR	-208,279,640	-231,950,504	-186,683,456	82,004,054	125,505,820	156,828,514
(10) = IRR(9)	FIRR		**6%**					
	ADJUSTMENTS TO THE ECONOMIC RETURN							
(11)	Additional coverage	%	2%	5%	7%	7%	7%	7%
(12)	HH Uptake rate projection	%	5%	10%	20%	28%	49%	65%
(13) = 1*(12)/70%	GDP effect coefficient (pp)	70%	0.071	0.143	0.286	0.400	0.700	0.929
(14) = (13)*50%	Technology adjustent	50%	0.036	0.071	0.143	0.200	0.350	0.464
(15) = (14)*50%	Penetration adjustment	50%	0.018	0.036	0.086	0.140	0.315	0.464
(16)	GDP in area considered w/o project	EURm	58,155	59,900	61,697	63,547	69,440	75,879
(17) = (16)*1+(15)	GDP growth with the project	EURm	58,165	59,931	61,780	63,720	70,168	77,636
(18) = (17)-(16)	Delta growth	EURm	10	31	83	172	728	1,757
(19)	Total project cost (non converted)	EURm	254	301	327	98	160	212
(20) = (19)-(18)	Cashflow	EURm	-243	-270	-243	74	568	1,545
(21)	Discount rate	2%	1.0	1.0	1.0	1.1	1.1	1.2
(22) = (20)/(21)	Real economic CF	EURm	-243	-264	-234	70	505	1,292
(23)	Cumulative	EURm	-243	-508	-742	-672	336	3,367
(24) = IRR(22)	ERR 7 YEARS	%	**32%**					
(25) = IRR(22)	ERR 5 YEARS	%	**23%**					

Due to the caution of not to double count the positive externalities, the decrease of the consumer prices were taken into account only in the extent of Internet customers existing before project implementation. Instead, and secondly, the increased take-up of communications services, another widely referred positive externality of a telecommunications investment, was accounted as a separate economic benefit. This is due to the fact that as these “new” users have not been paying for the services before, the price reduction does not produce added economic value per se, but their adaptation of the service does.

These benefits and other positive externalities were calculated as a growth impact to the country’s gross domestic product. Prior studies on developing countries have identified that a 10% increase in broadband take-up for instance provides 1.21-1.38% additional GDP growth to the country through increased productivity, foreign direct investment (FDI), exports and employment (other than directly involved in the telecommunications industry) for instance (source: World Bank). In our analysis, we applied conservative approach by estimating the growth effect of being in the developed nation level (1.21% additional growth per 10% increase in broadband take-up). Due to this conservative approach and as the Internet penetration level in the country is relatively high at the moment, a coefficient of 1 was applied. It was also estimated that during its life the cable contributes 30 percentage points higher household penetration than would happen with current satellite infrastructure. From the additional GDP growth, government tax revenues (25%) were calculated as economic benefit.

Figure 26.1:
Economic benefits deriving from decreased consumer prices and consequent increased broadband penetration based on price elasticity

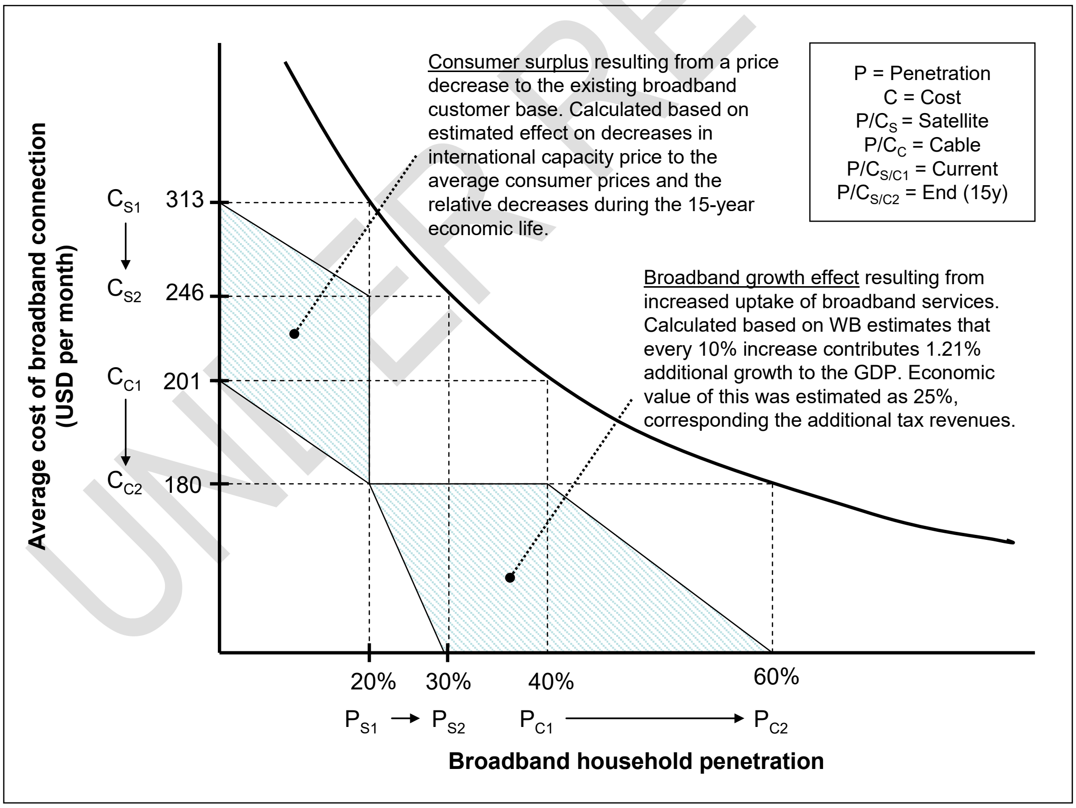


Figure 26.1 illustrates these benefits. The vertical axis displays the average cost of broadband connection, the independent variable. Without the project (i.e. satellite) the consumer prices are expected to slightly decline from the current EUR313 to EUR246 per month. With the project (i.e. cable) an immediate drop to EUR201 per month is foreseen, with a further decline to EUR180 per month by the end of the economic life of the project. The horizontal axis includes

the broadband household penetration, the dependent variable. Without the project (i.e. satellite) the broadband uptake is expected to slightly increase from the current 20% to 30% of the households in the country. With the project (i.e. cable) it is expected that an immediate increase to 40% of households will be seen due to the price decrease and increasing to 60% by the end of the economic life of the project.

Converting the costs and taking into account the positive externalities the project would result in an indicative economic net present value (ENPV) of USD108 million (corresponding to a real ERR=30%) with a discount rate of 10% (from nominal cash flow estimates). This value does not take into account any residual values of the project, and is based on a conservative estimate of 15 years economic life of the project. Technically the infrastructure can have a life of 25 years, but examples of other submarine systems show that in a 15 years time frame it may be substituted by more advanced infrastructures.

26.4 Case study 3. Network modernisation – Case of equipment swap out

The project consisted of the modernisation of the promoter's existing mobile telecommunications network in a European country. In technical terms, the project entailed swap out of total of 8,467 base stations with latest technology called single radio access network (SRAN). SRAN technology allows the promoter to run both GSM and 3G (Universal Mobile Telecommunications System, or UMTS) services through single network equipment, as opposed to having separate network equipment for both services. This will allow the promoter to save on operation and maintenance costs.

The financial return was calculated on the basis that the promoter would be able to reduce its network O&M costs on average by 30% in the replaced 8,467 sites, resulting in a total 5% O&M reduction. This would enable savings of around EUR38 million per annum. This correlated to the cost of the swap out would generate a FRR of 8% with an estimated economic life of 7 years. This can be considered a conservative assessment, as in addition to OPEX savings the swap out will increase slightly the quality and capacity of the networks. The revenues do not include potential upsides from the increased quality. If, however, a 2% additional increase in data revenues occurs due to the increased capacity, the resulting FRR for the project would be 22%.

Unlike projects which include coverage expansion or quality improvements of the network, modernisation, although it may have some impact on increasing the overall quality of the network, aims solely at efficiency improvements. Also unlike the two other types of telecommunications projects, where there is some accepted methodology regarding the economic impact, the assessment of the economic return in network modernisation projects is done through adding (and subtracting) externalities to the FRR. In this case the externalities derive from energy savings, and thereby consequent savings on the CO_2 emissions. The baseline for the calculation lies in the fact that the SRAN swap out would enable 33% savings in the energy consumption of the replaced site, estimated to drop from 1.5 kW to 1.0 kW after the swap out. Through the swap out of the 8,467 sites yearly electricity savings of 37 million kW/h can be reached, translating close to 20k tons of CO_2 equivalent (through applying national grid conversion factor). This can be monetised through applying the price of carbon (EUR25 per CO_2 ton).

As can be seen in Table 28.4, adding the monetised CO_2 savings would give 1 percentage point uplift to the IRR. The minor uplift illustrates that the energy consumption of the network is minor to begin with, and therefore even 33% energy savings will not lead to excessive economic value. On the other hand, this calculation illustrates that as the externalities involved in the project are predominantly positive, the ERR is inherently higher than the FRR.

Table 26.3: Calculation on network/service quality improvement returns

		Units	Year -1	Year 0	Year 1	Year 4	Year 7	Year 10	Year 13	Year 15
	PROJECT FINANCIALS									
(1)	EBITDA on cable	USD	0	-90,000	3,398,330	3,526,044	4,534,665	4,525,048	4,973,015	5,253,332
(2)	Total capex	USD	7,203,143	25,801,153	944,244	0	0	0	300,000	0
(3) = (1)-(2)	Project cash flow	USD	-7,203,143	-25,891,153	2,454,086	3,526,044	4,534,665	4,525,048	4,673,015	5,253,332
	OPEX AND CAPEX CONVERSION									
(4) = OPEX*CF	OPEX conversion	CF = 0.96	0	18,000	185,534	250,207	252,036	253,977	256,037	256,752
(5) = (2)*CF	CAPEX conversion	CF = 0.8	288,126	1,032,046	37,770	0	0	0	12,000	0
	TAXES AND CONSUMER SURPLUS									
(6)	Consumer surplus	USD	0	0	4,034,006	6,923,395	6,100,141	5,300,524	4,585,244	4,169,298
(7)	Additional tax revenues	USD	0	0	1,736,021	6,723,184	10,741,090	15,319,005	22,149,573	26,805,949
(8)	Taxes	USD	0	0	0	85,118	215,417	619,948	696,714	805,467
(9) = (7)+(8)	Total tax benefit	USD	0	0	1,736,021	6,808,302	10,956,507	15,938,953	22,846,288	27,611,416
	PROJECT RETURNS									
(10)=(3)+(4)+(5)+(6)+(9)	Economic cash flow	USD	-6,915,017	-24,841,107	8,447,417	17,507,948	21,843,349	26,018,502	32,372,584	37,290,797
(11)	Discount factor	r=10%	1.1	1.2	1.3	1.7	2.3	3.0	4.0	4.8
(12) = (10)/(11)	Economic real cash flow	USD	-6,585,731	-21,507,452	6,648,892	10,353,389	9,704,841	8,685,073	8,118,774	7,729,109
(13)	Cumulative	USD	-6,585,731	-28,093,183	-21,444,290	10,445,008	40,717,586	67,366,112	92,498,840	108,187,593
(14) = IRR(12)	ERR 15 years	%	**30%**							
(15) = NPV(10),10%	eNPV 15 years (r = 10%)	USD	108,187,593							

Table 26.4: Calculation on network modernisation returns

		Units	Year -2	Year -1	Year -0	Year 1	Year 4	Year 7
	ELECTRICITY SAVINGS CONVERSION							
(1)	Replaced sites with SRAN	#	2,467	3,267	2,733	0	0	0
(2)	Cumulative	#	2,467	5,733	8,467	8,467	8,467	8,467
(3)	Electrivity consumption w/o project	KW/year	111,252,000	111,252,000	111,252,000	111,252,000	111,252,000	111,252,000
(4) = (3)-(2)*SpS	Electrivity consumption with project	KW/year	100,448,000	86,140,000	74,168,000	74,168,000	74,168,000	74,168,000
(5) = (3)-(4)	Electricity savings	KW/year	10,804,000	25,112,000	37,084,000	37,084,000	37,084,000	37,084,000
(6) = (5)/(3)	Relative saving	%	9.7%	22.6%	33.3%	33.3%	33.3%	33.3%
(7)	Cumulative	KW/year	10,804,000	35,916,000	73,000,000	110,084,000	221,336,000	332,588,000
(8) = (5)*CF/1000	Saving in CO2 equivalent	tCO2	5,726	13,309	19,655	19,655	19,655	19,655
(9)	Cumulative	tCO2	5,726	19,035	38,690	58,345	117,308	176,272
(10) = (8)*PC	Value of the CO2 savings	EUR	143,153	332,734	491,363	491,363	491,363	491,363
(11)	Cumulative	EUR	143,153	475,887	967,250	1,458,613	2,932,702	4,406,791
	FINANCIAL AND ECONOMIC CASHFLOWS							
(12)	Delta decrease in operating cost	EUR	0	38,150,000	38,150,000	38,150,000	38,150,000	38,150,000
(13)	Per site	EUR		4,506	4,506	4,506	4,506	4,506
(14)	Relative	%		5.0%	5.0%	5.0%	5.0%	5.0%
(15) = (11)	Value of CO2 savings	EUR	143,153	332,734	491,363	491,363	491,363	491,363
(16) = (12)+(15)	Total revenues	EUR	143,153	38,482,734	38,641,363	38,641,363	38,641,363	38,641,363
(17)	Total cost	EUR	74,000,000	98,000,000	82,000,000			
(18) = (12)-(17)	Financial Cashflow	EUR	-74,000,000	-59,850,000	-43,850,000	38,150,000	38,150,000	38,150,000
(19)	Cumulative	EUR	-74,000,000	-133,850,000	-177,700,000	-139,550,000	-25,100,000	89,350,000
(20) = (16)-(17)	Economic Cashflow	EUR	-73,856,847	-59,517,266	-43,358,637	38,641,363	38,641,363	38,641,363
(21)	Cumulative	EUR	-73,856,847	-133,374,113	-176,732,750	-138,091,387	-22,167,298	93,756,791
	PROJECT RETURNS							
(22) = IRR(18)	FIRR 7 years	**8%**						
(23) = IRR(20)	ERR 7 years	**9%**						

Notes: SpS = Savings per replaced Site, CF = (grid) Conversion Factor

27 Biofuel Production

Oliver Henniges

27.1 Methodology

27.1.1 First and second generation biofuels

Biofuels can be roughly classified into first- and second-generation projects. They are referred to as “first generation” when either bioethanol is produced from sugar or starch containing crops to replace gasoline or biodiesel is produced from oil seeds to replace diesel. These biofuels have been produced on a commercial scale for several decades in Brazil and the USA. In the EU, large scale production began in the late 1990’s. The required feedstocks are generally available, the technology is proven, and fuels produced are almost price-competitive with fossil fuels. These biofuels automatically generate valuable co-products, which either serve as animal feeds or as sub-products for energy generation depending on the feedstock used. In the case of bioethanol production from wheat, 30% by weight of the input raw material remains as a co-product and is used for animal nutrition. In the case of biodiesel from rapeseed, this proportion increases, with even 60% of feedstock going back to the food chain.

From an EU perspective, the most relevant feedstocks for <u>bioethanol</u> production are grains and sugar beet. For both, Europe shows the highest output yields per hectare in the world. The EU has been for decades a net exporter of these feedstocks. At the same time it has always been a net importer of protein for animal nutrition; the co-product of European bioethanol production. Thus, by just fermenting the starch-derived sugar component and separating the protein content from the starch-containing material, bioethanol production leads to the import substitution of protein-containing soybeans from overseas. At the same time, it also leads to higher value-added within the EU by reducing cereal exports which the WTO often has classified as trade distorting due to the underlying agricultural policies.

For the production of <u>biodiesel</u>, the market situation is different since, partly for historical reasons, the EU is a net importer of all raw material and by-product components (seeds, oil and the protein meal). The Bank has mostly therefore not approved any of the biodiesel projects presented for direct financing.

Second generation biofuels refer to the conversion of various kinds of biomass such as wood, crops with high biomass production potential, agricultural co-products that are not currently used, or certain types of waste. These are converted through innovative industrial processes into either traditional or advanced biofuels which have the physical properties of fossil fuels. What all these processes have in common is that they are at the R&D stage. These technological developments are based on the assumption of higher biomass resource availability and lower feedstock costs. However, transformation costs are not yet at a level to make second generation biofuels competitive. The Bank is observing activities in this sector with interest, as more new investment projects in this sector are expected to be submitted.

27.1.2 Biofuel’s social benefits

Biofuels are a degradable renewable energy source and its utilisation supports the EU energy policy under the EU Biofuel Directive 2009/28/EC. The Directive seeks to reduce the dependency of the transport sector from fossil fuels, thereby introducing a mandatory biofuel use of 10% calculated on the basis of energy content by 2020. This Directive requires minimum greenhouse gas (GHG) savings of 35% compared to fossil fuels, as also required for EIB financed biofuel projects. Moreover, this directive sets other necessary sustainability criteria like avoidance of indirect land use change (ILUC).

The production and consumption of biofuels involve also other positive externalities, like the energy supply security as biofuels produced in the EU substitute for fossil fuel imports and protein supply security, which is of high importance since Europe largely depends on imported proteins. Mostly this protein comes from genetically modified soybeans in the USA and Brazil, whereas European protein is free of genetically modified foods (GMO).

Biofuel production and, in particular, sourcing of its raw material is located in rural areas suffering from emigration of skilled labour forces. These projects generate additional welfare in the local economies via spill-over effects.

27.1.3 Biofuel's social costs

Firstly, the fiscal support for EU domestic biofuels via import tariffs for competing bioethanol from low cost production countries like Brazil has to be taken into consideration. However, it has to be kept in mind that the bioethanol feedstock sugar cane in Brazil is not produced in accordance with EU Cross Compliance standards and the bioethanol needs to be in line with the strict ILUC criteria. Moreover, due to high sugar prices and the exchange rate moving towards a stronger Brazilian Real, biofuels from Brazil are nowadays almost as expensive to produce as in Europe.

Other incentives like blending mandates for biofuels or excise tax reductions can be considered as social costs if they overcompensate for politically justified positive externalities, which are not included in the production costs.

There has been a strong discussion on the competition of biofuels and food for raw materials leading to higher prices. Even though there is still substantial economic research to be carried out regarding this competition, high commodity prices have led to an increase in production by taking marginal land under cultivation or, as it is the case in Europe, reducing set-aside land, which finally leads to an increased production of food crops.

However, it appears that for a few years, for several reasons, the expectations on and concerns of the food sector's capacity to respond to increasing demand has played a more significant role in the formation of soft commodity prices than in the past. Moreover, while the demand for soft commodities is rather growing steadily and excessive buffer inventories are now depleted, exogenous supply shocks increase price volatility. The production of agricultural commodities is highly dependent on weather conditions during the vegetation period. In a globalised market with increasing physical trade, unfavourable weather conditions in any major agricultural production region in the world (e.g. Brazil, Canada or Australia) affect the price of agricultural products in Europe. The combination of supply shocks and expectations on future developments on the agricultural markets can lead to short-term price extremes, be it high or low. Since this not only significantly influences the profitability of biofuel projects but also arouses the debate on first-generation biofuels and their impacts on food markets, the Bank is carefully observing this issue.

