



Handbook on Cost-Benefit Analysis (CBA) of Public Investment Projects

Applications with Excel Examples



Strengthening Public Investment Management System Project
Programming Division
Bangladesh Planning Commission
Government of the People's Republic of Bangladesh
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Preface

The Users of this document are the desk officers responsible for 1) preparation of project proposal at the Ministry/Division/Agency, 2) project assessment at the Ministry/Division, and 3) project appraisal at the Sector Division of the Planning Commission (hereafter called the “User”).

This Handbook is to help its Users to develop a hands-on understanding of how to conduct a cost-benefit analysis (CBA) of a public investment project, using an Excel spreadsheet model and the User can also refer to when preparing, assessing, and appraising the Financial and Economic Analysis, especially the DPP item no 18.0.

This Handbook consists of the following three chapters and annexes.

Chapter I: Introduction. This chapter will help the User to understand the background and objectives of the Handbook on Cost-benefit Analysis.

Chapter II: Concepts, Methods, and Definitions. Chapter II explains and reviews the key concepts, definitions, and methodology related to CBA. This chapter will help the User to understand the specific points to consider in preparing, assessing, and appraising the Cost-benefit Analysis for the similar nature projects. A list of parameter and assumption are given to consider to help the User to identify the parameter and assumption for similar nature of project.

Chapter III: Step-by-Step Procedures of CBA for Public Investment Projects. Chapter III demonstrates how to apply CBA techniques to sample cases of power distribution, power transmission, and rural infrastructure development projects, using the Excel examples that accompany this Handbook. This chapter will help the User to conduct a Cost-benefit Analysis and getting the results of the similar nature of projects by inputting/changing the data/parameters value/assumptions. In addition, this chapter also helps the User to conduct the sensitivity analysis by inputting/changing the data/parameters value/assumptions.

Limitations of this Handbook

This Handbook **DOES NOT** give a comprehensive description of Cost-benefit Analysis. For example, the following contents are not included, 1) the history, background and importance of Cost-benefit Analysis, 2) how to conduct Cost-benefit Analysis, 3) the relation between Ministry Assessment Format (MAF) / Sector Appraisal Format (SAF) and Cost-benefit Analysis, and 4) the relation between DPP, Feasibility Study and Cost-benefit Analysis.

Acknowledgement

This “Handbook on Cost-Benefit Analysis (CBA) of Public Investment Projects” was developed with support from the Strengthening Public Investment Management System (SPIMS) Project.

The SPIMS project focuses on enhancing the project formulation, appraisal and capacity development. The SPIMS project has developed tools for project appraisal: Ministry Assessment Format (MAF) and Sector Appraisal Format (SAF). These formats ensure comprehensive assessment by Ministries/ Divisions and appraisal by Sector Divisions of the Planning Commission before project approval. The CBA is an integral part of project appraisal: MAF and SAF.

For the effective project formulation and appraisal, a basic knowledge of CBA is in essential. This Handbook offers a practical guide to conducting CBA for public investment projects using an Excel spreadsheet.

I would like to express my sincere gratitude to government of Japan and JICA for the technical support to implement the SPIMS project.

I am sincerely grateful for the collaboration and thoughtful feedback from officials across the Planning Commission, Ministries/Divisions, and Agencies. Their insights have made this Handbook a more practical and user-friendly tool for project preparation and appraisal.

I am especially grateful to the Member (Senior Secretary), Programming Division, and Chief of Programming Division for their guidance, invaluable advices, and guidance, which were instrumental to the success of developing this Handbook on CBA.

I appreciate and gratefully acknowledge the hard work of the officers of the PIM Reform Wing and JICA Expert Team (JET) consultants for developing /preparing this Handbook on CBA.

It is expected that this Handbook will help officers in the Planning Commission, Ministries/Divisions, and Agencies to learn CBA techniques.


Muhammad Anwar Uddin

Joint Chief, Programming Division
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and
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List of Abbreviation and Acronyms

BCR	Benefit-Cost Ratio
CBA	Cost-benefit Analysis
CD	Custom Duty
CIF	Cost, Insurance and Freight
CF	Cash Flow
DF	Discount Factor
DPP	Development Project Proforma/Proposal
ENPV	Economic Net Present Value
EIRR	Economic Internal Rate of Return
EBCR	Economic Benefit Cost Ratio
FNPV	Financial Net Present Value
FBCR	Financial Benefit-Cost Ratio
FIRR	Financial Internal Rate of Return
GED	General Economics Division
GCM	Growth Center Market
IRR	Internal Rate of Return
KWh	Kilowatt-hour
MSME	Micro, Small, Medium Enterprises
MVA	Mega-Volt Ampere
MWA	Megawatt Ampere
NPV	Net Present Value
O&M	Operation and Maintenance
PV	Present Value
PPP	Purchasing Power Parity
SD	Supplementary Duty
WTP	Willingness to Pay
WACC	Weighted Average Cost of Capital
SDR	Social Discount Rate
SER	Shadow Exchange Rate
SERF	Shadow Exchange Rate factor
SWRF	Shadow Wage Rate Factor