27.1.4 Screening criteria

The biofuel sector is one of the most controversial in the Bank. As a result of the political debate on biofuels the Bank has developed strict and detailed screening criteria for the appraisal of biofuel projects. The key issues analysed and evaluated in each submitted project proposal are as follows:

- Promoters should have industrial experience either in the energy, process technology, or agricultural sector;
- There should be a biofuel policy on the relevant off-take market;
- There should be sufficient equity and guarantees in place;
- Projects should have adequate off-take and supply contracts for the biofuel and its co-products as well as the required feedstock;
- Projects must be environmentally, socially and economically sustainable and comply with the EU Renewable Energy Directive (2009/28/EC) including GHG saving targets and calculation methods;
- Environmental Impact Assessment (EIA) and Integrated Pollution Prevention and Control (IPPC) permit must be in place;
- The project must show a sufficient profitability under realistic assumptions;
- A comprehensive feasibility study carried out by a qualified consultant or agency must be presented, taking into account all business risks.

27.1.5 The Bank's role

Although the Bank has only financed two biofuel projects so far, this sector plays a major passive role due to the large number of project proposals the Bank receives. The vast majority of these proposals simply fail to meet these strict screening criteria. Due to the political uncertainty, the above-mentioned fluctuating profitability and often unproven technology in case of second-generation biofuels, commercial banks are very reluctant in financing biofuel projects. The EIB can therefore play a key role as a project facilitator in the biofuel sector when promising project proposals are submitted.

27.2 First generation biofuels case study

The project comprises the construction and operation of a bioethanol plant in Europe. It will produce 100,000 t fuel bioethanol from about 330,000 t of wheat and barley as well as 104,000 t of protein containing Dried Distillers Grains and Solubles (DDGS) as a co-product used for animal nutrition. The plant has an economic life of 15 years.

For the calculation of the financial profitability, shown in Table 27.1, the key parameters to be defined and varied are the sales price for bioethanol (80% of revenues) and for DDGS (20%). If an average initial wheat price of EUR130/t, a DDGS price of 125% of the wheat price and an initial ethanol price of EUR550/m^3 is assumed the FRR is around 10.2%. The calculations were made in constant terms and there was no inflation taken into account. However due to an expected increase in demand for both, bioethanol and cereals, a price increase of 1% p.a. is assumed. All main parameters are commodities whose prices are rather cyclical and without direct linear link to annual inflation.

The FRR reacts very sensitively to ethanol- and wheat price changes. If ceteris paribus the wheat price goes up to an initial price of EUR173/t in 2013, a price level that has been achieved in 2010, the profitability becomes negative. However, this risk is mitigated by two factors:

1. Ethanol plants can be shut down ("mothballed") for a while if the production does not cover the variable costs. These high price periods have never lasted for more than one year in the past;
2. As plants are mothballed, the supply is limited. With a constant demand in Europe, defined by political targets, the ethanol price goes up.

In 2010, when wheat prices were high, ethanol prices were high too, although not directly correlated. So with the November 2010 price constellation of wheat prices of EUR200/t and ethanol prices of EUR60/m^3, the profitability of the plant was still around 10%, mainly achieved through the high DDGS sales price, which is linked by contract to the wheat price.

The real challenge of bioethanol plants are low product prices. Thus, the plant's profitability becomes negative if the sales price goes down to EUR480/t, a price level which was touched once in the past five years, in the beginning of 2009, when mandatory targets for biofuel production were not in place.

There are several positive externalities linked to the production and consumption of biofuels in this project, like the reduction of GHG emissions and energy as well as protein supply security, where Europe largely depends on imports. If on the one hand these social benefits are taken into account, but on the other hand the subsidies of EUR7.124 million are ignored the ERR is about 15.6%. The fact that the ERR is still higher than the IRR shows that, based on the assumption of a CO_2 price of EUR26/t of avoided emissions in 2011, increasing by EUR1/t each year, the CO_2 benefits are higher than the costs of the subsidies.

Taking into consideration the fiscal support for EU domestic biofuels via import tariffs for bioethanol from low cost production countries like Brazil, and thus calculating the project under a "free market" scenario, the ERR would be reduced to 7.7%. However, it has to be kept in mind that the feedstock sugar cane from Brazil does not need to be produced in accordance with the strict EU Cross Compliance standards and needs to be in line with the strict ILUC criteria. Thus possible negative environmental effects are not taken into account.

Table 27.1:
Calculation of ERR for a biofuels project

	(Values in k EUR)		Year -1	Year 0	Year 1	Year 2	Year 3	[…]	Year 15
(1)	Bioethanol sales		-	-	53,332	71,821	72,539	[…]	81,739
(2)	DDGS sales		-	-	12,950	17,439	17,613	[…]	19,847
(3)=(1)+(2)	**Total sales**		**-**	**-**	**66,282**	**89,260**	**90,152**	[…]	**101,586**
(4)	Total variable costs		-	-	- 50,859	- 68,489	- 69,174	[…]	- 77,947
(5)	Total fixed costs		-	-	- 1,836	- 2,473	- 2,497	[…]	- 2,814
(6)	Insurance, fees, etc.		-	-	- 383	- 515	- 520	[…]	- 586
(7)=(4)+(5)+(6)	**Total direct costs**		**-**	**-**	**- 53,077**	**- 71,477**	**- 72,192**	[…]	**- 81,348**
(8)=(3)+(7)	**Operating margin**		**-**	**-**	**13,205**	**17,782**	**17,960**	[…]	**20,238**
					0	*0*	*0*	[…]	*0*
(9)	Staff costs		-	-	- 1,720	- 2,317	- 2,340	[…]	- 2,636
(10)	Investment		- 59,532	- 59,532					4,902
(11)	Subsidy		3,563	3,563					
(12)=(9)+(10)+(11)	**Cash Flow**		**- 55,969**	**- 55,969**	**11,484**	**15,466**	**15,620**	[…]	**17,601**
(13)=IRR(12)	**IRR**		**10.2%**						
(14)=(2)+(7)x1000/(18)	Net costs for ethanol (EUR/m3)				*- 422*	*- 426*	*- 431*	[…]	*- 485*

	(Values in k EUR)		2011	2012	2013	2014	2015	[…]	2027
(15)	CO2 savings		52%	of fossil fuel chain					
(16)	CO2 savings		44.8	g CO2eq/MJ or kg CO2/GJ or t CO2 per TJ					
(17)	Ethanol contains		21	MJ/l					
(18)	Total bioethanol production	m3			95,057	126,743	126,743	[…]	126,743
(19)=(18)x(17)/1000	Total energy production (ethanol)	TJ			1,996	2,662	2,662	[…]	2,662
(20)=(19)x(16)	Avoided CO2eq	t			89,430	119,240	119,240	[…]	119,240
(21)	Price		26	EUR per t CO2					
(22)=(21)x(20)	Climate Benefit	1,000 EUR			894	1,192	1,192	[…]	1,192
(23)	Energy and Protein Supply Security premium		5%						
(24)=(1)x(23)		1,000 EUR			2,667	3,591	3,627	[…]	4,087
(25)	**Subsidy**		**-3,563**	**-3,563**					
(26)=(12)+(22)+(25)	**Social cash flow**	**1,000 EUR**	**- 59,532**	**- 59,532**	**15,045**	**20,249**	**20,440**	[…]	**22,881**
(27)=IRR(26)	**ERR I**		**15.6%**						
(28)	Less revenue if lower (Brazilian) price	1,000 EUR			-	-	-	[…]	-
(29)=(27)+(28)	**Social cash flow II**		**- 59,532**	**- 59,532**	**-**	**-**	**-**	[…]	**-**
(30)=IRR(29)	**ERR II**		**7.7%**						

28 Tourism

Campbell Thomson

28.1 Methodology

28.1.1 Introduction

As defined by the UN World Tourism Organisation (UNWTO), tourism typically represents some 10% of Gross Domestic Product (GDP), more in the case of countries such as Greece and Morocco which are dependent on leisure tourism.

Supporting tourism are a range of other economic activities, e.g. transport and infrastructure, water and waste, energy and construction, which will be covered by others. The analysis presented here will focus on activities falling directly under the tourism heading, including:

- Hotels and other forms of tourist accommodation;
- Services which target tourists: spas and wellness centres, theme parks, water parks, restaurants and cafés, etc.;
- Venues: stadia, arenas, theatres, concert halls, etc.;
- Tourism infrastructure, e.g. cycleways, information systems, signposting, public museums.

For convenience, these may be divided into three categories:

- Pure Private: Revenue generating with a profit maximisation objective, e.g. hotels, private spas, theme parks, privately owned venues. Projects in this category are the object of a Cost-Benefit Analysis (CBA).
- Hybrid: Revenue generating without a profit maximisation objective: e.g. publicly owned venues and museums, public therapeutic spas. Such projects are first checked for financial viability and, using this as a proxy, may be able to demonstrate economic viability on a CBA basis. However, more typically, an Impact Analysis is the more appropriate approach, albeit incorporating some elements generated via the financial analysis.
- Pure Public: Non-revenue generating activities; tourist offices, cycleways, etc. These may only realistically be assessed through an Impact Assessment.

There will always be exceptions, such as tourism offices which charge listing fees, and non-profit seeking privately owned facilities. However, these can be handled on a case-by-case basis.

28.1.2 Economic objectives, approaches and criteria

28.1.2.1 Pure private

For the EIB in general, and tourism projects in particular, the economic analysis of investment projects takes the form a differential Cost-Benefit Analysis on a "with project" and "without project" basis. In the case of tourism, the without project case means the absence of tourist numbers and their related expenditure at the destination and on their way to and from it. Private sector investments, or investments by the public sector when operating on a purely commercial basis, have the advantage of a clear and simply proxy for the economic profitability: the financial profitability, as measured by the Financial Internal Rate of Return (FRR) calculated in real terms, in line with the Bank's standard methodology. It should be noted that target returns for private investors in tourism are significantly higher than the Bank's historical Economic Rate of Return (ERR) benchmarks, i.e. 5% within the EU and double that outside the EU. The FRR may then be adjusted to arrive at a quantified ERR by taking into account externalities: positive and negative, shadow prices, etc.

It is very rare for an EIB tourism project to have negative externalities: the Bank does not finance projects with, for example, significant negative environmental or social impacts. At the same time, the Bank's eligibility criteria mean that most tourism related projects have either convergence/coherence as the eligibility criterion, or are based in developing countries, and the investment and continuing business activities are additional to the economy. Significant activities which are not captured by the FRR approach include:

- Supply Chain, including: (i) the provision of goods, mainly fresh foodstuffs, and services to the hotel. (ii) In areas in which tourism is an eligible EIB activity the shadow price of labour is low, meaning that the actual cost to the economy is lower than suggested by contractual labour costs.
- Tourist Spend additional tourist expenditure may support additional formal and informal business activities, ranging from fishing trips, to taxis drivers, to souvenir production and sale, to restaurant meals. The marginal net benefit from this expenditure (that is, net of costs) may be included in the ERR if it can be expected to be additional to the economy instead of substituting other expenditure that would have taken place anyway. This constitutes the so-called genuine indirect effect.

These additional benefits are relatively easy to quantify. However, there is another class which is equally valid but more difficult to quantify. A target for EIB tourism lending is the rehabilitation and upgrading of existing facilities. The alternative is the downgrading, first of the hotel in question, and then of the resort area, and even the country. Tunisia is a case in point. A failure to invest would have a wider negative impact which the Bank's project can avoid. This, plus the creation of flagship hotels have positive, but difficult to quantify, economic impacts.

28.1.2.2 Hybrid projects

Projects in this category are almost always public sector driven, often as part of a wider urban renewal programme, or the preservation of historic buildings. The public authority also often believes that they will be financially profitable. In practice they rarely are, and the larger the proportion of public/social activity they are required to undertake, the less financially viable they are. To avoid such investments becoming a drain on the taxpayer, the Bank applies a very simple test. Accepting that the investment represents a sunk cost on completion, a project must be capable of covering its current costs: employment, energy, routine and regular maintenance, etc., out of its commercial revenues for it to be considered for funding. Like "pure private" projects, the project financially profitability is used as a starting point for an Impact Analysis. Normally the FRR of these projects is negative, and externalities must be quantified which will justify the use of the Bank's resources.

It should be noted that the Bank does not have its own Impact Assessment methodology in this sector, but relies instead on promoters providing an analysis, normally by a competent third party, based on the standard methodology of the European Commission. In such cases, the Bank will review the assumptions included in the promoter's analysis, based on the (usually more conservative) assumptions it retained for the financial analysis, paying particular attention to the claimed positive impacts to be achieved and the proportion of costs attributed. It will then carry out a simplified analysis to confirm the project's suitability for funding. Each project is different, but the same externalities may be identified and quantified which apply to many of them, including the net benefit from:

- Visitor/Spectator overnight accommodation – with numbers and expenditure depending on the nature of the event;[79]
- Visitor/Participant accommodation for the period of the event in question – lower numbers but often spending more;
- Visitor spending on meals, parking, memorabilia, etc.

Other conventional benefits may also be applied to the project:

- Net economic benefits from employment and physical inputs during construction;
- Non-recoverable taxes and personal taxes payable during the construction phase;
- Personal taxes paid by special event staff;
- Personal taxes paid by other third party providers of services to the investment;
- Corporate taxes paid by contractors during implementation and operation – it may assumed that the investment itself will not generate any tax income.

[79] "Events" can include regular sports meetings, one-off international sporting events, exhibitions, congresses, conferences, religious festivals, concerts, arts festivals, weddings, funerals, political meetings, etc.

For completeness, negative externalities during the operational phase should also be taken into account, but these can be more difficult to identify and quantify. However, they could include: Increased congestion during events, displacement of normal economic activities during events, costs of additional policing for events.[80]

28.1.2.3 Pure public

Typically, such projects have no, or minimal, revenues and rely on an Impact Assessment to justify their existence. The approach taken follows the externalities considerations in the "Hybrid" section, but normally has to be both predictive and marginal, i.e. the number of additional cyclists which might come to an area following the construction of, say, a long-distance cycleway. Quantification of the benefits is complicated by the need for parallel investments to be made, usually be the private sector, in services to the project, e.g. cafés and bicycle repair shops along the cycleway.

28.2 Tourism case study

28.2.1 Introduction

The case study relates to a multi-purpose sports, social and cultural arena in a convergence region, comprising: a main arena, a “training” hall, a climbing wall, parking, and various facilities to be let to the private sector as concessions, e.g. spa and wellness centre, fitness centre, food and beverage outlets.

The project was promoted by a large municipality in one of the poorest regions in the country, with high levels of unemployment and a low rate of economic growth. The municipality will retain ownership, with the arena to be operated by a subsidiary SPV. In the longer term, operation by a commercial operator could be considered.

28.2.2 Background

Apart from providing local sports and leisure facilities, the project's objective was to act as a focus for economic regeneration by creating social and sporting facilities of international standing. The project should therefore not be seen in isolation. Large areas of this old industrial city had been rejuvenated using public funds, including areas close to the project site. The project was to be an economic showcase, drawing major events, and thus visitors and potential investors, to the city. The arena sits on the site of an abandoned football stadium, between the city’s main university campus and open parkland. The area of urban regeneration, referred to above, included the creation of a large open car park, within easy walking distance of the project.

The key components of the proposed EUR89 million project include:

- Land area – 104,807 sq.m., Built area – 69,272 sq.m., Main arena – 56,270 sq.m.;
- Seating: main arena seating – 10,000-16,660 depending on configuration, training hall seating – 3,000;
- Facilities: spa and wellness centre, fitness area, climbing wall, permanent restaurant and café, temporary facilities for major events, 928 places for car & truck parking.

Job creation: 700 person years during construction, 90 FTE in operation, not including temporary employment for major events, or the attributable employment by the organisations which hire the facility. This is expected to be at least the same again.

[80] Depending on ownership and budget responsibility, this last point could equally be a positive externality.

Table 28.1:
Calculation of economic returns of public leisure facility

		Year	0	1	2	3	4	5	22	23
(1)	Project Cost & Residual Value	(M local currency)	-123.49	-130.57	-76.30	0.00	0.00	0.00	0.00	165.18
(2)	Fiscal Effects	(M local currency)	0.96	1.75	0.98	2.07	2.07	2.07	2.07	2.07
(3)	User/Visitor Benefits	(M local currency)				18.68	19.33	19.33	19.33	19.33
(4)	Indirect Benefits	(M local currency)				3.18	3.18	3.18	3.18	3.18
(5)	Intangible Benefits	(M local currency)				0.80	0.80	0.80	0.80	0.80
(7)	Avoided costs	(M local currency)				1.32	1.32	1.32	1.32	1.32
Σ ((1) -(7))	**Economic Cost/Benefit Flows**	(M local currency)	**-122.53**	**-128.82**	**-75.31**	**26.04**	**26.69**	**26.69**	**26.69**	**191.87**
	ERR	**6%**								

28.2.3 Economic viability

The project, as presented, was not intended to be commercially viable. While many of the events would be fully commercial, most would not be. Commercial activities include popular music events, use of the arenas by professional sports teams, e.g. basketball, the spa, wellness and fitness concessions, and the restaurant and café concessions. The project was to benefit from EU financial support in the form of an annual grant, rather than a one-off capital grant.

The project had been the object of a comprehensive economic analysis as part of the proposal to the EC for structural funds support. PJ reviewed the assumptions and methodology on which the analysis was based, substituting more conservative values where appropriate, and arrived at a projected ERR of 6%. The main components of the economic analysis are presented in below. This was based on quantifiable benefits. Unquantifiable benefits, such as enhancement of the city's potential for FDI almost certainly were present, but were not included in the quoted ERR figure. Similarly, the negative impact of the "without" case was not quantified. The site was an abandoned football stadium which had to be kept in a safe condition by the city, while being an eyesore and presenting a negative image for a redevelopment and regeneration area. The avoidance of these negative impacts would tend to increase the ERR.

28.2.4 Financial issues

The project was the subject of a straightforward financial analysis. This showed that the revenues generated, plus the proposed EU annual support, would be sufficient to meet operating costs and the interest on the Bank’s loan in the early years. However, the calculated FRR in real terms was heavily negative. Servicing the Bank’s loan (interest and capital repayments) would not have been possible out of operational cash flows. The indicated support from EU funds of some EUR1.7 million per annum, plus a further EUR1.3 million per annum from the city budget, would be required to meet the project’s obligations towards the Bank. The need for continuing support is recognised in promoter documents and the calculated cash flows were broadly in line with PJ’s projections which were based on more conservative revenue assumptions than those of the promoter.

29 Interurban Railways

Alfredo Díaz

29.1 Methodology

29.1.1 Overview

The EC and the EIB developed the RAILPAG (Railway Project Appraisal Guidelines) in order to arrive at a harmonised EU procedure for socio-economic and financial appraisal of railway projects.[81] [82] The RAILPAG guidelines address the key factors that should be taken into consideration in the appraisal of rail investments.

The analysis of the project is made from two perspectives: financial and economic, the latter consisting of a standard Cost-Benefit Analysis (CBA). The CBA considers the information provided by the promoters which would usually include a complete (pre or) feasibility study, demand analysis, cost estimates, etc. Such information is updated during the due diligence process as in a number of cases projects have advanced and sometimes are under construction.

29.1.2 Appraisal of rail projects – process followed

The appraisal of rail projects requires addressing adequately a number of issues:

- The context and background of the project: the adequate identification of the project within the context of an investment program at a regional, national or European scale, depending on the type of project. The projects must be consistent with national and EU objectives.
- Scope of the project: the scope of the project is not always clearly (or not at all) defined. In such cases, the EIB would work together with the promoter to clearly define a project. The analysis of the project requires it to be self-sufficient, e.g. all components needed to make it operable must be included within the scope of the project.[83] This is not always straightforward and sometimes requires a wider view (e.g. a railway line from A to B requires also stations at both ends; upgrading of infrastructure to increase the design speed would also require rolling stock capable to operate at that speed, etc.). The scope of project should also avoid including components that are not related to it or are not necessary to make it operable (e.g. buildings not related to the operation of trains, road infrastructure with no interference with the rail project, etc.).
- Definition of alternatives if the EIB enters early enough in the decision-making process: considering investment in infrastructure and rolling stock, the latest being in line with demand requirements.
- Demand forecasting: a high-quality demand analysis is essential for an adequate planning and an accurate project evaluation. Generally, the implementation of the project would result in an increase of demand. Existing traffic, diverted traffic from other modes, and generated traffic must be clearly identified.
- Financial analysis.
- Economic analysis.

29.1.3 Definition of alternatives

Investment decisions should consider a set of alternatives in order to select the most adequate action to take. One of the options to be considered always is the “do-minimum” alternative which serves as reference to compare with possible alternative solutions (see chapter 3). The

[81] Other institutions acted as members of the steering committee, i.e. Community of European Railways, European Bank of Reconstruction and Development, International Union of Railways, European Rail Infrastructure Managers, and the World Bank.
[82] http://www.eib.org/attachments/pj/railpag_en.pdf
[83] The definition of the scope of the project can be an iterative process in which several alternatives are assessed and modified in order to find the most efficient solution. In such a pathfinder process, inefficient components that can be separated from the project can be withdrawn.

"do-minimum" should consider the option of investing enough in the system so that operations can continue (only necessary expenditures, which enable to keep the system operational at the same technical level as currently). It should not lead to a standstill of the system. The "do-something" alternatives should consider different design options to tackle with the objective set by the planning body. All "do-something" alternatives are then compared with the do-minimum alternative. This analysis can obviously be performed only in cases when the Bank gets involved early in the project definition process. Often the Bank gets involved in the operation after the project is fully defined. The objective of the analysis then becomes to make sure that the option chosen offers sufficient returns when compared against the "do-minimum" or "do-nothing" alternatives.

29.1.4 Financial analysis

The financial analysis basically considers the two main stakeholders, the Infrastructure Manager (IM) and the Railway Undertaking (RU). It analyses the implications of the implementation of the project in their cash-flows considering investments, operating costs and revenues. The main cash-flow streams considered are (all values expressed in financial terms):

- For the Infrastructure Manager (IM), responsible for the railway infrastructure (tracks, stations, special services):
  - Investment costs in infrastructure;
  - Maintenance cost of infrastructure;
  - Operating costs of infrastructure;
  - Operating revenues from Track Access Charges (TAC), stations, services.

- For the Railway Undertakings (RU) responsible for providing freight and passenger transport services:
  - Investment costs in rolling stock (and in some cases maintenance workshops);
  - Maintenance costs of rolling stock (and workshops if applicable);
  - Operating costs of rolling stock including TAC, personnel, services, etc.;
  - Operating revenues from freight and passenger transport.

Some railways still operate as (quasi) monopolist in certain regions or countries with no separation between infrastructure and operation of trains. A consolidated financial analysis is done in such cases (which represents also the overall project financial analysis). The cash-flow streams considered are:

- Investment costs (including rolling stock);
- Infrastructure maintenance and operating costs;
- Rolling stock maintenance and operating costs;
- Revenues for freight and passenger transport.

29.1.5 Economic analysis

The economic analysis examines the impacts of the project on the economic welfare of society. The impacts can be grouped in three categories: consumer surplus, producer surplus and externalities.

The CBA values the following variables:

- Investment costs: these include planning, design, supervision, management, land, construction and rolling stock. All costs must be expressed in economic terms thus market prices need to be adjusted to their opportunity cost.[84] The residual value of the assets is considered in the analysis.
- Maintenance and operating costs of infrastructure: usually this value is different in the "do-minimum" and "do-something" scenarios and can be higher or lower (e.g. some installations could result in rationalisation of working places). An increase of maintenance costs is expected in cases where new assets are installed. In some cases

[84] Economic transfers (e.g. taxes representing a pure transfer, subsidies, etc.) are discounted and corrections made (i.e. shadow prices) whenever applicable.

the amount of budget foreseen by the promoter for maintenance differs in the "do-minimum" and "do-something" scenarios for the same unit of infrastructure. This case appears when the infrastructure manager has a restricted budget for the maintenance of existing infrastructure (and sometimes insufficient thus leading to its deterioration) but allows a higher budget for the maintenance of the improved or new infrastructure. On the other hand, maintenance costs of a deteriorated infrastructure could escalate when trying to keep it functioning.

- Vehicle operating cost: considers passenger and freight diverted to rail from other modes (road, air).
- Rolling stock operating and maintenance costs, which could be of two types, including: (i) additional train services that might be required to serve additional demand created by the project; and/or (ii) changes of technology (e.g. use of electric trains instead of diesel trains in electrification projects).
- Journey times for three types of traffic: existing traffic, diverted traffic to rail from other modes, and generated traffic.
- Safety: accrued from diverted traffic to rail from other modes. The measurement considers different accident rates for each mode and measures the changes in potential accidents (accounting for No. of accidents and victims per accident) due to diverted traffic.
- Other user benefits such as reliability and comfort.
- Externalities: noise, CO_2 and other emissions are considered.

The economic indicators obtained are the Economic Rate of Return (ERR), Net Present Value (NPV) and Benefit/Cost (B/C) ratio. These indicators are used to estimate whether the analysed alternatives are economically sound and to compare the various alternatives amongst them identifying their order of efficiency in economic terms.

29.2 Railway case study

A single track railway line is operating close to capacity. The line is an important transit freight link and also distributes goods from a port to its hinterland destinations. It is also located at an important axis of movement of passengers, with an important component of long distance travellers. The passenger RU has a contract with the government to provide services under a public service obligations (PSO) framework. The track is in good condition and uses a state of the art signalling system. The line is electrified in its entire length.

Around seventy five trains per day are using the line from which fifty are freight trains and the rest passenger trains. The demand is increasing for both freight and passenger transport and this positive trend is likely to continue. There is a potential demand that could be served by the railways. However, the infrastructure does not allow operating additional trains without disruptions. This section of the railway network has become a bottleneck. Moreover, the single track section connects to double track sections at both ends. Therefore, the planning authority decided to investigate the possibility of increasing the capacity of the railway line by installing an additional track parallel to the existing one. The solution of increasing capacity of the railways instead of investing in roads is politically desired since the government has set the objective of alleviating emissions.

The single track line can be seen as a section of a longer railway connection since an important part of the demand is of long distance nature. Therefore, the area of influence of the project is extended to include origin-destination pairs that could be captured by the improved line.

The "do-minimum" scenario is defined as investing enough resources in the existing track to maintain its good operation conditions. The existing traffic is expected to keep using the railways. Additional freight and passengers can be transported by rail by improving the load factors and offering some additional services. However, since the line is operating almost at capacity, the IM cannot provide enough additional slots. This scenario implies that future demand can only be marginally captured. Assuming that the demand will in any case exist, it is reasonable to assume that other modes will capture it, in this case cars, buses, and lorries.

The "do-something" scenario includes the installation of an additional track to increase capacity. With two tracks, the capacity of the line increases above 300 trains per day, which would be enough to cope with future demand. No increase in the design speed is foreseen.

The time horizon for the cash flow analysis is 35 years. The weighted average economic life of the project is also 35 years. This implies that the residual value is zero. A correction factor of 0.9 is used in the economic analysis to correct financial transfers.

The summary of results is presented in the tables below.

Table 29.1:

Infrastructure manager cash flow and financial profitability

		PV	2011	2012	2013	2020	2030	2040	2048
(1)	**Investment and maintenance**	503.3	155.3	155.3	155.3	4.0	4.0	4.0	4.0
(2)	Net operating cash flow pass.	9.5	0.0	0.0	0.0	0.3	0.3	1.7	3.1
(3)	Net operating cash flow freight	63.4	0.0	0.0	0.0	4.6	4.9	5.3	5.6
(4)=(2)+(3)-(1)	**Total net operating cash flow**	72.9	0.0	0.0	0.0	4.8	5.2	7.0	8.8
	NET cash flow	**-430.5**	**-155.3**	**-155.3**	**-155.3**	**0.8**	**1.2**	**3.0**	**4.8**

IM FIRR	-6.8%
IM FNPV (EURm)	-430.5

As shown in Table 29.1, the IM is able to recover its marginal costs before the investment took place. However, the maintenance costs increase substantially after the doubling of the tracks. The existing demand is not enough to cover the resulting additional costs. Assuming that the track access charges are not adjusted after the opening of the second track, the IM would need governmental support in the medium-term. However, in the long-term (in this case from 2020 on), the demand will be enough to cover the marginal costs and the IM will be able to operate self-sustainable. It is however clear that the investment would need governmental aid.

Table 29.2 shows that the operator (RU) has a positive operative cash flow accrued through freight transport services. However, passenger transport services are unprofitable and would need governmental support.[85] Although the RU would obtain positive operative results in the long-term thanks to the good performance of freight transport services, the financial results are yet negative. A clear and transparent fiscal separation of freight and passenger transport services would allow the RU to obtain governmental support to cover the financial gap under a PSO framework whilst providing profitable freight transport services.

[85] The governmental support is not shown in this example.

Table 29.2:

Railway undertaking cash flow and financial profitability

		PV	2011	2012	2013	2020	2030	2040	2048
(1)	**Investment**	41.0	0.0	00.0	30.0	0.0	0.0	0.0	0.0
(2)	Net operating cash flow pass.	-67.7	0.0	0.0	0.0	-3.5	-4.2	-6.5	-8.8
(3)	Net operating cash flow freight	59.4	0.0	0.0	0.0	0.3	4.4	10.3	16.5
(4)=(2)+(3)	**Total net operating cash flow**	**-8.3**	**0.0**	**0.0**	**0.0**	**-3.2**	**0.2**	**3.7**	**7.7**
(5)=(4)-(1)	**NET cash flow**	**-49.3**	**0.0**	**0.0**	**-30.0**	**-3.2**	**0.2**	**3.7**	**7.7**
Operator FIRR	-1.5%								
Operator FNPV (EURm)	-49.3								

Table 29.3:

Combined (IM + RU) cash flow and financial profitability

		PV	2011	2012	2013	2020	2030	2040	2048
(1)	**Capital and operating expenditures**	544.3	155.3	155.3	185.3	4.0	4.0	4.0	4.0
(2)	Total net operating cash flow pass.	-58.2	0.0	0.0	0.0	-3.3	-4.0	-4.8	-5.7
(3)	Total net operating cash flow freight	122.8	0.0	0.0	0.0	4.9	9.3	15.6	22.1
(4)=(2)+(3)	**Total net operating cash flow**	64.6	0.0	0.0	0.0	1.6	5.4	10.7	16.4
(5)=(4)-(1)	**NET cash flow**	**-479.7**	**-155.3**	**-155.3**	**-185.3**	**-2.4**	**1.4**	**6.7**	**12.4**
Operator FIRR	-5.1%								
Operator FNPV (EURm)	-479.7								

The overall project, entailing both infrastructure and train operation, is financially not profitable, as shown in Table 29.3. By contrast, the economic analysis, which is summarised in Table 29.4, shows that the project generates enough benefits to society to justify the costs. The economic rate of return (ERR) is 7.2% and the B/C ratio is above one.

Table 29.4:
Economic returns of railway project

	Economic costs	PV	2011	2012	2013	2020	2030	2040
(1)	Infrastructure	399.5	139.7	139.7	139.7	0.0	0.0	0.0
(2)	Rolling stock	36.9	0.0	0.0	27.0	0.0	0.0	0.0
(3)	Renewals	0.0	0.0	0.0	0.0	0.0	0.0	0.0
(4)	Maintenance	133.7	0.0	0.0	0.0	9.0	9.0	9.0
(5)	Residuals	0.0	0.0	0.0	0.0	0.0	0.0	0.0
(6)	Ancillary projects	0.0	0.0	0.0	0.0	0.0	0.0	0.0
(7)=(1)+(2)+(3) +(4)+(5)+(6)	TOTAL	570.1	139.7	139.7	166.7	9.0	9.0	9.0
	Economic benefits							
(8)	VoT	64.6	0.0	0.0	0.0	3.6	4.7	6.0
(9)	OPEX	430.8	0.0	0.0	0.0	25.8	31.0	36.0
(10)	Comfort	20.9	0.0	0.0	0.0	1.2	1.5	1.8
(11)	Noise	33.3	0.0	0.0	0.0	2.0	2.4	2.8
(12)	Safety	65.8	0.0	0.0	0.0	3.9	4.7	5.5
(13)	Environment CO2	93.2	0.0	0.0	0.0	4.5	7.1	10.4
(14)	Environment other	24.1	0.0	0.0	0.0	1.4	1.7	2.0
(15)=(8)+(9)+ (10)+(11)+(12)+ (13)+ (14)	TOTAL	732.7	0.0	0.0	0.0	42.4	53.2	64.5
(16)=(15)-(7)	Total cash flow	162.6	-139.7	-139.7	-166.7	33.4	44.2	55.5

EIRR	7.2%
NPV	€ 163 m
B/C	1.3

30 Roads

Pierre-Etienne Bouchaud

30.1 Methodology

The bank applies a standard Cost-Benefit Analysis (CBA) in all its road projects – interurban and urban. Most projects concern interurban roads and can be of various types and sizes, from building a new motorway infrastructure on virgin land to rehabilitating an existing two-lane road. The Bank does not however consider pure maintenance projects. The economic appraisal of road projects usually consists of the following four main components: (i) identify the project scope and description; (ii) quantify the economic costs of building and maintaining the infrastructure; (iii) determine the associated benefits of this infrastructure over time – mostly in terms of travel time savings, vehicle operating cost savings and a reduction in accident levels; and (iv) evaluate whether the project is justified.

30.1.1 Project definition

The definition of road projects is the first issue to deal with when appraising a road project (e.g. when grand investment schemes are presented to the Bank). The project area is defined as the smallest area that allows for the development of robust results, although it also has to be large enough to capture network effects such as the demand diverted from other routes and modes of transport. If cross-border impacts are expected (e.g. when building an access road to a border crossing) then the study area is defined to incorporate both domestic and international travel. A national or transnational corridor route is, however, usually made of several components that are dealt with as distinct projects, which are analysed independently by the Bank. The type of infrastructure proposed (e.g. motorway versus two-lane road), the level of preparedness of these various components, the characteristics of the sections (in terms of traffic or topology) or the major landmarks on the corridor (intersection or cities) can all be grounds for distinguishing projects.

In its economic appraisal of projects, the Bank ensures that sufficient project alternatives are considered that maximise benefits while concurrently minimising costs and reducing risks. All too often the alternatives that aim at minimising costs (e.g. reconstructing the existing road) are “forgotten” on the altar of more ambitious and politically more rewarding projects (e.g. build a new motorway). The Bank ensures that the projects it presents to its Board have strong credibility, meaning that they pass not one economic test, but two: (i) the investment’s incremental benefits must exceed its costs; and (ii) the investment’s net benefits have to exceed the incremental net benefits likely to be achieved by other alternatives. Defining the project alternatives often goes beyond the Bank’s standard scope of work, but the choice of alternatives nonetheless needs to be checked at appraisal stage. This is especially relevant in situations of high budget constraints. Another issue relates to the inclusion of cross modal alternatives. The Bank considers that such alternatives belong to the sphere of transport policy rather than economic appraisal and does not require such alternatives to be included.

30.1.2 Economic costs and benefits

The economic cost of a road project is based on bills of quantities and encompasses a unit price analysis for reference. It includes costs actually paid for by the project promoter (such as construction and maintenance costs), as well as all other costs when they correspond to a use of resources, and this even when they are not paid for (e.g. land if it is freely available to the promoter as it could be used for another productive activity otherwise). However, expenditures that do not correspond to actual usage of resources such as most taxes or interests, even when they are paid by the promoter, are not considered economic costs as they merely represent transfers from one group of society to another.

Therefore, the economic cost of the project usually differs from the financial cost presented to the Bank by the project’s promoter. In most cases, it is enough for the Bank to consider the promoter’s project cost net of value-added taxes as a proxy for the project’s economic cost. In a number of countries, however, more adjustments are required to fully consider such transfers, especially in regards to taxes and subsidies. Less frequently, shadow pricing and conversion factors are applied due to distortion between actual costs and “real” costs (notably for foreign exchange rates in case of regulated market and wage rates in case of significant underemployment of unskilled labour or severe shortages of skilled labour).

The benefits of road projects financed by the Bank are generally made of: (i) time savings; (ii) vehicle operating cost savings; and (iii) reduction in accidents. Other direct benefits can arise from the environmental impact (lower pollution through shorter route or reduced congestion) and even sometimes from a reduction in maintenance expenditures if the existing road assets have become very expensive to maintain. It is important to note that all these benefits could actually represent additional economic costs to the project. For example, vehicle operating costs can increase with the project when the route is longer (e.g. due to a bypass) or when the speed is higher (e.g. a motorway replacing a two-lane road). In the same vein, accidents can be more numerous or deadlier with a new road allowing faster rides, etc. It is also important to note that all these benefits (positive or negative) are compounded when traffic is induced. Except in rare cases, and in order to be conservative, wider benefits are not included in the analysis.

As illustrated above, the key parameter to determine benefits is traffic. The EIB performs a thorough demand/market analysis, in most cases based on existing studies. In the case of a tolled motorway, this traffic analysis should consider the impact of toll levels. Average Annual Daily Traffic (AADT) is assessed from the year of opening of the road section(s), along with a capture rate allocating traffic on the new road as a share of traffic volumes using the existing road. If the new road replaces the existing road (e.g. in case of upgrading or reconstruction), then the capture rate is simply 100%. Traffic is divided into light and heavy vehicles. The capacity with and without project is also assessed, as well as speed flow curves and other such parameters as minimum and maximum speeds, occupancy characteristics of vehicles and trip purpose. The demand analysis also consists in forecasting traffic, in terms of existing traffic growth and traffic either diverted from other connecting roads or generated by new economic activities. Along with the value of time, these parameters pertaining to the traffic analysis serve at determining the benefits associated with the road projects financed by the EIB, among which time savings usually represent between 80 and 90%.

The economic assessment of a road project relies on data, assumptions and forecasting. The Bank usually performs its own assumptions and forecasts of key variables (especially traffic growth rates) but has to rely, to some extent, on data gathered by external consultants. The data has to be reliable and recent. It is compared to available benchmarks (e.g. unit costs, rules-of-thumbs, hedonic methods, etc.). The concept “garbage in – garbage out” is relevant because an economic assessment – and hence its results – based on weak data inputs will itself be weak even if the model used is reliable. A critical judgement is applied and conservative assumptions over the analysis period are made. In most cases, the Bank is using its own model to perform the economic assessment of projects, at least for inter-urban roads: the audited version of Economic Road Investment Appraisal Model (ERIAM). It is a simple yet reliable and transparent model that provides a good yardstick of economic profitability. The Bank acknowledges that ERIAM can be, on the margin, quite sensitive to some key parameters. For example capacity assumptions might need to be adapted to “local circumstances” (e.g. higher average capacity on Italian motorways as compared to German ones) when reaching congestion. Other models/methods are usually used for urban roads or rehabilitation projects.

Economic results are shown in terms of Internal Rates of Return (IRR), Net Present Value (NPV), and Benefits-Costs Ratio (BCR). These ratios indicate whether an alternative is economically justifiable and how it stacks up against other alternatives.