Chapter I

Introduction

1.1. Background

Public investment is carried out through public sector development projects and programmes. Development projects and programmes should be formulated to align with the existing national and sector Development Plan, e.g. Delta Plan, Perspective Plan, Five Year Plan, and relevant Master Plans. After approval of a development project, the development budget/public investment for the approved project is allocated through the Annual Development Programme (ADP) for project implementation.

Development Projects and programs must be formulated, appraised and approved by following the Planning Division's Circular "Instructions on Development Project Formulation, Processing, Approval and Revision" (Memo no: 20.00.0000.404.014.61.2020 (Part- 1)/133, Date: 12 June 2022).

The development projects are proposed in a format called 'Development Project Proforma (DPP), stipulated in the said Circular. One of the Items in DPP is "financial and economic analysis" (item 18).

Clause 1.1.8.2(CHHA) of the said Circular emphasizes the importance of conducting financial and economic analysis for each project, when the Agency, Ministry/Division, and Planning Commission formulate and appraise the project.

The development project is approved by either the Executive Committee of the National Economic Council (ECNEC) or Minister/State-minister for Planning. The results of financial and economic analysis are presented and used as one of the factors for making decisions at the meeting for project approval.

1.2. Objective of the Handbook

The objective of this Handbook is to help its users to develop a hands-on understanding of how to conduct a cost-benefit analysis (CBA) of a public investment project, using an Excel spreadsheet model. The focus of the Handbook is on the *ex-ante* assessment and appraisal of the performance of public investment projects in the context of Bangladesh, and its target users are Desk Officers working in Agencies, Ministries/ Divisions, and Sector Divisions of the Planning Commission. By applying the methods and procedures explained in the Handbook to the assessment and appraisal of public investment projects, the users of the Handbook are expected to be able to assess and appraise a proposed project's financial and economic costs & benefits and their impacts on the economic welfare of the society.

The remainder of the Handbook is structured as follows: Chapter I briefly explains objectives of the Handbook. Chapter II explains and reviews the key concepts, definitions, and methodology related to CBA. Chapter III demonstrates how to apply CBA techniques

to sample cases of power distribution, power transmission, and rural infrastructure development projects, using the Excel examples that accompany this Handbook.¹

¹ These Excel CBA models are available upon request from the SPIMS Project/ PIM Reform Wing of Programming Division for the Desk Officers engaged in the formulation, assessment, or appraisal of DPPs. Or See the Planning Commission web site: <https://plancomm.gov.bd/>.

Chapter II

Concepts, Methods, and Definitions

2.1. Role of Cost-Benefit Analysis in the Assessment/Appraisal of Public Investment Projects

2.1.1. What CBA Is

Cost-benefit analysis (CBA) is a systematic way of measuring and comparing the total costs to the total benefits expected from undertaking a project. The purpose of conducting CBA in the assessment and appraisal of a public investment project, in particular, is to measure and compare the total costs to the total benefits and thereby to ensure that scarce resources are allocated efficiently, and the proposed investment are likely to contribute to the welfare of the society as a whole.

The standard CBA of a public investment project consists of the following three main stages:

1. Financial analysis
2. Economic analysis
3. Sensitivity analysis

Through financial and economic analyses, as well as sensitivity analysis, CBA helps decision-makers to identify an economically viable project and also to select project with higher economic efficiency. For a project to be **economically viable**, it needs to meet the following requirements:

1. It generates an economic surplus above its opportunity cost (i.e., positive net economic benefits).
2. It is more efficient than alternatives to achieve the intended project outcomes (i.e., least-cost or most efficient option).
3. It will have (but not necessarily generate by itself) sufficient funds and the necessary institutional structure for successful operation and maintenance (i.e., financial sustainability in a broader sense).

CBA helps decision-makers to decide on public-sector involvements. Government should only invest in projects which are economically beneficial to the society. Even if a project is not financially profitable but economically beneficial, the government, given the availability of resources and economic efficiency of the project, may decide to invest in it.

If a project is a revenue-generating one and there are potential private-sector entities who could implement it, the government must demonstrate not only that the society will be better off with the project but also that the project is not financially sustainable without public-sector involvement (see Figure 1).

In short, if the financial analysis shows that the project is profitable for private-sector entities, public-sector involvement is not justified unless the law and regulations prohibit private entry to the market. This first condition is tested with the assessment of the financial performance indicators, such as FNPV (financial net present value) and FIRR (financial internal rate of return). In case the project is in need of public funds, only if the economic analysis shows that the society will be better off with the project, the government’s contribution to the project is justified. This second condition is tested with the assessment of the economic performance indicators, such as ENPV (economic net present value) and EIRR (economic internal rate of return). If the project is not a revenue-generating project, the test for the first condition through financial analysis can be skipped.

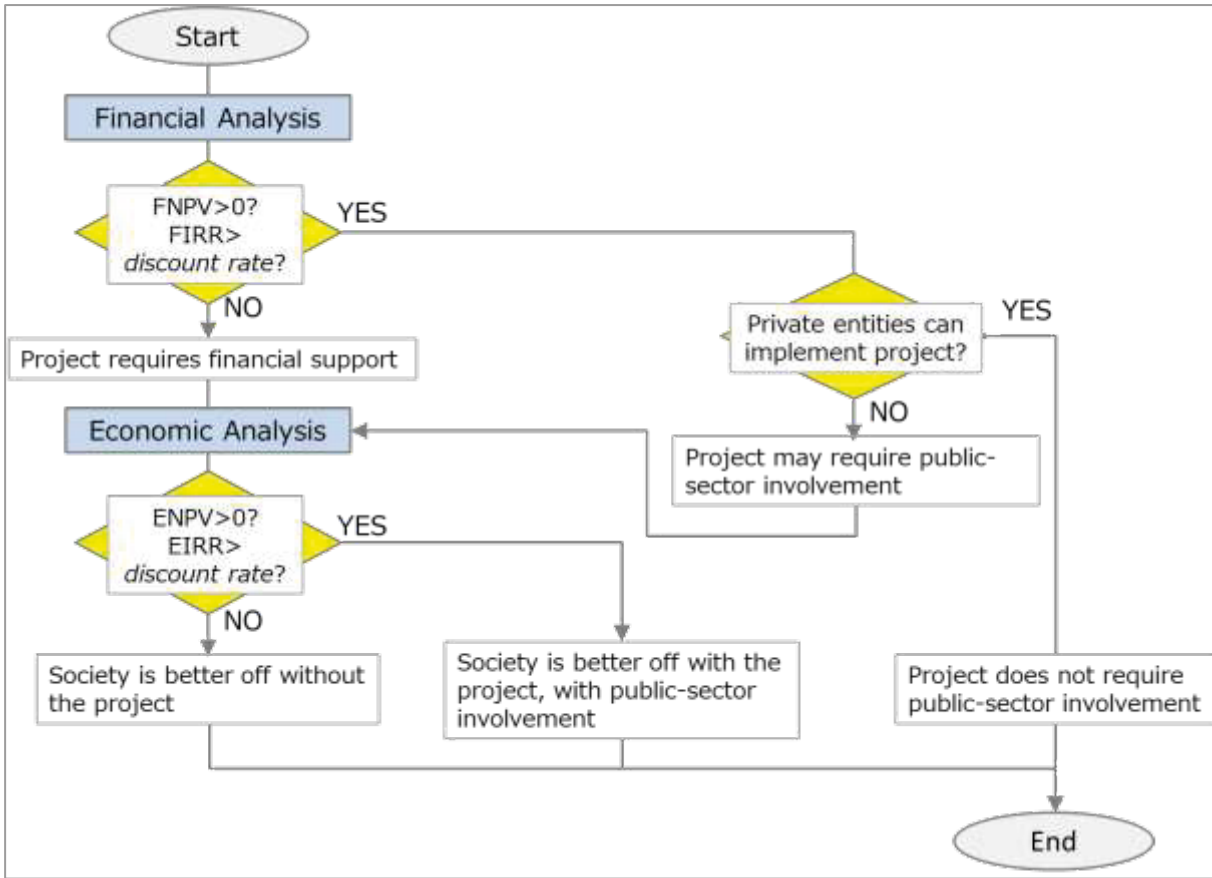


Figure 1. Flow Chart for Public Investment Decision

2.1.2. Comparison of Financial Analysis with Economic Analysis

As mentioned earlier, the standard CBA of a public investment project entails both financial and economic analyses. The key question for financial analysis is whether a project is profitable for the project implementing entity, whereas that for economic analysis is whether a project sufficiently contributes to the welfare of the entire society (see Table 1 that summarizes the differences between financial analysis and economic analysis).