The case study example below also includes a sensitivity and risk analysis against key assumptions, and projects shall demonstrate that their economic case is robust to downside scenarios. Most often, the critical project inputs used to assess the reaction of the results to their foreseeable changes are investment cost and demand for transport. The sensitivity analysis also includes a switching value analysis, which defines the critical value that makes a project’s results turn negative. The risk analysis calculates the probabilities of a project achieving a certain level of net benefit specifying probability distribution for the key inputs mentioned above.

30.2 Case study of a road project

This section concerns a typical economic appraisal of a road project, as undertaken by the Bank in the Profitability Analysis of its Appraisal Report. The road project has a total length of 20km and is going from two major cities. The project consists in a new motorway, to be added to the existing low capacity road network. The situation with the proposed project was compared to a “do minimum” scenario of simply maintaining this existing – two-lane – route which crosses a number of urban areas.

This section: (i) defines the project; (ii) assesses construction costs; (iii) analyses traffic; (iv) enumerates the assumptions pertaining to the benefits of the project; (v) identifies the main results of the economic analysis; and (vi) performs a sensitivity and risk analysis.

30.2.1 Project definition

The project road is 20km and is a 2-lane interurban road going through densely populated areas. It represents continuity to a wider corridor that has mostly been upgraded to motorway standard. As a result of the project, the new alignment will have four lanes and a design speed of 120 km/h to accommodate the significant volumes of traffic observed – including substantial percentages of heavy vehicles.

30.2.2 Costs

The total financial cost of the project is estimated at almost EUR62 million. Besides civil works, this cost includes preliminary studies, management costs, supervision, land acquisition, cost of environmental mitigation measures and technical contingencies, but excludes financial contingencies and interests during construction. The investment cost equates to around EUR3 million per km. This average unit cost is considered reasonable as a whole.

Costs used in the profitability analysis are economic costs and therefore exclude taxes, payment of interest and other “transfers”. They are expressed in constant terms. However, economic costs include societal costs, such as land acquisition, even if these costs do not lead to an actual payment or are not financed by the Bank. The total economic cost of the project is derived from the financial cost using a financial to economic coefficient of 92%. The use of this coefficient is used to convert domestic market prices to international economic prices, as well as to adjust for unskilled labour and the levy of some taxes other than VAT. Economic cost is estimated at EUR47 million.

Preparatory works started early in 2011. Construction works started beginning of 2012. Works will be completed end of 2016/early 2017. The project will therefore be implemented over a five-year period.

The project will add significant maintenance costs to the country, as the project aims at adding new road sections to the network. Annual maintenance costs, including life-cycle costs, will increase by EUR17,500/km if the project is implemented or EUR350,000 per year once all the road sections have been built.

30.2.3 Traffic analysis

Large traffic volumes are observed in general on the corridor. In particular, the sections around the capital city have around 30,000 vehicles per day. On the project road specifically, traffic stood in 2010 between 4,800 and 9,200 vehicles per day (vpd) in the interurban sections and between 6,900 and 14,600 vpd in the urban sections. This is too heavy for the existing road, which has two lanes, especially because heavy good vehicles represent a relatively high percentage of total traffic – between, 12% and 19% depending on the sections. The issue is compounded in some sections with a strongly seasonal annual flow pattern.

The project will, for the most part, add a new road alignment to the corridor, therefore providing the possibility to road users to use the existing route as a local road through the major cities or the new alignment as a transit route. Transit heavy vehicles above a certain size will be prevented from using local roads through urban areas.

Traffic growth has been uneven but high on average over the past few years (6% per year on average). As these growth rates are not deemed sustainable in the long-term, more conservative traffic growth assumptions were made, based on GDP growth rates forecasts and using elasticity factors of respectively 1.2 for light vehicles and 1.0 for heavy goods vehicles.

Traffic induction was assumed as capacity will increase substantially, which will have a positive effect on travel speed. Induced traffic was estimated to be 8% of existing traffic. A ramp up period of three years was assumed. Induced traffic is expected to increase at the same growth rate as normal traffic after 2017, the opening year of the new motorway.

30.2.4 Benefits

As stated previously, benefits are mostly stemming from time savings (76% of benefits in NPV terms), as the project will add new capacity to the existing East-West Corridor, which will ease traffic flows and increase average travel speed. Another direct and substantial benefit is the decrease of vehicle operating costs due to the improved corridor – 20% of total benefits. Other benefits include: (i) some safety-related benefits thanks to the avoidance of urban and highly populated areas, as well as the higher safety standards adopted on the new corridor – 2% of total benefits; and (ii) a small reduction in CO_2 emissions – also 2% of total benefits.

The project has a small impact in terms of CO_2 emissions as the slightly longer route and the increased average speed will be somewhat compensated by a more fuel-efficient ridership. On the basis of assumptions on traffic, speeds and fuel consumption made in the economic cost benefit analysis, the project will decrease CO_2 emissions by 1,200 tons per average operating year (1% of baseline emissions).

The project will significantly increase the life-cycle cost of maintaining the new corridor. However, when the residual value of the investment is deducted, the effect becomes marginally positive.

30.2.5 Project assumptions

The following main assumptions were made to determine the benefits of the project:

- Thanks to the project, the corridor capacity will increase dramatically, in terms of vehicles per hour. The final capacity of the corridor is defined as the maximum hourly flow rate at which vehicles can reasonably be expected to traverse a point or uniform section of road under prevailing road, traffic and control condition. On the new corridor, final capacity will be on average 4,600 vehicles per hour, which will be added to the present capacity of 3,400 vehicles per hour of the existing road network.

  The final capacity of the new motorway broadly corresponds to a level of service C, where the posted speed can usually be maintained, although the ability to pass or change lanes is not always assured. At this level of service, experienced drivers are comfortable; roads remain safely below – but efficiently close to – capacity.

- Maximum speed, in terms of km per hour for Light Vehicles (LV) and Heavy Vehicles (HV) are defined as follows: (i) 90 km/hr for LV on the existing roads against 120 km/hr on the new motorway; and (ii) 80 km/hr for HV on the existing roads against 100 km/hr on the new motorway.

  The minimum speed is estimated to be 15 km/hr on the existing road network for LV and 10 km/hr for HV, while it will become: (i) 20 km/hr and 15 km/hr for LV on the new motorway; and (ii) 25 km/hr and 20 km/hr for HGV on the new motorway.

- Road condition goes from poor to fair in the existing roads, while it is considered as very good all the way on the new corridor.

  Values of Time (VOT) are also applied to calculate time-related costs as this cost is based on the loss of productive time. VoT is assumed to grow based on GDP growth and using an elasticity factor of 0.9.

- Trip purposes for HV are assumed to be 100% working time, with an average occupancy rate of one person per vehicle. A vehicle occupancy rate of three persons per LV is assumed. Trip purposes for LV are assumed to have the following breakdown, on average on the network, with and without project: 30% work, 30% commuting and 40% leisure.

- Accident rates are assumed to be 0.3 per million vehicle-km on the existing 2-lane interurban road. For the new motorway, an accident rate of 0.06 per million vehicle-km is applied while keeping the same levels of severity as in the scenario without improvement.

  Considering the average income for the country, the values used to assess the benefits associated with lower accident rates are set for fatalities; for serious accidents; and for light accidents.

- A residual value was considered at the end of the analysis period (2040), as this period is shorter than the estimated physical life of the project assets (34 years). The discrepancy between the two periods corresponds to about 9 years of economic life of the assets, which corresponds in turn to a residual value of more than 12 MEURO in 2040.

30.2.6 Main results of the economic analysis

The Bank conducted its own economic cost benefit analysis of the project using the audited version of the Economic Road Investment Appraisal Model (ERIAM). The analysis starts in 2011 and was performed until 2040.

The road project is economically sound. Its economic rate of return (ERR) is estimated to be above 16% in the base case. This corresponds to a present value of net benefits over EUR137 million (using a 5% discount rate) and a Benefits / Costs ratio of 3.9. For the given set of assumptions, the economic performance indicators for the road project are shown in Table 30.1.

30.2.7 Sensitivity and risk analyses

The results of the sensitivity and risk analyses can be considered as quite satisfactory. They show the economic profitability of the project to be robust to foreseeable downside scenarios.

The sensitivity analysis shows that the project is better protected against construction cost increases than against drops in traffic levels. With construction costs increasing by 20%, the ERR goes down to 12%. In fact, construction cost has to almost triple before the project gets in “negative” territory – i.e. the ERR falls below 5% and overall NPV turns negative. A 10% reduction in base year traffic has a more pronounced impact on the economic feasibility of the project. In this sensitivity analysis, the ERR decreases to only slightly more than 7%. In fact, initial traffic levels cannot decrease by more than 18% before the NPV turns negative (ERR less than 5%) for the project as a whole. This sensitivity analysis indicates that the project as a whole would still have a reasonable economic profitability in the event of reasonable cost overruns and drop in base year traffic.

Table 30.1: Results of economic appraisal of a road project

				2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2040
			Economic Costs (€M)											
	Costs		**NPV**											
1	**Construction**	€M 2011	**-46.5**	-0.6	-6.9	-9.7	-9.7	-17.8	-12.6					
2	**Annual Cost Impacts**	€M 2011	**-3.6**							-0.4	-0.4	-0.4	-0.4	-0.4
3	**Residual Value**	€M 2011	**2.8**											12.3
1+2+3=4	**Total Costs**	**€M 2011**	**-47.3**	**-0.6**	**-6.9**	**-9.7**	**-9.7**	**-17.8**	**-12.6**	**-0.4**	**-0.4**	**-0.4**	**-0.4**	**12.0**
			Economic Benefits (€M)											
	Benefits		**NPV**											
5	**VoT Impacts**	€M 2011	**141.0**							2.2	3.2	4.4	6.0	27.1
6	**VOC Impacts**	€M 2011	**36.9**							1.8	2.5	2.9	3.3	1.2
7	**Safety Impacts**	€M 2011	**2.9**							0.1	0.1	0.2	0.2	0.5
8	**Environmental Impacts**	€M 2011	**3.3**							0.0	0.1	0.1	0.1	0.6
5+6+7+8=9	**Total Benefits**	**€M 2011**	**184.1**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**4.1**	**5.9**	**7.5**	**9.6**	**29.4**
			Economic Case											
	Economic Cashflows		**NPV**											
9-4=10	**(Costs + Benefits)**	**€M 2011**	**137**	**-1**	**-7**	**-10**	**-10**	**-18**	**-13**	**4**	**6**	**7**	**9**	**41**

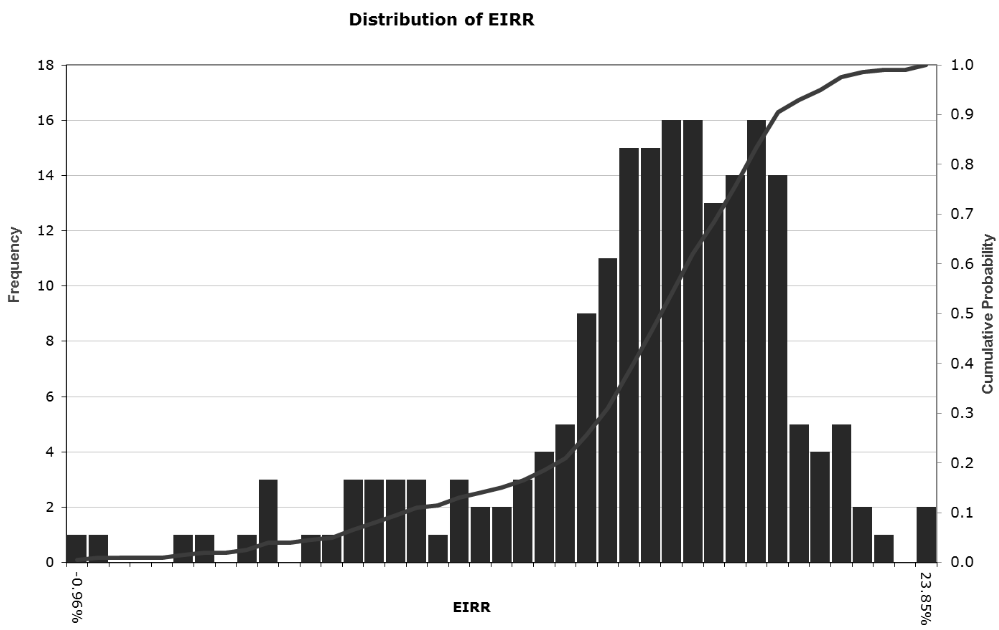
EIRR	**16.3%**
NPV	**137**
Discount Rate	**5%**
B/C ratio	**3.9**

Benefits (m EUR)	**NPV**	**% total**
VoT Savings	141.0	76%
VOC Savings	36.9	20%
Safety benefits	3.3	2%
Environmental benefits	2.9	2%
Total benefits	**184.1**	**100%**

A Monte Carlo analysis of the expected ERR was performed at the project level using 500 discrete scenarios where the values of key parameters were varied. The distributions applied in the analysis are applied to the following sensitivity parameters: (i) Traffic growth; (ii) Initial traffic; (iii) Capture rate; (iv) Value of time; (v) Investment cost; and (vi) Vehicle operating cost savings. Figure 30.1 includes the probability distribution and probability distribution of project outcomes.

The results of the risk analysis show that the ERR has a 96% chance of yielding a return over 5% – taken to be the threshold rate of return for this project.

Figure 30.1:
ERR probability distributions for a road project



31 Urban Public Transport

Mauro Ravasio

31.1 Methodology

31.1.1 Introduction

Urban public transport projects are financed by the Bank if they contribute to the objective of protecting and improving the environment and promoting sustainable communities. Eligible projects in this sub-sector are expected to help in reducing congestion and environmental externalities through either the promotion of modal shift from private cars to more sustainable transport modes and/or improvements in transport efficiency, including improved inter-modal connections.

Although quite diversified, the vast majority of urban public transport projects undergoing an economic appraisal in the Bank are represented by entirely new rail infrastructures such as new suburban railway, metro and tramway lines. Other transport modes (e.g. trolley busses and busses) are also covered.

The perimeter of an urban public transport operation includes normally: 1) civil works and equipment for the new line and stations; 2) the construction of the depot and maintenance centre; 3) the acquisition of rolling stock. Although these three components are normally integrated in one single operation, there are cases in which only one component is financed, for instance when new rolling stock is purchased for renovation purposes or to increase the capacity on an existing line.

The methodology applied by for Bank project appraisal and for JASPERS is the same in the case of urban public transport projects, although the parameters used for the analysis may be different.

31.1.2 Project benefits

Project benefits can be split in two broad categories: generalised cost of travel and externalities. Regarding the former, the economic appraisal considers both users and non-users. Among the first category a distinction is made depending on the previous mode of transport for diverted passengers while generated passengers (i.e. journeys that would not occur without the project) are treated separately. Non-users are passengers that keep on travelling on the same transport mode – typically private cars – and do not switch to the new service but benefit however from a reduction in congestion.

A specific time saving is then attached to each category of users and non-users. Time savings are generated by the traffic model underpinning demand forecasts and are normally provided by the promoter. Total time savings are then monetised using values of time[86] that are country specific and differentiated by trip purpose and transport mode. The “rule of a half” applies as explained elsewhere in this report (cf. chapter 15).

For users diverting from private transport modes, savings in vehicle operating costs are also calculated through the estimate of the reduction in vehicle kilometres and the use of a coefficient representing unit cost per kilometre.

Economic benefits associated to the generalised cost of travel grow across time with demand and real GDP per capita. Demand growth affects the total amount of time savings and car kilometre savings. In this respect, it is worth stressing that average time savings are often kept constant across time in the economic analysis of urban public transport projects carried by the EIB, although they will actually evolve with demand for both the project and all other competing

[86] Study specifically developed by RAND for the EIB.

modes of transport.[87] Real GDP per capita growth affects the value of time to a different extent depending on the assumed elasticity (normally comprised between 0.5 and 1).
A second broad category of benefits is represented by externalities. This group includes at least: reduction in air pollutant emissions, reduction in GHG emissions and increase in road safety. When adequate and reliable information is available, the assessment of project impacts can be extended to other externalities such as reduction in noise emissions and vibrations.

Concerning air emissions of both pollutants and GHG, the method is similar. For each transport mode the difference in vehicle kilometres with and without the project is determined. This difference is then multiplied by specific emission factors and monetised through a specific value of each pollutant. While for standard pollutants this exercise concerns only transport modes with combustion engines, also transport modes with electric engines are considered when assessing the project impact in terms of GHG emissions. In this latter case, a balance in energy consumption is first made and then an average CO_2 emission factor per country[88] is used.

A similar method is used also for assessing project impacts in terms of road safety. In this case, road accident coefficients are attached to the difference of vehicle kilometres generated by the project to determine the reduction in fatalities and injuries to which specific monetary values are then attached.[89]

Economic benefits associated to the externalities grow across time with demand and real GDP per capita. Demand growth affects the total amount of only car related pollutants. In this respect, it is worth stressing that changes in the production of other public transport modes are not estimated through demand as this is rarely a good proxy in urban transport. Real GDP per capita growth affects the value attached to pollutant/fatality/injury.

31.1.3 Project costs

Project costs can be split in two broad categories: construction costs and operating costs. Regarding the former, construction costs are estimated through a standard methodology that is common for all Bank's projects.[90] To the end of the economic appraisal, the total project investment is considered with the exception of price escalation and interests during construction. This means that the cost is expressed in the year of the analysis (constant prices) and that shadow pricing is not applied. A residual value is considered in the last year of the analysis and is calculated based on the economic life of the project.

Concerning operating costs, the total production of the new service is considered and a unit cost per kilometre is attached. Depending on the nature of the project (entirely new line or extension of an existing network), the unit cost may represent either average or variable costs. The additional operating costs are often compensated by a reduction in the production of other public transport modes. This benefit is calculated in the same way as operating costs for the new service.

31.2 Urban public transport case study

A European urban area of some 250,000 inhabitants is suffering from increasing road congestion. Public transport is provided by bus only and its quality is decreasing due to a reduction in the commercial speed. Public transport share of urban mobility is therefore very low and expected to further deteriorate in the future with the associated negative external impacts on traffic and the environment. The Transport Authority proposes the construction of a new tramway infrastructure that is expected to change this negative trend and increase the public transport share.

[87] For instance, if demand is assumed to grow during the time span of the analysis for both the project (say a new metro line) and competing modes of transport (say private cars) the impact on time savings will be uncertain. Indeed, commercial speed for the project will probably decrease once the optimal capacity is reached but the same is likely to occur on the road network. As traffic models are often run for one, maximum two or three key dates any assumption in this respect is likely to be inaccurate. However, when the traffic model provides clear evidence of changing average time savings across project economic life, this will be considered in the economic appraisal.
[88] EIB Carbon Footprint Methodology.
[89] Study specifically developed by RAND for the EIB.
[90] EIB Project Investment Cost methodology.