Table 1. Differences between Financial Analysis and Economic Analysis

	Financial Analysis	Economic Analysis
Perspective	Project implementing entity/ investor	Economy-wide/society as a whole
Objective	To measure the profitability of the project (financial sustainability)	To measure the impact of the project on the economic welfare of the society (economic viability)
Costs	Expenditures	Welfare losses, opportunity costs
Benefits	Revenues	Welfare gains (values generated, satisfaction of the members of the society), resource cost savings
Market assumptions	Existing markets with price distortions	Ideal “perfectly competitive, efficient” market
Prices	Financial or market prices that are actually paid or received by the project implementing entity	Economic or shadow prices that removed the effects of market distortions from the financial prices (price=marginal benefit)
Transfers	Included	Excluded
Externalities	Excluded	Included
Discount rate	Financial discount rate/market borrowing rate (e.g., weighted average cost of capital: WACC)	Economic (Social) discount rate (reflecting the social view on how future costs and benefits should be valued against present ones)
Performance indicators	FNPV, FBCR, FIRR	ENPV, EBCR, EIRR

2.1.3. Overview of Performance Indicators

As shown in Figure 1, CBA provides an objective framework for investment decision-making based on the assessment of performance indicators. Both financial analysis and economic analysis generate the following three key performance indicators from the cash flows of project costs and benefits for investment decision:

1. Net present value (NPV)
2. Benefit-cost ratio (BCR)
3. Internal rate of return (IRR)

Whereas financial analysis calculates financial net present value (FNPV) and financial benefit-cost ratio (FBCR) based on the cash flows of financial costs and benefits discounted at the financial discount rate, economic analysis calculates economic net present value (ENPV) and economic benefit-cost ratio (EBCR) based on the cash flows of economic costs and benefits (expressed in monetary terms) discounted at the economic discount rate. Similarly, financial internal rate of return (FIRR) is calculated based on the cash flows of financial costs and benefits and is compared to the financial discount rate, whereas economic internal rate of return (EIRR) is calculated based on the cash flows of economic costs and benefits and is compared to the economic (or social) discount rate.

In the next sections, the fundamental concepts and methods used in both financial and economic analysis (i.e., cash flow analysis, time value of money and discounting, and incremental analysis) are explained, followed by the presentation of the definitions of NPV, BCR, and IRR to demonstrate how the values of those indicators should be interpreted for public investment decision.

2.2. Fundamental CBA Concepts and Methods

2.2.1. Cash Flow Analysis

CBA measures and compares the total costs to the total benefits of the project using the framework of cash flow analysis.

Cash flow refers to measuring total earnings/revenues (cash flows in) and expenditures (cash flows out) of an agency in regard to a specific project in a specific period of time (project's lifetime). Net cash flow is the difference between the total revenues and total costs/expenditures of a project for every year during the project's lifetime.

In the financial analysis of a project, the cash outflow (i.e., expenditures) that the project is likely to incur is subtracted from the cash inflow (i.e., revenues) that the project is likely to generate for every year during the project life to get the net cash flow.

The economic analysis of the project is also based on the same framework. In the economic analysis of the project, the cash outflow of the economic costs (i.e., financial costs + societal losses expressed in monetary value - transfers) that the project is likely to incur is subtracted from the economic benefits (revenues (if any) + societal benefits expressed in monetary value + cost savings) that the project is likely to generate for every year during the project's lifetime to get the net cash flow.

Because CBA bases its analysis on cash flows, some important accounting concepts and items that do not entail cash outlays, such as depreciation, are excluded from financial and economic cash flows used to calculate NPV, BCR, and IRR.

2.2.2. Time Value of Money and Discounting

Time value of money refers to the concept that money received today is more valuable than money received in the future. For example, \$100 received today can be spent immediately to buy some goods and services. Or, if deposited in a bank account that earns an annual interest rate of 12%, \$100 deposited today will be about \$176.2 in five years through compounding ($=100 \times 1.12^5$). But \$100 received five years from today apparently cannot be spent until then, and its value is far less than \$176.2 (see Figure 2).

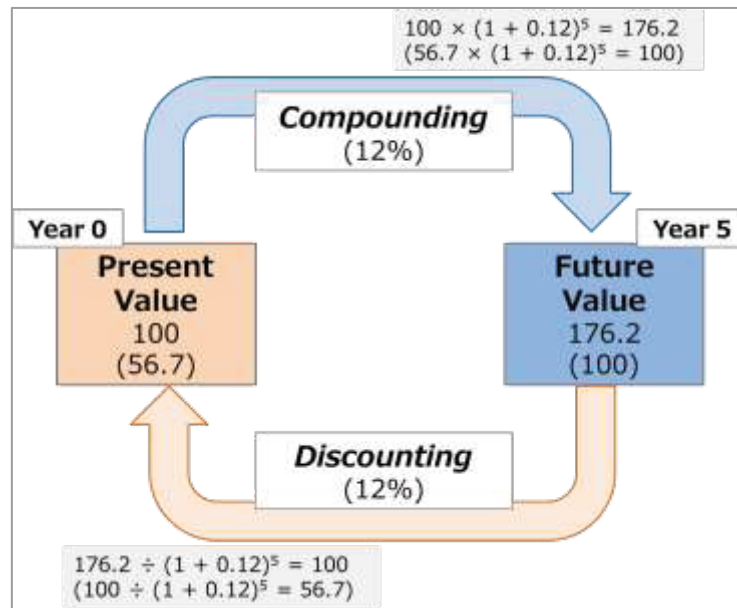


Figure 2. Compounding and Discounting

The concept of time value of money is essential in CBA because CBA compares the cash flows of costs and benefits occurring in different years. The technique used to convert a stream of future costs and benefits into a present value is called **discounting**. *Discounting is the reverse procedure of compounding.* Therefore, if the annual interest rate is 12%, \$176.2 received five years from now is worth \$100 ($=176.2 \div 1.12^5$) today. It also means that \$100 received five years from now is worth only \$56.7 ($=100 \div 1.12^5$) today.

Future streams of money in later years are more heavily discounted than those in earlier years. Thus, as Table 2 indicates, the present value of \$100 received 10 years from today is only \$32.2 (with a discount rate of 12%), whereas the present value of \$100 received 5 years from today is \$56.7. Moreover, *the present value is strongly influenced by the discount rate.* If the discount rate applied decreases from 12% to 8%, for example, the present value of \$100 received 10 years from today increases 43.8% from \$32.2 to \$46.3. On the contrary, if the discount rate applied increases, the present value of future streams of money decreases.

Table 2. Present Values of \$100 from Different Years

Discount Rate	Year									
	1	2	3	4	5	6	7	8	9	10
8%	92.6	85.7	79.4	73.5	68.1	63.0	58.3	54.0	50.0	46.3
10%	90.9	82.6	75.1	68.3	62.1	56.4	51.3	46.7	42.4	38.6
12%	89.3	79.7	71.2	63.6	56.7	50.7	45.2	40.4	36.1	32.2
14%	87.7	76.9	67.5	59.2	51.9	45.6	40.0	35.1	30.8	27.0

Chapter III shows how to apply the discounting technique to calculate the present value of a future stream of costs and benefits more in detail.

2.2.3. Incremental Analysis (With-Without Comparison)

CBA requires that the costs and benefits of the project are defined as *incremental* compared to the without-project scenario. This is not the same as the before-after comparison, which assumes *status quo* without the project and may erroneously estimate the net benefits of the project. *The with-without comparison attempts to compare the incremental costs and benefits arising from the project with what would happen in the absence of the project* (see Figure 3).

For example, assume that we are estimating the net benefits of a new transmission project and that the annual total electricity supplied is expected to increase from 100,000 million kWh to 200,000 million kWh after the completion of the project. Additionally, an on-going distribution project, which is about to be operational next year, is expected to increase the supply of electricity in the same area to 120,000 million kWh (but the transmission project's increased electricity supply will remain 200,000 million kWh annually). Then, the baseline value in the absence of the project must be 120,000 million kWh, not 100,000 million kWh, and failing to account for the change that would occur without the project would overestimate the incremental annual benefits by 25% ($=((200,000-100,000)/(200,000-120,000)-1) \times 100$) in this hypothetical example.