Table 31.1:
Calculation of urban public transport project returns

		NPV	2010	2011	2012	2013	2014	2015	2043
	Traffic								
(1)	Total traffic (m journeys/year)		0.0	0.0	0.0	0.0	20.9	21.3	30.7
	Existing users								
(2)=%(1)	Tramway		0.0	0.0	0.0	0.0	0.0	0.0	0.0
(3)=(2)*Time_Saving*VoT	Time savings compared to tramway	M EUR 0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Diverted users								
(4)=%(1)	Bus		0.0	0.0	0.0	0.0	14.6	14.9	21.5
(5)=%(1)	Car		0.0	0.0	0.0	0.0	1.0	1.1	1.5
(6)=%(1)	Heavy car		0.0	0.0	0.0	0.0	1.0	1.1	1.5
(7)=(4)+(5)+(6)	Total diverted users		0.0	0.0	0.0	0.0	16.7	17.0	24.6
(8)=(5)/Car_load_factor*Car_VOC	Car savings	M EUR 31.8	0.0	0.0	0.0	0.0	2.1	2.2	3.0
(9)=(5)/Car_load_factor/Heavy_Car_VOC	Heavy car savings	M EUR 9.5	0.0	0.0	0.0	0.0	0.7	0.7	0.9
(10)=((5)+(6))*Time_Saving*VoT	Time savings compared to car	M EUR 39.0	0.0	0.0	0.0	0.0	2.0	2.1	5.2
(11)=(4)*Time_Saving*Vot	Time savings compared to bus	M EUR 261.9	0.0	0.0	0.0	0.0	13.4	14.0	35.1
	Generated users								
(12)=%(1)	Generated traffic		0.0	0.0	0.0	0.0	4.2	4.3	6.2
(13)=(12)*Time_Saving*VoT/2	Benefits	M EUR 36.4	0.0	0.0	0.0	0.0	1.9	1.9	4.9
	Environmental benefits								
(14)	Nox	M EUR 0.2	0	0	0	0	18,717	19,473	13,179
(15)	PM	M EUR 2.7	0	0	0	0	582,292	605,817	69,220
(16)	VOC	M EUR 0.0	0	0	0	0	2,316	2,410	6,057
(17)	SO2	M EUR 0.1	0	0	0	0	5,653	5,881	14,783
(18)	CO2	M EUR 1.8	0.00	0.00	0.00	0.00	0.13	0.13	0.13
(19)	Noise	M EUR 0.0	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Other benefits								
(20)	Reduction in fatalities	M EUR 3.5	0.00	0.00	0.00	0.00	0.18	0.19	0.47
(21)	Bus Savings	M EUR 107.6	0.00	0.00	0.00	0.00	8.53	8.53	8.49
(22)	Time savings for users remaining on roads	M EUR 101.6	0.00	0.00	0.00	0.00	5.99	6.14	12.32
	Costs								
(23)	Investment cost	M EUR 329.9	87.50	137.39	120.01	64.03	0.00	0.00	-180.75
(24)	Electricity generation social cost	M EUR 2.0	0.00	0.00	0.00	0.00	0.12	0.13	0.22
(25)	Additional operating cost	M EUR 195.1	0.00	0.00	0.00	0.00	15.42	15.42	15.42
(26)	Upgrades	M EUR 64.4	0.00	0.00	0.00	0.00	0.00	0.00	0.00
(27)=(3)+(8)+(9)+(10)+(11)+(13)+(14)+(15)+(16)+(17)+(18)+(19)+(20)+(21)+(22)	Benefits	M EUR 596.0	0.00	0.00	0.00	0.00	35.53	36.45	70.60
(28)=(23)+(24)+(25)+(26)	Costs	M EUR 591.4	87.50	137.39	120.01	64.03	15.55	15.55	-165.10
(29)	EIRR	5.1%							
(30)=(27)-(28)	NPV	M EUR 4.7							
(31)=(27)/(28)	B/C	1.01							

The new tramway lines will carry some 21m passengers in the first year of operation. Demand is expected to grow at 2% per year until 2024 and at 1% from 2025 onwards. Users are split as follows: 70% of passengers are diverted from existing bus services; 10% of passengers are diverted from private cars; 20% of passengers are newly generated journeys. Although differentiated among different categories of users, an average time savings of some 5 minutes is considered for each journey with the new tram line. The traffic model has also calculated the total amount of time saved per year for non-users (i.e. private car users) that is equal to some 500,000 hours. Time savings are computed in the analysis through appropriate values of time. Benefits for new users are halved in compliance with the "rule of a half".

Concerning externalities, those resulting from a reduction in car kilometres are calculated starting from diverted passengers from car and assuming an average trip length (8 km) and a car load factor (1.3). Externalities deriving from changes in vehicle kilometres of public transport modes are calculated on a fixed amount of production that is 2.2 million additional tram kilometres and a reduction of 0.4 million bus kilometres.

Production of public transport modes is also used for assessing the operating costs of the new tramway (on the basis of a unit cost of EUR7.08 per tram kilometre) and the savings in existing bus services (on the basis of a unit cost of EUR4.50 per bus kilometre).

Finally investment costs are equal to some EUR409 million and spread over a construction period of four years. In this respect, a residual value of some EUR181 million is calculated on the basis of the principles recalled elsewhere in this report (cf. chapter 7). This is the result of linear depreciation of the initial investment and the subsequent upgrades and renewals that have been included in the analysis for a total non-discounted amount equal to EUR204 million.

Table 31.1 summarises the results of the project economic appraisal. The table also offers the present value (PV) for each benefit and cost item described above, discounted at 5%. All monetary figures are expressed in constant prices. The economic performance of the project is summarised in three indicators: an Economic Internal Rate of Return (equal to 5.1%), a Net Present Value (equal to EUR8 million) and a Benefit to Cost Ration (equal to 1.01).

32 Airports

J. Doramas Jorge-Calderón

32.1 Methodology

32.1.1 Introduction

Airport infrastructure can be divided into landside and airside, with regard to capacity expansion. Landside involves infrastructure to process passengers or cargo. Projects can involve expanding capacity of cargo or passenger terminals; improving access to terminals through parking facilities or rail stations; and enhancing product quality through increased use of jetways to access aircraft. Airside involves infrastructure to process aircraft. Projects can involve new runways or the widening or lengthening of existing ones; taxiways to increase the capacity of existing runways; apron space to expand aircraft parking capacity; or air traffic control facilities at the airport or at the airport's vicinity. Projects can involve any combination of these items or the construction of entirely new airports.

While this chapter focuses on the elements above mentioned, the EIB also finances resilience projects, aimed at improving safety and security, as well as projects aimed and cleaning existing fleets (currently, mostly in the landside).

The methodology applied by for Bank project appraisal and for JASPERS is the same in the case of airport projects.

32.1.2 Landside benefits

The benefit of projects is measured using the standard transport sector framework of generalised cost of travel. The sources of benefits of investing in landside capacity are threefold. First, to avoid traffic diversion as passengers follow alternative travel arrangements. Traffic diversion can take place in two ways: in time and in mode. Passengers are diverted in time when they are forced to take trips at different times than desired. The cost to the user will then be related to the time difference between the desired and actual travelling times, and to the traveller's value of time. Diversion in mode consists of forcing travellers to use second-best transport modes or alternative airports. This involves greater generalised cost to the traveller because it implies greater access and egress times, as well as possibly the use of less efficient transportation modes.

Both types of diversion are valued as two hours worth of travel time by default, which reflects the conditions in most projects the Bank appraises, and is adjusted when project conditions differ. Diversion is assumed to occur once the annual traffic of the airport is at least 33% higher than terminal design capacity. This percentage corresponds to the relative difference between IATA (International Air Transport Service Association) level of service C, generally the reference level of design, and service level E, just before system breakdown.

The second source of benefit would be relieving congestion in terminals, reducing user throughput time. This starts to compute once traffic reaches level of service C, until it reaches level of service E, and is valued at 10 minutes of user travel time.

The third source of benefit is generated traffic, consisting of traffic that would not have travelled at all without the project. This is valued as the difference in generalised costs between using the airport and the alternative to the airport, and applying the "rule of a half."

In addition, where the project involves an upgrade in the quality of service to the passenger through the substitution of remote stands by contact stands, such an improvement is valued at about EUR10-15 per applicable passenger. However, to the extent that the airport appropriates that benefit through higher charges, such benefit is not added to project returns as it would double count benefits already accounted for as producer surplus.

32.1.3 Airside benefits

Investment on the airside will produce two potential benefits. First, enhanced airside capacity will enable increase in the frequency of departure and range of routes from the airport. This will yield the benefit of reducing the frequency delay,[91] as well as potentially the trip duration, both of which contribute to a reduction in the generalised cost of transport. This delay is valued through the standard value of time by assuming a flat distribution of passengers throughout the day, or along a number of daily or weekly traffic peaks, depending on traffic conditions at the airport under appraisal. Second, airside investments may speed the processing time for aircraft, reducing operating costs to airlines.

When the airside investment consists of increasing peak aircraft movements, the "without project" scenario assumes that airlines would increase aircraft size to the extent allowed by the airport. This tames the benefit of airside expansion as larger aircraft are cheaper to operate per passenger. The analysis uses an elasticity of unit cost relative to aircraft size of -0.5.

32.1.4 Producer surplus and costs

Producer surplus before investment cost is measured through airport operating profit before depreciation, including both aeronautical and non-aeronautical revenues and costs. Diverted traffic would travel through alternative airports, and the project will therefore have an adverse effect on the producer surplus of that alternative airport. Therefore, the net producer surplus of the project consists of the portion of surplus that is attributed to generated traffic.

The costs of the project would include both the capital investment related to construction of the infrastructure and the additional airport operating costs once the new infrastructure is in operation. Unless the promoter supplies specific project data in this respect, the Bank analysis assumes increasing returns to scale until 4 million passengers per year, constant returns thereafter, and density economies while the terminal facility is utilised below design capacity.

Should the new operative requirements of the airport imply significant increases in aircraft operating costs, these are also taken into account as additional costs attributable to the project.

32.1.5 Externalities

Air transport is associated to four main external costs, including emissions of GHG, air pollution through the emission of particles, noise emissions, and relocations necessary to make room for infrastructure. Of these only the last one, relocations, can be attributed directly to airports, and are included in airport appraisals using the standard Bank methodology (see Chapter 5). The first three external costs are caused primarily by airlines. Emissions by airlines operating from an airport cannot be attributed to the airport or to air traffic control. An appraisal incorporating all airline emissions would also need to take into account economic flows arising from aircraft investment and operation. Only aircraft emissions that are attributed to air traffic generated by the project, that is, traffic that would not have travelled at all in the absence of the project, can be attributed as costs of the airport (or air traffic control) project. The external costs of generated traffic are measured using standard aircraft emission data, valued at standard EIB emission values (see Chapter 4).[92] Any emission that is internalised, such as that proportion of GHG emissions that are paid for through the EU Emissions Trading Scheme, are subtracted from external costs.

[91] The frequency delay is the difference in the average passengers' preferred departure time and the closest flight departure feasible for the passenger. Other things being equal, the greater the departure frequency, the lower the frequency delay, and hence the time cost of travel to the passenger.

[92] For an example of a study estimating of aircraft emissions, see CE Delft (2002) "External Costs of Aviation" CE Delft: the Netherlands, available online:
http://www.cedelft.eu/publicatie/external_costs_of_aviation_(background_report)/279?PHPSESSID=ad8353cb75ccfdf097561c2fc46a6f6a

32.2 Airport case study

An airport has a terminal capacity of 5 million passengers per year at IATA service level C, and annual traffic is nearing 4.5 million passengers. Throughput is growing at 4% per year and is expected to do so over the long-term. At that rate of growth, traffic is expected to reach design capacity four years from now (year 4). The project to be evaluated consists of expanding the terminal building to increase annual capacity to 10 million passengers.

Without the project, airport management would cap passenger throughput once IATA level of service E is exceeded, which would occur once annual throughput reaches 6.7 million passengers. At the expected average annual growth rate of 4%, such throughput would be reached in year 11. Because management is conscious also about the level of quality offered to the passenger, they would like the new capacity to enter operations well before year 11. So, they propose that construction begins on year 1, extending for just over four years, with the terminal entering operation in year 5. With the expanded 10 million passenger terminal facility the airport would be able to accommodate traffic with Service Level C or better until year 23.

Following its opening in year 5, the new terminal would have an economic life of 20 years, until year 25. By that time, traffic would have reached over 11 million passengers, exceeding design capacity, but well below the 13 million passengers that would cause system breakdown.

Table 32.1 summarises the results of the project economic appraisal, including selected years in the “with project” and “without project” scenarios. The table also offers the present value (PV) for each benefit and cost item, discounted at 3.5%, (values are discounted to the 1st of January of year 1). All monetary figures are expressed in constant prices, so the discount rate constitutes the real discount rate.

The investment cost is budgeted at EUR260 million, spread over five years, yielding a present value of EUR237 million (row 30 in Table 32.1). Investments to refit the existing terminal would be incurred equally whether the project is carried out or not, so they cancel each other out as far as the calculation of the economic return is concerned.

The airlines serving the airport will have to own emission rights, of which 70% were grandfathered and 30% paid for in year 1. Any future traffic growth will require the purchase of new emissions rights, meaning that as time passes the proportion of emissions internalised increases. By year 25 about half of emissions will be internalised (see rows 31 and 32 in Table 32.1). Noise and air pollution are not internalised, and hence the cost of emissions (of generated traffic only) constitutes a next cost of the project.

Rows (3) and (12) in Table 32.1 determine the passengers affected by diversion “without project” and “with project”, respectively. Without the project, by year 25 some 4.4 million passengers would be diverted. Those passengers will be diverted on average for 2 hours. At an average value of time of EUR20 per hour, increasing at an annual rate of 1.5% per year, that translates into a cost of time diversion “without project” of EUR50 million by year 15, reaching EUR248 million by year 25 (row 7). Avoiding the costs associated with such traffic diversion constitutes the most important justification for the project.

Other sources of benefit for the project include avoiding traffic deterrence. The project will generate half a million new passenger movements by year 25 (row 14), consisting of passengers that would not have travelled at all in the absence of the project. The benefits of traffic generation accruing to passengers are estimated through the rule of a half (row 29). Another benefit to passengers includes avoided congestion (rows 9 and 19).

The terminal experiences congestion when it operates above design capacity, resulting in an increase in throughput time of 10 minutes per passenger, or 20 minutes per return trip. By year 25, congestion costs in the “with project” scenario (row 19) are higher than in the “without project” scenario (row 9) because the number of passengers affected is larger in the former, due to the larger capacity of the terminal.

Table 32.1:
Calculation of airport project returns

		Units	**PV ***	**1**	**5**	**15**	**25**
	WITHOUT PROJECT						
(1)	Design passenger capacity	(thousand)		5,000	5,000	5,000	5,000
(2)	Passengers	(thousand)		4,500	5,264	6,650	6,650
(3)	Diverted passengers	(thousand)		0	0	1,028	4,396
(4)	Deterred passengers	(thousand)		0	0	114	488
(5)	Operating revenues	(EUR m)	1,975	90.0	105.3	133.0	133.0
(6)	Operating costs	(EUR m)	987	45.0	52.6	66.5	66.5
(7)=(3) x time cost	Cost of diversion	(EUR m)	783	0.0	0.0	49.9	247.7
(8) = 0.5 x (4) x time cost	Cost of deterrence	(EUR m)	44	0.0	0.0	2.8	13.8
(9) = (2) x time cost, if(2)>(1)	Cost of congestion	(EUR m)	346	0.0	18.6	27.3	31.7
	WITH PROJECT						
(10)	Design passenger capacity	(thousand)		5,000	10,000	10,000	10,000
(11)	Passengers	(thousand)		4,500	5,264	7,793	11,535
(12)	Diverted passengers	(thousand)		0	0	0	0
(13)	Deterred passengers	(thousand)		0	0	0	0
(14) = (4) - (13)	Net traffic generation	(thousand)		0	0	114	488
(15)	Operating revenues	(EUR m)	2,305	90.0	105.3	155.9	230.7
(16)	Operating costs	(EUR m)	977	45.0	52.6	63.7	77.0
(17) = (12) x time cost	Cost of diversion	(EUR m)	0	0.0	0.0	0.0	0.0
(18) = 0.5 x (13) x time cost	Cost of deterrence	(EUR m)	0	0.0	0.0	0.0	0.0
(19) = (11) x time cost, …if (11)>(10)	Cost of congestion	(EUR m)	90	0.0	0.0	0.0	55.0
(29) = (8)-(18) = 0.5x(14) x … … x time cost	Value of traffic generation	(EUR m)	44	0.0	0.0	2.8	13.8
(30)	Investment cost	(EUR m)	237	60.0	20.0	0.0	0.0
	NET EXTERNALITIES						
(31)	Cost of carbon emissions	(EURm)	39	0.0	0.0	2.3	13.4
(32)	Internalised GHG costs	(EURm)	18	0.0	0.0	1.0	6.7
(33)	Cost of noise emissions	(EURm)	5	0.0	0.0	0.3	1.4
(34)	Cost of air pollution	(EURm)	3	0.0	0.0	0.2	1.0
(35)=(31)-(32)+(33)+(34)	Total external cost	(EURm)	29	0.0	0.0	1.9	9.1
	PROJECT RETURNS						
(36)=-(5)+(6)+(15)-(16)	Gain in producer surplus		330	0.0	0.0	25.7	87.2
(37)	PS diverted traffic		188	0.0	0.0	12.2	58.6
(38)=(7)+(8)+(9)+(36)	Benefits	(EUR m)	1,513	0	19	106	380
(39)=(17)+(18)+(19)+… …+(30)+(35)+(37)	Costs	(EUR m)	545	60	20	14	123
(40)=(38)-(39)	Net benefit	(EUR m)	**969**	-60	-1	92	258
	ERR		**16%**				

Note: * PV is the present value at year 0 discounted at 3.5%

Airport charges remain constant with and without the project. Still, the larger operation produces additional operating profit for the airport which constitutes a gain in producer surplus (row 36). However, the project would cause a loss of producer surplus in the alternative airport (row 37). The net gain in producer surplus would consist of (36)-(37).

The broader economic benefit and costs of the project are calculated on rows (38) and (39), respectively. The economic net present value of the project is the difference between rows (38) and (39), and stands at EUR969 million, shown in row (40). The economic internal rate of return (ERR) of the project is 16%.

33 Seaports

J. Manuel Fernández Riveiro

33.1 Methodology

33.1.1 Introduction

Port projects usually involve expanding capacity of cargo and passenger terminals and can be divided into infrastructure and superstructure investments. Infrastructure includes maritime works – breakwaters, quays, and dredging works – aiming to the provision of the necessary berthing conditions, and land side works – reclamation and other civil works – aiming to provide the required handling space. Superstructure includes pavement, buildings and the equipment required to handle cargo and passengers.

Economic appraisal should consider both infrastructure and superstructure investment costs, even if the project to be financed by the Bank is composed of elements belonging exclusively to one of the categories mentioned above.

33.1.2 Project benefits

The benefit of projects is measured using the standard transport sector framework of generalised cost of travel. The sources of benefits of investing in port capacity are usually twofold. First, to avoid traffic diversion as passengers and cargo would be forced to use less convenient alternative ports once the existing facility has reached congestion levels. This would involve greater generalised cost to the traveller and cargo shippers because it implies greater access and egress times, as well as possibly the use of a less efficient supply chain. This benefit would thus be measured though reduced land transport costs – including environmental external costs – as a result of the availability of adequate infrastructure to accommodate certain categories of vessels which were force to call at less convenient ports. A second benefit would be relieved congestion at the port, which would result in reduced waiting times at both anchorage and berth. However, this kind of benefit can be considered to be limited, as the assumption is that once reached the theoretical capacity of the ports, users will seek alternative facilities in the region.

For the purposes of assessing the project benefits it is worth distinguishing two main categories of port projects: transhipment hubs and gateway ports. Projects benefits at gateway ports are usually assessed by quantifying the first category of benefits and ignoring benefits from relieved congestion. This allows for a relatively straightforward methodology, as the only key parameters to consider are the distance from main origin/destination centres to the alternative port with available capacity – or adequate infrastructure – as well as unit land transport costs. The benefits would thus be estimated by multiplying this distance by the unit land transport costs.