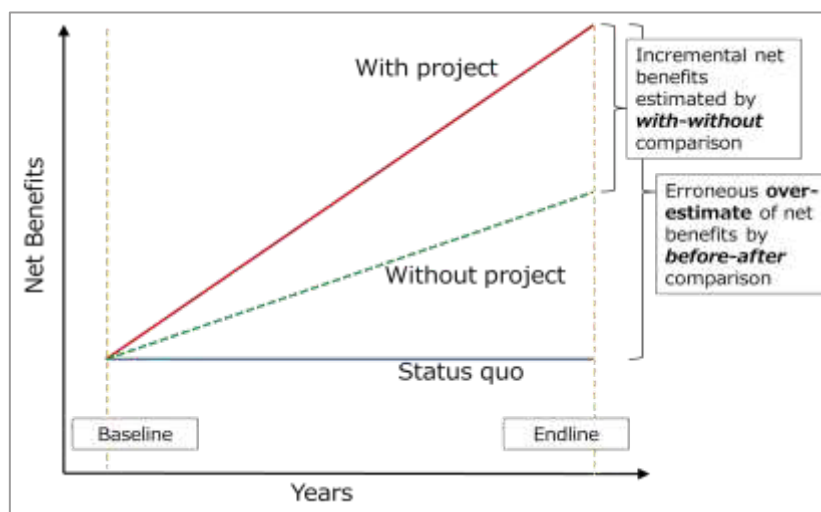


Figure 3. With-Without Comparison and Before-After Comparison

In the case of a rehabilitation project, the expected benefits decrease over time without the project. Thus, the estimated size of the incremental net benefits of the project depends crucially on how accurately the counterfactual of what would happen in the absence of the project can be estimated (see Figure 4).

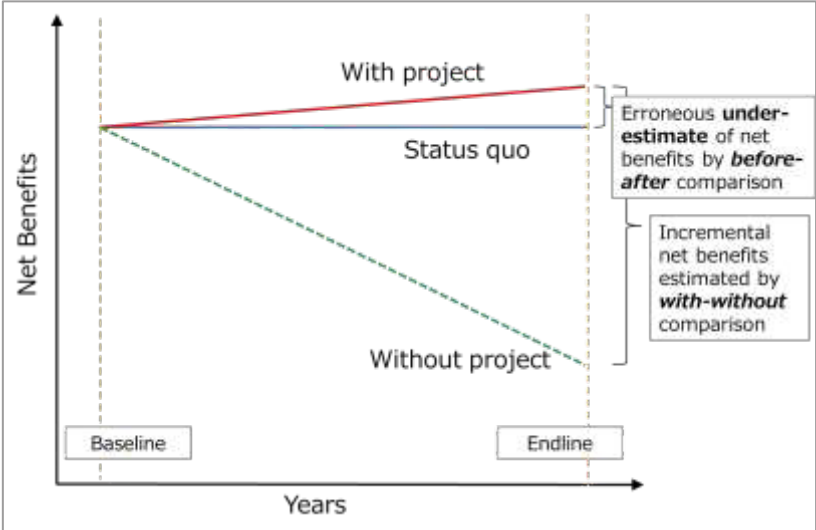


Figure 4. Incremental Analysis for a Rehabilitation Project

2.3. Performance Indicators and Decision Criteria

As discussed above, the commonly used indicators to determine financial sustainability and economic viability are net present value (NPV), benefit-cost ratio (BCR), and internal rate of return (IRR).

2.3.1. Net Present Value (NPV)

Net present value (NPV) is the difference between the sum of the present value of cash inflows and the sum of the present value of cash outflows over a project life. It represents the present amount of the expected net benefits (i.e., benefits minus costs) generated by the project.

$$NPV = PV \text{ of Benefits} - PV \text{ of Costs} = \sum_{t=0}^N \frac{(CF \text{ of Benefits})_t - (CF \text{ of Costs})_t}{(1 + i)^t}$$

where *PV* = present value; *CF* = cash flow of a period; *i* = discount rate; *N* = total number of periods; *t* = time of the cash flow

The balance of costs and benefits in the early years of a project during the construction period is always negative, and it becomes positive only some years later once the project has become operational. Because future streams of net benefits in later years are more heavily discounted than those in earlier years, the determination of the

net present value of a project is strongly influenced by the discount rate. Table 3 shows the NPVs of a hypothetical cash flow at different discount rates. As expected, *the NPV decreases as the discount rate increases, whereas it increases as the discount rate decreases.*

Table 3. NPVs of Cash Flow at Different Discount Rates

Discount Rate	Year										NPV
	1	2	3	4	5	6	7	8	9	10	
	-30.0	-70.0	15.0	20.0	25.0	25.0	25.0	25.0	25.0	25.0	
8%	-27.8	-60.0	11.9	14.7	17.0	15.8	14.6	13.5	12.5	11.6	\$23.8
10%	-27.3	-57.9	11.3	13.7	15.5	14.1	12.8	11.7	10.6	9.6	\$14.2
12%	-26.8	-55.8	10.7	12.7	14.2	12.7	11.3	10.1	9.0	8.0	\$6.1
14%	-26.3	-53.9	10.1	11.8	13.0	11.4	10.0	8.8	7.7	6.7	-\$0.7
16%	-25.9	-52.0	9.6	11.0	11.9	10.3	8.8	7.6	6.6	5.7	-\$6.4

Decision rule: The NPV is a simple and precise performance indicator. *A positive NPV means that the project generates a net benefit and is desirable either in financial or economic terms.*

- NPV > 0 → Financially profitable/Economically viable
- NPV = 0 → Neither
- NPV < 0 → Not financially profitable/Not economically viable

When choosing only one project among different options, the ranking of the net present values of all alternatives indicates the best one. The expected NPV of the selected project must be at least as high as the NPV of the second-best alternative.