As for port transhipment hubs, the economic benefits are very difficult to quantify, as they are linked to the network strategies of the shipping lines calling at the port. We normally assume that: a) in the absence of the project similar facilities would be built elsewhere in the region at a similar generalised cost; and b) inputs and outputs are traded in reasonably competitive markets. Under these circumstances it is assumed that the project financial rate of return is a close proxy of the economic rate of return, and hence the producer surplus before investments will be used as an indication of the project benefits. This will be measured by the port operating profit before depreciation, including both port authority's and port operator's revenues and costs.

33.1.3 Project costs

For gateway ports, the costs of the project would include: a) the capital investment related to construction of the infrastructure; b) additional superstructure costs needed for the operation of the project; and c) additional port maintenance and operating costs once the new infrastructure is under operation. Unless the promoter supplies specific project data in this respect, the Bank analysis assumes new infrastructure maintenance costs to be in the order of 1% of investment costs. As for point b), the analysis should include only those investments that are incremental to what is assumed would take place in the “without project” scenario. For transhipment hubs, the economic analysis is based on the financial returns and hence project costs should also include all superstructure costs, including all handling equipment.

33.1.4 JASPERS approach

The methodology applied by the Bank for project appraisal is generally similar with JASPERS’ approach in the case of port projects. However, due to different project contexts and depending on project particulars, JASPERS may work as well with alternative ways of quantifying the economic benefits e.g. benefits from released congestion at the port or reduced maritime transport costs as a result of the provision of transhipment infrastructure, as opposed to the PJ approach consisting of using the financial revenue as a proxy of economic benefit.

33.2 Seaports case study

A port has a container terminal capacity of 300,000 TEU and annual traffic is nearing 230,000 TEU. Throughput is growing at 5% per year and is expected to do so over the long-term. At that rate of growth, traffic is expected to reach design capacity six years from now (year 7). The project to be evaluated consists of expanding the capacity of the container terminal by expanding the container yard and enlarging the quay of the container terminal by 300m at a draft of -14m, to increase annual capacity to 600,000 TEU and allow for the accommodation of container vessels of up to 8,000 TEU.

In the absence of the project, and once the existing container terminal would be operating at full capacity by year 7, the shipping lines would be forced to call at additional ports to load/unload cargo with origin/destination in the natural hinterland of the port, which would originate additional land transport costs for cargo owners. There are currently two alternative ports with potential spare capacity for container handling, located at 200km and 300km away from the project port. These ports have suitable infrastructure but lack the equipment needed to handle those additional traffic flows (quay cranes, container yard equipment, etc.). In view of main origin and destination centres for container flows in the region, it has been estimated that, should the project container terminal not be expanded, additional container flows would need to be transported by land to the alternative ports mentioned above, which would mean an extra road distance of 150 km. The port has no rail connection and it has been estimated an average unit road transport cost of EUR1.5 per TEU-km.

Following its opening in year 5, the new terminal would have an economic life of 25 years, until year 29. By that time, traffic would have exceeded the project design capacity.

Table 33.1 summarises the results of the project economic appraisal, including selected years in the “with project” and “without project” scenarios. The table also offers the present value (PV) for each benefit and cost item, discounted at 5% (values are discounted to the first of January of year 1). All monetary figures are expressed in constant prices, so the discount rate constitutes the real discount rate.

The investment cost is budgeted at EUR130 million (row 5), spread over four years; yielding a present value of EUR119 million (row 9). Investments concerning the equipment required to handle the extra traffic have not been considered, as the alternative ports would have to invest in this kind of assets if the project is not carried out in order to adapt to the new levels of demand, so they cancel each other out as far as the calculation of the economic return is concerned. However, the new infrastructure will require additional annual maintenance costs of approximately EUR1 million (row 6).

The existing container terminal would reach full capacity by year 7. Additional cargo flows will then either have to be loaded and unloaded at alternative ports. Row (3) determines the volumes of TEU affected by diversion. Without the project, by year 10 some 56,000 TEU would have been affected, and by year 20 almost 300,000 TEU. Avoiding such traffic diversion constitutes the main justification for the project (row 7).

Table 33.1:
Calculation of port project returns

	Year	1	2	3	4	5	10	20	29
1)	Traffic without project (TEU)	230,000	241,500	253,575	266,254	279,566	300,000	300,000	300,000
2)	Traffic with project (TEU)	230,000	241,500	253,575	266,254	279,566	356,805	581,199	600,000
3)	Traffic diverted to alternative ports (TEU)	0	0	0	0	0	56,805	281,199	300,000
5)	Invesment Costs (M EURO)	15	40	55	20				
6)	Additional maintenance costs					1	1	1	1
7)	Economic Benefits (M EURO)	0	0	0	0	0	9	42	45
8) = 7-6-5	Economic Cash Flow (M EURO)	-15	-40	-55	-20	-1	7	41	44
9)	NPV	EUR119							
10)	ERR	9%							

The project net benefit is the difference between the sum of all economic project benefits (row 7) and the project economic costs rows (5) and (6). The project's economic net present value is stands at EUR119 million (row 9) and the project's economic internal rate of return (ERR) is 9% (row 10).

34 Regional and Urban Development

Sebastian Hyzyk and Brian Field

34.1 Methodology

34.1.1 Introduction

Regional or urban development projects often comprise a number or portfolio of multi-sector sub-projects (sometimes called schemes). The sub-projects are usually generated by the investment programmes of the regions or cities involved (public promoters), reflecting their development strategies as embedded in their respective spatial development plans. These authorities, via such investment programmes, are attempting to stimulate local growth and development conditions and improve the quality of life (welfare) of their inhabitants, primarily through public works and the provision of public services.

Typical sectors in such operations include: urban renewal and regeneration, transport, cultural heritage, healthcare, education, energy efficiency, public buildings, water and wastewater infrastructure, etc.

34.1.2 Economic assessment

A typical project comprises a number of different sub-projects/schemes across several sectors, which generate various benefits and associated externalities (both negative and positive). For example, direct benefits may include:

- For urban renewal and regeneration components of the project – significant improvements in the built environment and associated urban infrastructure and street furniture, the creation of quality urban space, conservation and preservation of cultural heritage, the provision of social and affordable housing, etc., with significant positive impact on quality of life of the affected communities;
- For transport components of the project – improved accessibility to key regional and urban services, road safety improvements, reductions in travelling times and vehicle operating costs;
- For healthcare components of the project – the provision of new and/or improved therapeutic environments, attractive working conditions for personnel, improvements in the efficiency and quality of the services provided by the hospitals benefiting from investment,
- For energy efficiency components of the project – reduction of CO_2 emissions, etc.

Although methodologies exist to value the non-monetised costs and benefits associated with the project, the Bank is not in a position to commission or undertake the complex surveys/studies which, even if methodologically sound, should be specific to local conditions and circumstances, i.e. there are problems due to deficiencies in the data available and with its aggregation, and the limited time for its economic assessment. Therefore, a primarily descriptive/qualitative methodology is applied, in which “informed professional judgment” is used in the evaluation and weighting of selected performance indicators and project outputs. The evaluation builds on the appraisal process, which determines the actual need for the investment programme (demand for public intervention and the specificity of the sub-project portfolio) and the efficacy of the policy response chosen by the promoter for the respective schemes, in a process that is inevitably multi-criteria in perspective.

“Synthetic” examples of how this approach might be translated into a more formal “scorecard” methodology have been prepared for illustrative purposes (see below), although it should be noted that these are only for demonstration and do not reflect current practice. Although the economic analysis is obviously informed by CBA methodological imperatives, it clearly and necessarily includes other criteria, lending credence to the suggestion that some form of the multi-criteria analysis would provide a more appropriate tool of evaluation. To this end, REGU is currently reviewing its appraisal procedures, with a view to developing a more robust MCA-based methodology that will be introduced in due course.[93]

Table 34.1:

Scorecard for the assessment of the regional development project

Criterion	**Score**			**Weight**
Capacity of the promoter				
Is the promoter capable of delivering a sound project e.g. at cost, on time, with adequate procurement procedures etc. also taking into account past monitoring experience, if applicable? Is the promoter capable to plan, generate, prioritise, design, procure, implement and operate projects? Is there a capacity to manage a full project cycle and an adequate sectorial expertise?	Low - 0 promoter capabilities do not allow for a satisfactory project preparation, implementation or operation, even if TA included.	Moderate - 5 Adequate project management capability to enable the promoter to deliver the project.	High - 10 Good project management capability, which will enable the promoter with a high probability to deliver the project on time and in budget.	**40%**
Perceived impact of the programme (outcome)				
Population affected (population affected/total population of the region)	<=0.1 - 0	(0.1;0.5> - 5	>0.5 - 10	**10%**
Degree to which benefits of the programme contribute to the attainment of the objectives of the development strategy	Low - 0	Moderate - 5	High - 10	**40%**
Cost effectiveness				
Cost of the programme (inputs) in relation to expected outputs	Low - 0 Poor value for money;	Moderate - 5 Adequate value for money;	High - 10 Good value for money;	**10%**

Overall assessment	Not acceptable	Satisfactory	Good
	<=6	(6; 8>	>8

[93] The efficacy of MCA deployment is currently under review, including the preparation of more appropriate methodological and operational guidelines.

In the examples, the appraisal is informed by the results of the scorecard (Table 34.1), which reflects major factors influencing the soundness of a typical regional development project, which the Bank is assessing. In the absence of the information on the individual schemes, the scorecard focuses on the capacity of the promoter, perceived impact of the programme (in terms of population affected and benefits provided), and cost-effectiveness. The scorecard implicitly assesses the programme against the blueprint provided by the regional development strategy (or other relevant planning document).

In the absence of a typical quantitative analysis, performance indicators may be used to complement the qualitative approach. Such indicators quantify medium to long-term objectives to be achieved by the project (outcome indicators) and also immediate physical results to be delivered (output indicators). Output indicators may also be used to assess the cost effectiveness of the sector components of the investment programme.

It should be noted, however, that large schemes[94] and some medium-sized schemes (if deemed necessary) are subject to a separate and individual appraisal and more rigorous economic assessment, according to the prevailing sector methodologies (quantitative, where appropriate). In principle, this appraisal is deferred in time from the approval to the allocation stage of the project cycle.

Schemes may fall within sectors that do not generate revenues and consequently the Financial Rate of Return may be low or even negative. The qualitative economic analysis therefore takes stock on the externalities resulting from the implementation of the schemes. A project must normally render a positive Economic Rate of Return, which satisfies Bank requirements.

Individual large schemes which are separately appraised by the Bank, within a regional or urban context may be subject to JASPERS preparation and such cooperation and details of the approach will normally be discussed in the sector chapters. Regional and urban Investment programmes are not normally subject to JASPERS intervention.

34.2 Case study (1): Regional development

The project involves support/funding for the multiannual investment programme of a Region, the implementation of which is underpinned by a comprehensive development strategy that addresses the objectives of sustainable development (including transport and energy), sustainable communities, and improvement of human capital.

Given the variety of sectors included in the operation and incomplete information available at the stage of appraisal (an intrinsic feature of framework loans of this type) the financial rate of return for the operation is not calculated.

The assessment is based on the institutional capacity of the promoter (capability and procedures, including project generation/design capacity, prioritisation criteria, project implementation and control capacity/capability, monitoring and control systems, both financially and for project operation, and management of environmental, competition and public procurement requirements) and the overall impacts of the strategy and the programme to be achieved. This criteria is summarised in Table 34.2. On the basis of the appraisal outcomes, the capacity of the promoter is judged as *High*.

The project is expected to generate a number of economic benefits and positive spill-over effects in the Region. In the first instance, the implementation of the schemes in sustainable transport should result in the improvement of the regional railway service, including suburban lines, helping increase its competitiveness, effectiveness and attractiveness for passengers. Improvement of hydrological security will allow for the development of urban areas and create new quality public space, whilst the renewal and regeneration measures will improve the quality of the urban fabric. The programme aims at increasing broadband access to 99% of population

[94] Large schemes is normally considered to have project cost of at least EUR50 million, while medium-sized schemes are defined as between EUR25 million and EUR50 million. Sub-projects with cost less than EUR25 million are referred to as small schemes.

of the Region, particularly by addressing the outermost and disadvantageous areas. The increased broadband coverage is expected to bring benefits for business, public administration and citizens through the provision of various advanced services and also contribute to the creation of job opportunities in the IT sector. The support for research and development (R&D) within the programme aims to facilitate the setting up of high value added production in the Region in the long run, and to improve human resources and to encourage private sector investments in R&D. The renewable energy and energy efficiency schemes are expected to contribute to the reduction of CO_2 emissions in the Region and increase security of supply. In conclusion, the various interventions included in the project, and synergies between them, will enhance the quality of life in the Region. Hence, the impact of the programme is expected to be *High*.

The experience in the analysis country suggests that public procurement (which the promoter is bound to follow) may sometimes not provide cost-effective solutions. However, a mitigating measure is the internal rigorous procedure employed by the promoter. Hence, cost-effectiveness is *Moderate*.

The qualitative economic analysis identifies a number of positive externalities resulting from the implementation of the investment priorities supported by the operation, which permit one to categorise the project as *Good*. Taking into account the overall appraisal results and this supplementary categorisation, it is expected that the project is likely to render a significant positive economic rate of return.

Table 34.2: Criteria used to evaluate a regional development project

Criterion	**Weight**	**Points**	**Score**
Capacity of the promoter			
High - 10 Good project management capability, which will enable the promoter with a high probability to deliver the project on time and in budget.	**40%**	10	4
Perceived impact of the programme (outcome)			
Population affected (population affected/total population of the region) 3/9.5 = 0.3	**10%**	5	0.5
Degree to which benefits of the programme contribute to the attainment of the objectives of the development strategy High - 10	**40%**	10	4
Cost effectiveness			
Moderate - 5 Adequate value for money	**10%**	5	0.5
Total			**9**

Good

34.3 Case study (2): Structural Programme Loan (SPL)

The operation structured as a Framework Loan/SPL supports the Operational Programmes of one of the Member States. The content of these programmes and capacity of the promoter to implement them were the primary focus of the appraisal by the Bank prior to project approval. The interventions are focused on the following sectors: research, technological development and innovations, solid waste management, water and environmental protection, transport, urban development, education, health and energy.

Table 34.3:
Outcome indicators for a structural programme loan project

Outcome indicators	**Baseline (year)**	**Target (year)**
Employment rate (%) among people aged 15-64	64,4% (2005)	72% (2014)
Productivity of companies – per employee from EU-25 average	58,6 (2005)	80% (2013)
Research and development investment of companies as percentage from GDP	0,42% (2004)	1,6%(2013)
Employment in high-tech and medium-high-tech industry and service (% from total employment). *Companies belonging to NACE code 24, 29-35, 64, 72 and 73 sectors are considered as high- and medium-high-technology industrial and service companies.*	7,57% (2004)	11% (2013)
Number of full time scientists and engineers per 1,000 employees	5,1 (2004)	8,0 (2013)
Rate of participation in lifelong learning. *Measured as the percentage of adults participating in adult training among the residents aged 25-64.*	6,5% (2006)	11,5% (2013)
Poverty risk rate. *Measured as the percentage of people living in poverty from the total population.*	19,3% (2004)	15% (2014)
Percentage of people included in the information society: - percentage of Internet users - use of Internet at home. *A 15-74 year old resident, who has used the internet during the last 6 months, is regarded as an internet user. A 15-74 year old resident who has used the internet during the last 6 months and one of the places of use has been his/her home, is regarded as a user of internet at home.*	 53% (2005) 36% (2005)	 75% (2013) 70% (2013)
Percentage of water in good state. *The good ecological condition is determined on the basis of the results of monitoring of biological, hydro-morphological and physical chemical quality indicators.*	65% (2004)	100%(2015)
Recycling rate of solid waste (excluding oil-shale and agricultural waste)	36,7% (2004)	60% (2015)
Primary energy usage.	60,0 TWh (2005)	60 TWh (2015)

This Programme is expected to generate a number of economic benefits and positive spill-over effects for the Member State. The list of expected outcomes is summarised in Table 34.3. Improved accessibility in the country should be achieved by high priority interventions in the transport sector. This is expected to contribute to the development of the local economy and improvement in the conditions for national and international trade. Moreover, the Government intends to improve the attractiveness of the country by investing in environment, tourism and RDI. These key assets will provide further opportunities for employment created through SMEs and are expected to spur growth in the area. Environmental investment will benefit the wastewater, waste and energy sectors. Investments in the water sector aim at ensuring the optimal usage of this key resource on a social, economic and environmental level. The Programme will also contribute to the objectives of the Lisbon Strategy as almost 50% of the expenditure will target such objectives, with funding allocated to research, technology transfer, innovation and entrepreneurship. Overall, the macro-economic impact of the Programme is considered high, based on the analysis of its quantified outcome objectives. The enhancement of the sectors included in this project are likely to contribute to the sustainable development of the Member State, improve economic competitiveness and social and regional cohesion. The Programme is expected to support the ongoing growth in the country's economy and continued convergence.

The implementation of the National Strategic Reference Framework is expected to have a considerable positive impact described by the indicators in Table 34.3. Therefore, the impact of the programme against the national development strategy is judged as *High*.

The experience in the analysis country suggests that public procurement (which the promoter is bound to follow) may sometimes not provide cost-effective solution. However, supporting measure is the control framework of the promoter to ensure adequate procedures are applied. Hence, cost-effectiveness is *Moderate*.

The results of this analysis are summarised in Table 34.4 below.

Table 34.4:
Results of evaluation of a structural programme loan project

Criterion	**Weight**	**Points**	**Score**
Capacity of the promoter			
Moderate - 5 Adequate project management capability to enable the promoter to deliver the project.	**40%**	5	2
Perceived impact of the programme (outcome)			
Population affected (population affected/total population of the region) 1.3/1.3 = 1	**10%**	10	1
Degree to which benefits of the programme contribute to the attainment of the objectives of the development strategy High - 10	**40%**	10	4
Cost effectiveness			
Moderate - 5 Adequate value for money	**10%**	5	0.5
Total			**7.5**

Satisfactory

The qualitative economic analysis identifies a number of positive externalities resulting from the implementation of the investment priorities supported by the operation, while the capacity of the promoter and cost-effectiveness are moderate, which permits categorisation of the project as *Satisfactory*. Taking into account the overall appraisal results and this supplementary categorisation, it is anticipated that the project is likely to render a positive economic rate of return.

35 Public Buildings

Lourdes Llorens, Mariana Ruiz, and Brian Field

35.1 Methodology

35.1.1 Introduction

Public buildings are those promoted by a public administration for housing the required resources to provide services to citizens in the exercise of its powers and functions. The general term "public administration" includes all levels of the public administration and public societies. The services delivered are wide-ranging, extending from the provision of business licences to tax collection (Health and Education buildings are not included in this summary since they are addressed in the more generic investment portfolios of the health and education sectors).

Two types of public building can be distinguished according to the services they provide, i.e. non-revenue and revenue generating services public buildings. Examples of the former would be the headquarters of local authorities and, of the latter, municipal museums.

35.1.2 Economic appraisal of public buildings

In the first instance, it is necessary to justify the investment in the public building in question. The aim is usually to satisfy an identifiable need that is not supplied by the market, and the justification to undertake the construction of new premises is often policy-driven and informed by prevailing development plans. The resulting action plans are derived from objectives established in the national, regional or urban contexts, i.e. in all respects, they are the result of a policy decision. The policy decision entails both prioritising the selection and efficiency level, and enhancing the operation and maintenance of public services (quality, accessibility and synergies). Other aspects that must be considered are the suitability of the chosen projects and the capability of the responsible institution to ensure the implementation and sustainability of the project (cost-efficiency).

Given this background, the Bank must consider the following three assessment dimensions embedded in the appraisal of a project:

- The analysis of the strategic context and the policy framework in which the project is set and integrated with other development objectives in the subject constituency, and its applicability/relevance to the Bank's corporate objectives;
- The quantitative and/or qualitative evaluation of the project in comparison with known feasible alternatives;
- The assessment of the promoter's capabilities regarding the sustainable implementation and operation of the project.

The strategic context comprises: review of the general framework in which the policy has to be developed, including diagnosis of the current situation (e.g. high pendency rate of the justice system, administrative burdens for the creation of new businesses…); the long-term vision (general objectives such as improving judicial services, increasing competitiveness etc.) and the strategic lines (goals and targets such as reducing the pendency rate, reducing the number of days to create a business etc.); programmes and action plans that are prepared to achieve the long-term vision (for example, building new courts, creating a one stop shop etc.). In the case of public buildings, projects (refurbishment, new infrastructure to replace rental accommodation or to increase capacity) can also address the requirements set out by administrative reforms, with the objective of rationalising the provision of public services per se. In all cases, initiatives have to respond to identified public needs. Thus, the Bank has to verify that the investment reflects the long-term vision and the priorities established in the action plans and/or operational programmes.

The project must also be compliant with prevailing urban, environmental, technical, etc. regulations. In particular, it has to respect the urban plans and other sector plans that affect its locale and design, which may concern the technical aspects of the project. Such aspects may generate an upgrading of the project due to the application of horizontal plans or even to the Bank's sector objectives not related with the final quality of service provision. The potential effects are threefold: an increase in the final investment cost, decrease in operation and maintenance protocols, and the generation of additional externalities following project implementation.

Further, the identified solution has to be assessed in comparison with other potential alternatives. In the case of non-revenue generating public buildings, the benefits of the services provided to the population and enterprises are very difficult to measure. These are considered public services but, because they are rarely priced and cannot be charged individually, over-consumption is likely which can generate significant congestion costs. Such congestion costs produce negative effects on economic activity, including inefficient allocation of inputs.

Despite these potentially measurable possible congestion costs, the information provided by the promoters is usually qualitative and, therefore, the appraisal has to be undertaken considering both monetised and non-monetised benefit and cost criteria. These criteria are used to compare the selected project with other options that have been identified in the feasibility studies carried out by the promoters.

Finally, together with the qualitative and quantitative aspects of the selected project and the alternative options, it is necessary to evaluate the promoter's capacity to carry over the project in due time and proportionate cost to ensure value for money of tax payers and higher quality services to direct users.

Although the financial sustainability of the project is verified by a conventional financial analysis, key economic impacts are often not measurable so a cost and benefit analysis cannot be applied in the majority of cases. Changes in real estate values can be used as a proxy for all these benefits and costs, but appropriate statistics are seldom available for meaningful comparison (before the project is announced, after the announcement of the project and once the project is implemented). Against this backdrop, other tools such as those deploying a Multi-Criteria Analysis (MCA), can be a useful.

35.1.3 MCA approach

The use of multi-criteria analysis is currently been considered and evaluated, and the development of appropriate methodologies is work in progress. The selection of variables and the deployment of respective weighting criteria will depend on the nature of the project and the preferred scenarios. The proposed quantitative/qualitative analysis takes into account the following criteria:

- Total costs for the whole life cycle: derived from the normal financial analysis;
- Service quality: improvements in waiting times and number of users served;
- Services synergies: derived from concentration in single locales;
- Services accessibility: one stop shops, improvement of mobility;
- Ease and implementation time: promoter capacity to implement each alternative option in time and on budget;
- Urban improvements: upgrading of derelict areas, de-congestion of other areas, redeployment of vacated properties, catalyst for regeneration;
- Socio-economic and environmental improvements, such as reduction of GHG emissions, increase in energy efficiency, enhancement of social cohesion, reduction in crime and improvements in safety.

The analysis assumes that the priorities set are policy driven and not, therefore, subject to appraisal. The goal of the appraisal is to assess the feasibility and sustainability of the project within an established policy framework. The only evaluation that the Bank can undertake regarding the policy context is to verify that the main goals are in line with EU policies and the Bank's corporate objectives.

35.2 Public building case study

The case study presented is an example, albeit atypical, of an urban project, and involves a public-private collaboration. The project consists of a new Administrative and Business Centre for the Regional government. The new facility will centralise all the services of the region, which are currently dispersed around the city, thus improving the quality and efficiency of services offered to citizens. The nature, scale and location of the project also reinforce the regeneration strategy for a dilapidated former industrial area.

Necessitated and informed by the country's administrative reform, the Centre will house the headquarters of the Region as well as the General Directorates and the Regional Council, and will thus contribute to the realisation of the principles guiding the reforms. The Centre's 1,500 employees are currently spread over 25 different locations scattered throughout the city, although most are located in the eastern sector which is heavily congested. Some of the current locations are rented. The concentration of offices in a single location is intended to improve the quality efficiency and accessibility of services to the population. The selected constructor will receive a payment in kind, 15% of the land ownership; this will mean an equivalent discount on the capital expenditure. A new commercial centre will be promoted.

35.2.1 Strategic context and the policy framework

The Bank's services reviewed the publicly available documents and material provided by the promoter. The services verified that the material reflected the strategic context that is, the national and regional policy addressed to the modernisation of public services provision which also gives priority to increasing productivity and efficiency in service delivery. In this context, the localisation structure of the regional government services delivery did not seem adequate to the new situation. The Bank also verified that the selected project was in line with the urban criteria established in the latest iteration of the master plan for the city.

35.2.2 Options evaluation

The evaluation of the alternative options involved two stages. The first was to decide whether to carry on with the number of rented offices currently hosting the regional government (base scenario) or to centralise all facilities in one location in order to improve service delivery (scenario 1). A site was selected with the additional objectives of upgrading a degraded area, a former industrial locale, and reducing congestion in the eastern part of the city. The promoter insists that the concentration of services in one building will reduce users' waiting times and will improve the efficiency of the administrative procedures. It is also likely that the administration reaction time will be reduced due to the installation of new facilities. The administrations productivity is likely to increase by gathering all employees on one site and the average accessibility to services by users will improve.

The second step, once the site was selected, was related to the way to develop the site. The region, in order to minimise the cost of construction and to increase the attractiveness of the area decided to make a payment in kind, 15% of the land ownership to develop a commercial centre to the selected constructor (scenario 2). This arrangement translates into lower capital investment for the administration and provides incentives to the constructor to implement the project on time.

35.2.3 Urban improvements and other externalities

The main benefits came from the action on a degraded old industrial area and from the decongestion of other city areas currently suffering from traffic jams and the consequent environmental deterioration. Thus the project not only dovetails with urban policy, but is also likely to generate positive land rents and a diminution of congestion costs.

The construction of a new public building following best practice with regard to energy consumption will generate a general improvement of the environment and may also generate a number of jobs.

Table 35.1: Benefit scores (MCA)

		option scores			weighted option scores		
Benefit criteria groups	Criteria weights	No relocalisation Base Scenario	Only public building Scenario 1	Public building and commercial centre Scenario 2	No relocalisation Base Scenario	Only public building Scenario 1	Public building and commercial centre Scenario 2
Services quality	20	3	9	9	60	180	180
Services synergies:	20	3	10	10	60	200	200
Services accessibility:	15	4	9	9	60	135	135
Ease and implementation time	15	8	3	5	120	45	75
Urban improvements: upgrading of derelict areas, de-congestion of other areas	20	0	8	9	0	160	180
Socio-economic and environmental externalities	10	0	6	8	0	60	80
Total scores (B)	100	18	45	50	300	780	850
Rank		3	2	1	3	2	1
Advantage from base scenario (% increase in B)		0	150%	178%	0	160%	183%
Ratio C/B		2,33	1,61	1,25	0,14	0,09	0,08
Advantage from base scenario (% decrease in Ratio C/B)			31%	46%		34%	47%
Advantage from scenario 1 (% decrease in Ratio C/B)				22%			21%

35.2.4 Economic evaluation – discounted cash flows

The costs of the three options evaluated are presented in Table 35.2 below.

Table 35.2: Costs and benefits of options evaluated (EUR million)

Costs and benefits	No relocalisation	Only public buildings	Public buildings and commercial centre
Initial investment costs	0	65,56	55,73
Life-cycle investment costs	0	1,62	1,62
Annual operational cost	41,95	11,96	11,96
Residual values	0	-6,89	-6,89
Net present cost at 5% for 30 years including residual value (C)	41,95	72,25	62,42
Rank	1	3	2
Difference from the base scenario		72%	49%

The appraisal also includes Table 35.1 with an explicit quantitative evaluation for some the evaluation criteria and according to the impacts and effects described by the promoter in the business plan.

At a 5% discount rate and 30 year discount period, the new building constructed together with a commercial centre is assessed to generate average cost per benefit point that are 47% lower than the minimum option and 21% lower than the option not including a commercial centre. This analysis does not include the investment costs incurred by the contractors. It is assumed that the constructor will act rationally to maximise the benefits of its investment.

36 Solid Waste Management

Patrick Dorvil

36.1 Methodology

36.1.1 Introduction

Solid Waste (SW) projects in the Bank context may include: Collection equipment, sorting/recycling units, Mechanical Biological Treatment (MBT) plant, aerobe and anaerobe treatment facility, thermal treatment, waste disposal, etc.). Most of them show significant differences in cost according to geography. In addition, the focus must be made on the total cost of the waste management system, instead of on the cost of one single component. Therefore, the issue of the appraisal of SW projects for their fundamental economic justification is complex.[95] Demonstrating the benefits of the costs in a comparable metric is challenging. In a large number of cases, prices are lacking. PJ uses a set of criteria to appraise the economic resource implications of projects in the sector grouped around cost-efficiency and affordability.[96] The following sections address these two concepts in a succinct manner.

36.1.2 Cost-efficiency

The classic treatment of examining the comparative resource is a financial analysis to set the scene, with the true PJ decision based on Cost-Benefit Analysis (CBA), expressed as an ERR figure, and judged against a threshold of 5% in real terms. The ERR can be an IRR modified by shadow price elements.[97] Theoretically, there can be a direct computation of “Willingness to Pay” (WTP), often deduced from surveys of affected persons. The Average Incremental Cost (AIC) methodology has been adopted as most suitable for this task. AIC allows investigating which option is more cost-efficient for the beneficiaries of the SW services. AIC is calculated only for the options that are technically, institutionally and legally viable. All options shall comply with both the relevant EU Directives and national waste legislation. AIC is a discounting-based indicator expressed by the following formula: [98]

$$AIC = \frac{\sum_{t=0}^{t=n} \frac{(IC_t + NOM_t)}{(1+r)^t}}{\sum_{t=0}^{t=n} \frac{(OP_t)}{(1+r)^t}}$$

Very often, the AIC includes only the project component to be financed and not the comprehensive SW system costs. Another shortcoming is the time horizon (T). It has to be set at the level that represents the life span of the most important assets. Furthermore, the discount rate is 5% corresponding to financial discount rate in real terms recommended by the EC as an indicative benchmark for public investment projects co-financed by the Funds.[99]

36.1.3 Affordability

The affordability of Solid Waste Management (SWM) Services is an issue which can be looked at from at least three different perspectives: beneficiaries (those receiving the service), municipalities (those providing the service), and society as a whole.

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[95] Because of, among other factors: shadow-pricing; opportunity costs of avoided landfill; property value impact; opportunity cost of avoided leachate, as a pollutant; carbon values, costs of pollution

[96] In this context PJ’s approach and JASPERS’ are essentially the same. However, since JASPERS is largely involved in project preparation, it assesses the cost-effectiveness of different technical options, whereas only the selected option is presented to the Bank for lending operations. Furthermore, as required for any project supported by the EC the project funding gap is calculated by JASPERS whereas this does not play a vital role for the due diligence carried out by the Bank.

[97] Shadow price for labour wage when there is unemployment, shadow exchange rate etc.

[98] Where **AIC**: Average Incremental Cost; **IC**$_t$: Investment Costs in year t; **NOM**$_t$: Net Operating and Maintenance Cost in year t; **OP**$_t$**:** Project output in year t (i.e. tons of MSW treated); **R:** Discount rate; **N:** Number of years

[99] Guidance on the methodology for carrying out Cost-Benefit Analysis. Working Document No 4. The Programming Period 2007 – 2013. European Commission. 08/2009.

Affordability to the Beneficiaries[100]
Charging for SWM services is based on the ‘polluter pays principle’.[101] The polluter pays principle is an economic policy which attempts to allocate the costs of pollution and environmental damage to the polluters. Pricing may attempt to encompass the costs to human health, the environment, natural resources as well as social and cultural harm.[102] Nonetheless, the SW services must be affordable to all individuals.[103] Very often a household income distribution is requested to ensure that household in the lowest (or sometimes the two lowest) deciles do not pay more than 1.5% of their income for the services.

Affordability to Municipalities / Regions
Municipal affordability relates to the ability of municipal governments to raise the income required to pay for a service. In terms of user charging, the range of methods can vary widely between municipalities, even within a single country. Some costs are calculated on the basis of m^3 or weight, others in accordance with the number of people in a household and still others as a lump sum price (a method which completely ignores the polluter pays principle). The charges may vary between urban and rural areas.[104]

Affordability to the whole Society
This relates to the costs of the proposed service relative to national income. It is particularly important as it means that solutions which are affordable to one country may be unaffordable to another. Once the unit cost of a given SWM system is known, a comparison can be made with the typical indicative cost for the provision of such services in countries with similar income levels. Estimates of the percentage of household expenditure typically allocated to SWM services range from 0.2-0.8% for an average income of USD44,000/capita/annum; 0.2-0.7% for an average income of USD8,000/capita/annum; to 0.4-1.6% for an average income of USD500/capita/annum.

If service costs are affordable in relation to average income levels but not affordable to low income inhabitants of society, this too should be taken into account when structuring cost recovery policy. Affordability must therefore also bear in mind the distribution of incomes around the average.

The broad conclusion is that, for the European client states of the EIB (EU-15+12, “Middle-Income” for FEMIP potentially), the actual average expenditure on waste management services runs up to an approximate maximum of 0.8%. The Commission, in Structural Funds applications, adopts a threshold of 1.5% for affordability of SWM services (if a programme will end up costing a region or commune more than this, the investment becomes eligible for SF grant support), a threshold also followed by the Bank.

36.2 Solid waste case study

The project includes the following waste management facilities: 3 composting plants with a capacity of 31,100 tpa, 1 anaerobic digestion plant with a capacity of 22,330 tpa, 1 Mechanical Biological Treatment (MBT) plant with a nominal capacity of 205,000 tpa and 1 Waste to Energy (WTE) plant (including 1 slag recovery) with a nominal capacity of 256,000 tpa. Within the project, it is also foreseen to increase the capacity of 3 existing landfills in order to treat waste generated while the new treatment facilities are being implemented. The population of the targeted region is about 700,000 inhabitants. In 2006, approximately 60% of SW generated was landfilled, with only 40% being recycled. Therefore, the revised Waste Master Plan targets

[100] Another related concept is the willingness-to-pay. The extent to which an individual is willing to pay for a hypothetical service also depends on how much he or she can afford. Therefore, in the marketing of SW services, both willingness-to-pay and ability-to-pay must be considered simultaneously.
[101] or ‘user pays’ principle or pay as you throw – PAYT.
[102] This principle presents some shortcomings in terms of identifying and billing of the polluters since waste collection is not performed via a fixed network.
[103] Another shortcoming: Those who cannot afford the services have to be served because of the presence of externalities.
[104] At the time of writing, in France the cost ranges between EUR63 and EUR74 per ton in rural areas and between EUR54 and EUR65 per ton in urban areas; In Germany, an average household of 3 people pays EUR100.80 per ton, but this differs not only from urban to rural areas but also between *Länder* (regions).

an increase in the rate of recycling from 37% in 2006 to 46% in 2016. It is expected that 11% of the total generated waste will be composted, biological mechanical pre-treatment will handle 34% and energy recovery 9%.

Table 36.1: Investment cost

INVESTMENT COST	NPV(5%)	TOTAL M EUR	2008	2009	2010	2011	2012	2013
Engineering, planning	**9**	9.9	2.1	2.6	2.4	1.7	1.0	-
Composting plants	**27**	29.5	-	10.5	7.6	11.4	-	-
Landfills	**3**	3.3	-	3.3	-	-	-	-
Transfer centres	**20**	22.2	-	0.2	22.0	-	-	-
Construction and demolition waste facilities	**6**	6.6	-	-	3.3	3.3	-	-
MBT	**37**	43.2	-	-	6.5	17.3	15.1	4.3
WtE	**201**	236.8	-	-	35.5	94.7	82.9	23.7
Technical contingencies	**23**	26.4	0.2	1.2	5.8	9.6	7.4	2.1
Sub total in M EUR	**325**	**377.9**	**2.3**	**17.9**	**83.1**	**138.1**	**106.5**	**30.1**
Interest during construction	**19**	23.9	-	0.1	0.7	3.4	8.0	11.7
TOTAL	**345**	**401.8**	**2.3**	**18.0**	**83.7**	**141.5**	**114.5**	**41.8**

Table 36.2: Financial / economic analysis

REVENUES (M EUR)	NPV (5%)	2008	2009	2015	2020	2025	2032
Fees to mancommunidades	**464**	0.00	16.66	35.81	35.35	35.55	36.00
Power sales	**105**	0	0	11.2	11.0	11.1	11.2
Heat	**3**	0	0	0.23	0.33	0.33	0.33
Recycling/metals	**7**	0	0	0.800	0.770	0.777	0.790
Compost sales	**3**	-	-	0.31	0.32	0.32	0.33
Total revenues	**583**	**-**	**16.66**	**48.37**	**47.81**	**48.07**	**48.66**
OPEX (M EUR)							
Composting & AD (M EUR)	**29**	-	1.23	2.30	2.32	2.33	2.34
MBT (M EUR)	**32**	-	-	3.47	3.38	3.39	3.44
Incinerator (M EUR)	**126**	-	-	13.38	13.33	13.35	13.38
Transport (M EUR)	**30**	-	1.68	1.86	1.78	1.79	1.81
Transport cost (EUR/t)		-	15.30	12.56	12.56	12.56	12.57
Landfill gate (2008-2012) M EUR	**69**	0.83	9.60	-	-	-	-
Overhead GHK	**13**	-	0.1	1.1	1.1	1.1	1.1
Total expenditures	**299**	**0.83**	**12.60**	**22.11**	**21.91**	**21.96**	**22.07**
Cash flows (M EUR)	**- 8**	**- 3.09**	**- 13.32**	**26.25**	**25.89**	**26.11**	**26.59**
FIRR	**4.7%**						

Discounted treatment cost (incineration)	**161**
Discounted treatment cost (composting & AD)	**88**
Discounted treatment cost (MBT)	**43**

+ Discounted treatment cost (for all facilities)	**149**
- Discounted recycling revenues	**30**
=Discounted net waste treatment cost (EUR/t)	**119**

The tariff system is based on the polluter pays principle and targets full cost recovery i.e. all costs of transfer, transport and treatment of waste, including debt service and replenishment of a fund for asset renewal. The tariff for 2009 is EUR117.51/t plus VAT. The following third party incomes have been considered in the project's cash flows: electricity sales, district heating), recycling materials and compost. Third party income generates up to 26% of total income. The financial analysis in constant terms shows a low profitability of 4.7% and high sensitivity of the

FRR to variations in the project's investment cost or operational expenditures (the FRR falls below 4% with an increase in the project's cost or operational expenditures above 5%). Should the financial analysis take into account construction and demolition waste the project's waste flow would raise from an average of 300,000t p.a. to 700,000t p.a. This would result in an increase of the FRR to 16.6% and a decrease in the average incremental cost to EUR62/t.