2.3.2. Benefit-Cost Ratio (BCR)

Benefit-cost ratio (BCR) is the ratio of the sum of the present value of cash inflows to the sum of the present value of cash outflows over the project life. It is the present value of project benefits divided by the present value of project costs.

$$\text{BCR} = \frac{\text{PV of Benefits}}{\text{PV of Costs}} = \frac{\sum_{t=0}^N \frac{(\text{CF of Benefits})_t}{(1+i)^t}}{\sum_{t=0}^N \frac{(\text{CF of Costs})_t}{(1+i)^t}}$$

where *PV* = present value; *CF* = cash flow of a period; *i* = discount rate; *N* = total number of periods; *t* = time of the cash flow

Decision rule: *If the BCR is greater than or equal to one, the project is desirable either in financial or economic terms, because the present value of the benefits is greater than the present value of the costs or equal.*

- BCR > 1 → Financially profitable/Economically viable
- BCR = 1 → Neither
- BCR < 1 → Not financially profitable/Not economically viable

When the NPV calculated applying the same discount rate is positive, the BCR always becomes greater than one. However, *unlike the NPV, the BCR, as a ratio, is independent of the size of the investment*, and it does not consider the total amount of net benefits, as illustrated in Table 4.

Table 4. BCR Compared to NPV

Discount Rate: 12%												
Project	Year										Indicator	
	1	2	3	4	5	6	7	8	9	10	NPV	BCR
X	-30	-70	15	20	25	25	25	25	25	25	\$6.1	1.07
Y	-300	-700	150	200	250	250	250	250	250	250	\$61.2	1.07

The BCR can be used to assess the project's *efficiency*, and the most appropriate case for using the BCR is under capital budget constraints. (Investment decision under budget constraints will be considered below.)

2.3.3. Internal Rate of Return (IRR)

Internal rate of return (IRR) is a discount rate that makes the NPV of all cash flows equal to zero. Using the following NPV formula, set NPV equal to zero, and solve for the discount rate to get the IRR.

$$NPV = \sum_{t=0}^N \frac{(CF \text{ of Benefits})_t - (CF \text{ of Costs})_t}{(1 + IRR)^t} = 0$$

where *NPV* = net present value; *CF* = cash flow of a period; *N* = total number of periods; *t* = time of the cash flow

Using the same hypothetical data presented in Table 3, Figure 5 illustrates that *the IRR calculation is just a process of trying to find the discount rate that makes the area below zero (i.e., net present value of projects costs) equal to the area above zero (i.e., net present values of project benefits)*.

Note that the IRR does not exist for the projects whose streams of net benefits are negative even before discounting. Or, more than one IRR may exist for the projects whose stream patterns of net benefits oscillate over time.

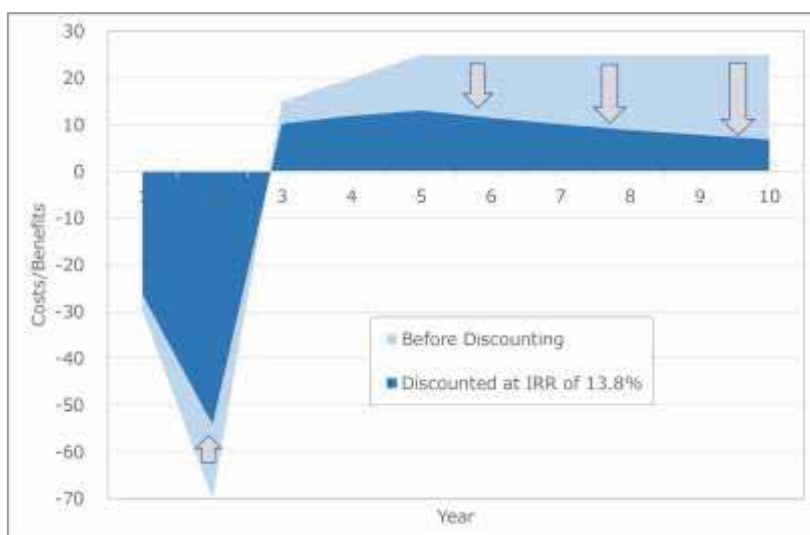


Figure 5. IRR Process of Finding the Discount Rate at which NPV = 0

Table 5 represents the hypothetical cash flow data of Table 3, on which Figure 5 is based, along with the present values of costs and benefits discounted at different discount rates. It shows that the NPV becomes zero when the discount rate applied is 13.8%.