Based on statistics for the year 2008, the mean income per person in the region is EUR30,599. Estimates of the percentage of household expenditure typically allocated to SWM services range from 0.3%-0.8% for high-income countries. Thus, annual expenditure is between EUR92 and EUR244 (based on each inhabitant generating approximately 600kg of SW per year). The discounted treatment cost for the region is calculated to be EUR119/tonne, which therefore does not pose a problem for beneficiaries as far as affordability is concerned. The project provides a cost-effective response to European regulations and is within the affordability constraints of the project's beneficiaries. In this context the project is justified on economic grounds.

37 Water and Wastewater

Thomas van Gilst and Monica Scatasta

37.1 Methodology

37.1.1 Introduction

Investment in the water and wastewater infrastructure contributes to the improvement of human health through improved quality and reliability of water supply. It also enhances environmental protection through the reduction of untreated wastewater discharges into the recipient water bodies and into ecosystems. With the environmental and health benefits resulting from safe water, sanitation and pollution abatement hard to quantify, for EIB projects, a quantitative CBA is at times replaced by other approaches such as the CEA (cost effectiveness analysis). Larger EU grant programmes (e.g. DG REGIO) require a CBA.

37.1.2 Cost/effectiveness

In the EU, sector investments are strongly driven by the need to comply with EU Directives such as the Water Treatment Directive, the Urban Wastewater Treatment Directive, and the Water Framework Directive. With failed compliance resulting in commission imposed fines, the economic case is straightforward and justification for EIB projects can rely on just a CEA. A CEA is used for comparing the relative merits of such project options where benefits are identical or similar to one another (even if difficult or impossible to quantify), and where costs instead, can be established with some confidence. In these cases in the water sector it implies the identification of the least cost option for achieving the compliance objective.

The key step of such a CEA is a thorough option analysis which should normally take place at the feasibility study phase. It is important that the intended objective is defined broadly so as to avoid overlooking more efficient alternative solutions. Needless to say, the solutions should also be sufficiently well designed, paying particular attention to demand forecast and the inclusion of alternatives with appropriate (incremental) phasing to avoid unnecessary and expensive over-dimensioning. Once the options have been identified, a ranking can be made based on the present value of the costs.

It is not uncommon in feasibility studies that even this basic option analysis is preceded, supported or simplified to, for example, multi-criteria analysis (MCA). Though being less quantitative, such an analysis does allow for comparison between options with wider implications/benefits, e.g. politically sensitive decisions on treatment plant locations, or for pre-screening of options prior to the CEA. In cases when the analysis goes no further, affordability (see below) becomes the critical last step.

Most countries outside of EU today have legislation that requires compliance with environmental and other standards, at times irrespective of their economic and technical capacity to sustainably attain these standards. It follows that some form of phasing of investments is often required.

37.1.3 Average incremental cost analysis

Average incremental cost analysis is an extension of CEA that involves dividing the present value (PV) of project costs by the PV of the water or wastewater volumes, producing an estimate of average cost per unit of service provision. This tool allows the comparison and ranking of options with different cost impacts whilst at the same time providing a rough indicator of the unit cost per cubic metre. An indication of cost effectiveness is obtained by comparing this figure against reference unit costs.

37.1.4 CBA

When the CEA procedure alone for Directive (or other, national legislation) compliance cannot be followed, a CBA is the indicated tool to validate (the magnitude of) the investments identified following a CEA. To do the CBA, the benefits need to be calculated. Since the water and wastewater services are (usually) provided in a regulated monopoly environment, i.e. with numerous price and cost distortions, tariffs do not always reflect the benefit attributed by consumers to the services received. A better indicator of the value attributed to the benefits of the services would be the "willingness to pay" (WTP).

WTP is usually determined via contingent valuation (i.e. based on surveys). However this technique is inherently susceptible to "strategic" responses or ill-informed responses due to the interviewees, often from low-income, un-served areas finding the questions on hypothetical service levels highly abstract and beyond their personal experience and environment. Revealed preference analysis through for example the rates that un-served customers pay private vendors can strengthen the WTP analysis. However, perhaps as a result of the cost of conducting WTP studies, they are almost never available or are unreliable and other methods are often used.

The more common starting point for an economic analysis is thus the financial profitability analysis, which approach is already touched upon in the introductory chapters. The first step involves moving from financial to economic prices (including the elimination of inter-societal transfers such as taxes and subsidies which should be cost/benefit neutral from a societal perspective). The assumption is that the tariff here represents the value of direct benefits of the basic service provision, i.e. equivalent to the avoided private costs, such as private investment and operational costs for wells, septic tanks and (expensive) water purchased from vendors. If this is not the case, it is preferable to replace the tariff directly with an assessment of mentioned avoided costs.

In a second step, despite the difficulties of estimating water and sanitation externalities and indirect benefits, the quantifiable benefits and costs are added.[105] These are typically:

- Health: Improved health and living conditions leading to savings in private and public health costs;
- Time savings: e.g. time saved of people that fall ill or that otherwise need to fetch water from afar, and that is made available for (i) income generating activities or (ii) leisure (not to be under-estimated);[106]
- Environmental benefits, of which a part can be more easily valued by assessing the decreasing treatment cost and assessing the recreational value; the other, more difficult to quantify part would include benefits derived from the preservation of natural habitats and species which provide ecosystem services such as air quality, climate, water purification, pollination, prevention of erosion, spiritual and aesthetic values, knowledge systems and the value of education;
- Other indirect benefits e.g. generated economic activities that would otherwise not take place (note that some approaches are controversial hence such benefits are rarely used at EIB).[107]

Note that there is an inherent risk that the different items above overlap and hence could lead to double counting. Clearly, this must be avoided.

Accurate estimates are hard to come by and each CBA requires judgement in order to evaluate what degree of which economic benefits and costs can be determined with sufficient accuracy in monetary terms to be included. Besides the unit costs, also the quantum of units to apply the above unit rates to can be challenging to determine with any accuracy: For example the estimation of the number of sick-person-days avoided as a result of a new wastewater treatment plant which only solves one part of the water supply contamination. This may seem trivial, but like accurate demand forecasting, is prone to optimistic inflation by project promoters.

Indeed some benefits are better left un-quantified and considered qualitatively as a complement to the calculated ERR. This qualitative analysis may have a significant impact on the decision.

[105] Whittington D. (1994), The economic benefits of potable water supply projects to households in developing countries (www.adb.org/Documents/EDRC/Staff_Papers/es53.pdf).
[106] Esther Duflo et al; Happiness on Tap: Piped Water Adoption in Urban Morocco. Available at: (www.nber.org/papers/w16933.pdf)
[107] OECD: Benefits of Investing in Water and Sanitation; World Bank (Scatasta): Indirect Economic Impacts of Dams

A useful approach is to reverse-calculate what the value of the unquantifiable benefits would need to be in order to achieve an acceptable ERR, e.g. the health benefits would need to be EUR X per person per year to have an ERR of say, 5% (the typically used threshold). The ERR threshold can be considered satisfied if the value of X is within a realistic range. Given the many uncertainties in the “building blocks” of a CBA described above, a sensitivity analysis is recommended to test the robustness of the findings.

The physical life is usually 25 years and above for water projects depending mainly on the “pipes and cement” vs. electromechanical content. The economic life is usually deemed in line with the physical life due to the service being of monopolistic nature and with limited foreseeable substitutes.

37.1.5 Affordability
Price elasticity of domestic demand is low for water services (especially for the minimal lifeline quantities of water), however, affordability remains a key determinant to the “political sustainability” of a project as well as of water demand. Whilst it is perhaps not directly an input to the economic profitability, the full uptake of the service through affordable tariffs affects the realisation of the benefits. Affordability is also an additional signal of the appropriateness of solutions or components thereof.

The affordability ratio is defined in the form of the share of monthly household income (or expenditure) that is spent on water and wastewater services.[108] The most commonly internationally quoted affordability thresholds are 4% of average household income for water services and 1% for sanitation. Wealthier countries often apply lower thresholds, however. EIB uses 5% as total for water and sanitation in ACP countries and else the national standards where these exist, provided they are reasonable (e.g. HUN 3.5% to 4%; CZ/SK 2.5%; PL 3%).

Affordability analysis can be done at two levels of detail: macro (average cost of the given service level) and micro for the poor and vulnerable, whereby the former looks at the ratio of average household water charges to average household income or expenditure, and the latter looks at how costs are (or should be) allocated between users within the service area, taking into account income levels (e.g. lowest income decile) and tariff structures (e.g. rising block tariffs) and completes the picture in regards to true “sustainable cost recovery.”[109]

37.1.6 JASPERS
The JASPERS approach also commences with an option analysis to make sure the project is cost-efficient. Prior to calculating the funding gap (in order to determine the level of justified subsidy) for the selected option, a full CBA is carried out. The CBA is also built up using the financial projections as a basis mainly for the cost component, whereby certain line items such as non-traded goods and unskilled labour are converted from financial to economic costs using conversion factors to eliminate market distortions. This is a perfectly valid approach when reliable conversion factors are available. However, in a number of countries this factor approaches 1 as distortions are disappearing with time.

37.1.7 Multi-purpose schemes
Some water resources projects presented for funding are multi-purpose, i.e. some combination of water supply, hydropower, irrigation, flood control, and/or navigation. Alternative water resources projects involving treatment for re-use in agriculture or desalination plants are increasingly common. Like the options within a project, any complex water resources project requires a full economic analysis of all components carried out at an appropriate scale, usually the river basin, and applying multiple decision criteria. Demand forecasts under different tariff scenarios and the valuation of environmental benefits further complicate the analysis. In such cases, the Bank will normally assess the quality of analysis performed by others and, where necessary, insist on additional studies to fully justify the selected option.

[108] Frankhauser/Tepic (2005) propose to use household expenditure which is higher in low income countries where there is a larger informal sector.
[109] Scatasta, 2008: Pricing Water Resources and Water and Sanitation Services (OECD)

37.2 Case study (1): water and wastewater inside the EU

The project concerns the extension and rehabilitation of water and wastewater systems in the county A area, in country B. The project aims to improve environmental protection and public health in 8 agglomerations with a total population of 520,000, located across a region. The project consists of the expansion and rehabilitation of the water and wastewater networks, construction and refurbishment of pumping stations and treatment facilities for waste and wastewater, as well as provision of necessary technical assistance for project implementation. The economic analysis of the project was calculated by consultants on behalf of the promoter, using the relevant EC guidance as adapted for Country B with JASPERS assistance.[110]

In order to calculate the economic costs behind investment costs, replacement costs and operations and maintenance (O&M) costs, a shadow wage rate [(1-u)*(1-t)] was calculated and applied to every year of the period of analysis, with u standing for the regional unemployment rate and t for the rate of social security payments and relevant taxes. The average rate for this project amounts to 0.50. The financial costs of labour are therefore multiplied by 0.50 in order to reflect the economic costs. All other potential conversion factors have been set to 1, as no major distortions in the prices of traded and non-traded items are expected. Also, there are no externalities on the cost side that have to be taken into account.

The main economic benefits of the project are the positive impact on compliance with the environmental acquis – among others the direct environmental impact, improved drinking water quality and positive effects on public health. Furthermore it is assumed that the rehabilitation and extension of the water supply and sewerage system will result in an increase of life quality of the population in form of improved health and comfort. In order to quantify the economic benefits of the project a comparison of scenarios “with project” and “without project” was carried out. Economic benefits have been grouped as follows:

- Improved access to water and sewerage services: The relevant measure is the additional volume of water sold per year as a result of the project, which can be valued from the economic point of view by using the average fee per m^3 paid by the customers (applied for water and wastewater according to the respective incremental connections).
- Resource cost savings: a) Resource cost savings to the customers are avoided capital and O&M cost for drinking water wells and septic tanks. Residential users are assumed to use on average 0.5 well units and 1 septic tank units per household. Non-residential users are assumed to use on average 3 well units and 4 septic tank units per economic agent. It is also assumed that connection to the water supply system would substitute the consumption of one bottle of mineral water per person and day. b) Resource cost savings to the operator: There are two major components: avoided O&M cost due to reduced water losses and avoided emergency replacement of obsolete equipment. As the avoided O&M cost are already implicitly considered by applying the incremental approach, these benefits are evaluated at zero in this specific case. In the “without project” scenario, emergency replacement cost for out-dated and obsolete equipment is considered starting from 2013. This cost can be avoided with the project. A provision for these cost (approximately EUR2 million/year) is already included in the O&M cost of the “without project” scenario, therefore it is set to zero in the benefits section.
- Avoided carbon emissions through the production of electricity in the wastewater treatment plants (WWTPs): The specific emission factor for the country – considering its power production mix – was estimated at 0.9 tCO_2 per MWh. The electricity to be produced with methane gas in the WWTPs would avoid a total of 186 thousand tCO_2 between 2010 and 2036.
- Avoided opportunity cost of water: Through loss reduction and other efficiency measures, less raw water has to be abstracted, i.e. more water will be available for alternative purposes or left in the natural environment.

[110] “Guidance on the methodology for carrying out Cost-Benefit Analysis.” Working Document No 4. The Programming Period 2007 – 2013. European Commission. 08/2009.

- Benefits of compliance with the environmental acquis: published values are used to evaluate benefits to human health; impacts on aquatic environments mostly concerning fish and shellfish resources; to ecosystems via biodiversity protection; social benefits, such as access to clean bathing waters and rivers for recreation; and wider economic benefits, such as tourism. The benefits of full EU compliance to water related directives were estimated to have a total value ranging between 400 and EUR1,250 million per year in 1999 prices. This would be equivalent to a range of EUR22 to 68 per year and inhabitant in 2006 prices. For the present analysis a value of EUR68 per person and year was chosen. The higher value was chosen because a separate assessment of access to service benefits already yielded quite a high result.

The project is a first phase of a series of investments that will contribute to achieve full compliance in the region, and the share of the project in achieving full compliance was estimated at about 38%. Furthermore, the percentage of compliance achieved was stepped according to the approximate percentage of population progressively benefiting from the improved water and wastewater systems, in line with the rate of connection to the sewer systems. The ERR was calculated to be a satisfactory 6.8% based on 30 year projections from 2007 to 2036.

37.3 Case study (2): Water and wastewater project outside the EU

The project is expected to improve the water supply service in the East Zone of town C, including population not yet properly served by means of financing a number of works included in the Town C Water Company (TCWC)'s investment programme for the period 2006-2010. These works aim at improving the reliability and efficiency of the existing systems, reducing non-revenue water and expanding the water supply to concession areas not yet served.

The main benefits of the project are: (i) improvement of the reliability and efficiency of the water supply service, with optimisation of the performance of the systems and reduction of illegal connections; (ii) improvement in the use of scarce existing water resources, with reduction of leakage in the distribution system; and (iii) better quality of life including reduction of health risks for the population in the service area through the increase of coverage of the water supply service.

For the items (i) and (ii) above the main project impact is the reduction of the percentage of non-revenue water from the current 34% to about 30%. TCWC estimates this reduction at 56 MLD (20.4 million m^3/year). Therefore, assuming that most of this reduction is achieved through the reduction of leakage, the economic value of this benefit is given by the variable cost of production per m^3, which is about Local Currency Units (LCU) 1.03/m3 or EUR0.3 million per year.[111] [112] There are also savings in operation and maintenance costs due to renewal of equipment and preventive maintenance, which have not been quantified.

For item (iii), which is in fact the most important from the economic point of view, the main project impact is the new customers' access to continuous access to safe water at an affordable price as well as the effects of this in the reduction of incidence of water-borne diseases. That is, the project will provide access to safe water to a population of about 666,000 (in approximately 111,000 households) that currently get their water from a combination of private wells, vendors and purchase of bottled water. Current water consumption of these households is somewhat difficult to assess, but given the reference of comparable situations it is difficult to imagine that consumption will be higher than 50 l/c/d. Using this average consumption and an estimated price currently charged by the private wells and vendors, a rough calculation of what these households pay for water would be the range of the 104 LCU/m^3, about 10 times the tariff charged by TCWC to residential customers and equivalent to 11% of their household income. The described consumption and expenditure data is summarised in Table 37.1 below.

[111] Basically, energy cost and chemicals.

[112] That is, non-revenue water has in fact two components: physical losses and administrative losses (i.e. illegal connections). Given that the economic value of water supplied to an illegal connection is the tariff, which is higher than the variable cost of production, the assumption made is on the conservative side.

Table 37.1:
Key consumption and customer expenditure data before project

Beneficiaries	
Area A	372,000 inhabitants
Area B	144,000 inhabitants
Area C	150,000 inhabitants
Total	666,000 inhabitants
Consumption	50 l/c/d
From private wells	25%
From vendors	50%
Price	
Private wells	40 LCU/m^3
Vendors	125 LCU/m^3
AVERAGE PRICE >>	104 LCU/m^3
Monthly expenditure	936 LCU
Monthly expenditure	EUR14.60
% of Household income	11.1%

After project completion, the project beneficiaries are expected to increase their consumption to about 135 l/c/d, which is a conservative assumption consistent with the average consumption in other areas of the East Zone served by TCWC. Also, since the residential tariff charged by TCWC is significantly lower, even despite the increase in consumption the average expenditure on water for these new customers will be below the recommended affordability threshold of 4% of household income. The described future consumption and expenditure data is summarised in Table 37.2 below.

Table 37.2:
Key consumption and customer expenditure data after the project

Beneficiaries	666,000 inhabitants
Consumption	135 l/c/d
Residential tariff:	10.67 LCU/m^3
Monthly expenditure	259 LCU
Monthly expenditure	EUR4.04
% of Household income	3.1%

With this scenario, the economic benefit of this component of the project can be measured by the increase in the economic welfare of the new customers, which is based on their increase of consumption at a lower price with lower monthly expenditure for a service that is now reliable and safe. The specific quantification of this benefit involves the following calculation, which results in EUR57.35 per beneficiary and year:[113]

$$EB= Qw*Pw+Qwo*(Pwo-Pw)+0.5*(Qw-Qwo)*(Pwo-Pw)$$

where:

EB is the economic benefit (in EUR/beneficiary/year)
Qwo is the consumption without project (in m3/ beneficiary /year)
Qw is the consumption with project (in m3/ beneficiary /year)
Pwo is the tariff without project (in EUR/m3)
Pw is the tariff with project (in EUR/m3)

After deducting the operation and maintenance costs associated with the provision of water to the new customers (6.82 LCU/m3), this component of expansion of coverage has a net economic benefit of EUR34.7 million/year.

The comparison of the total investment cost (EUR201.7 million) and the above-calculated economic benefits of the reduction of non-revenue water (EUR0.3 million per year) and the increase of coverage (EUR34.7 million per year) results in a project Economic Rate of Return (ERR) of 13.1%.[114] Also, there are additional benefits for the reduction of water-borne diseases through the improvement of the quality of water received by the new customers that have not been included in the calculation because they are difficult to quantify. The proposed project is highly profitable from the economic point of view and therefore justified.

[113] Technically, this is the measurement of the project incremental revenue plus the increase in the consumer surplus before and after the project assuming that the demand function is linear.
[114] This figure corresponds to the project base cost plus the cost of other investments being financed by TCWC outside the project (i.e. the phase 1 of the Area A component and the construction of a new water treatment plant in the W river for the Area B-Area D) that are necessary to fully deliver the economic benefits considered in the calculation.

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