Table 5. IRR and NPVs of Cash Flow at Different Discount Rates

Discount Rate	Year										NPV
	1	2	3	4	5	6	7	8	9	10	
	-30.0	-70.0	15.0	20.0	25.0	25.0	25.0	25.0	25.0	25.0	
8%	-27.8	-60.0	11.9	14.7	17.0	15.8	14.6	13.5	12.5	11.6	\$23.8
10%	-27.3	-57.9	11.3	13.7	15.5	14.1	12.8	11.7	10.6	9.6	\$14.2
12%	-26.8	-55.8	10.7	12.7	14.2	12.7	11.3	10.1	9.0	8.0	\$6.1
13.8%	-26.4	-54.1	10.2	11.9	13.1	11.5	10.1	8.9	7.8	6.9	\$0.0
14%	-26.3	-53.9	10.1	11.8	13.0	11.4	10.0	8.8	7.7	6.7	-\$0.7
16%	-25.9	-52.0	9.6	11.0	11.9	10.3	8.8	7.6	6.6	5.7	-\$6.4

Unlike the NPV and the BCR, the IRR does not incorporate the discount rate into its formula. Thus, the IRR can be calculated without assuming any discount rate. On the other hand, by the IRR alone, it cannot be decided whether a project is financially profitable or economically viable. *The results of the IRR values should be interpreted in conjunction with the minimum required discount rate, which is, in the context of Bangladesh, the financial discount rate of 12% for financial analysis, or the social discount rate of 12% for economic analysis.*

Decision rule: If the IRR equals or exceeds the discount rate, i , then the project generates a net benefit and is desirable either in financial or economic terms.

- $IRR > i \rightarrow$ Financially profitable/Economically viable

- $IRR = i \rightarrow$ Neither
- $IRR < i \rightarrow$ Not financially profitable/Not economically viable

Similar to the BCR, the IRR does not reflect the size of net benefits, as illustrated in Table 6.

Table 6. IRR Compared to NPV and BCR

Discount Rate: 12%													
Project	Year										Indicator		
	1	2	3	4	5	6	7	8	9	10	NPV	BCR	IRR
X	-30	-70	15	20	25	25	25	25	25	25	\$6.1	1.07	13.8%
Y	-300	-700	150	200	250	250	250	250	250	250	\$61.2	1.07	13.8%

When considering a single project, the IRR leads to the same conclusion as the NPV and BCR. A project in which an IRR is greater than the discount rate, i , the NPV is always greater than zero (at the discount rate, i), and the BCR is always greater than one (at the discount rate, i).

When considering alternatives, however, the IRR may come to different conclusions from the NPV and the BCR. Table 7 shows that if the discount rate applied is 12%, the IRR, like the NPV and BCR, selects Project Y over Project X. On the contrary, if the discount rate applied changes to 8%, the NPV and BCR prefer Project X to Project Y but the IRR still selects Project Y.

Table 7. IRR vs. NPV and BCR Decisions When Considering Alternatives

Discount Rate: 12%													
Project	Year										Indicator		
	1	2	3	4	5	6	7	8	9	10	NPV	BCR	IRR
X	-30	-70	15	15	20	20	30	50	50	70	\$33.4	1.40	19.4%
Y	-30	-70	50	50	30	20	20	20	15	15	\$39.3	1.48	27.2%
Discount Rate: 8%													
Project	Year										Indicator		
	1	2	3	4	5	6	7	8	9	10	NPV	BCR	IRR
X	-30	-70	15	15	20	20	30	50	50	70	\$63.3	1.72	19.4%
Y	-30	-70	50	50	30	20	20	20	15	15	\$58.6	1.67	27.2%

When the IRR and the NPV lead to different conclusions, the NPV decision rule usually should be followed, as it maximizes the values generated by the project; that is, profits in the case of financial analysis or the welfare of the society in the case of economic analysis.

2.3.4. Investment Decision Under Budget Constraints [Optional]

If there are no budget constraints, all projects that have positive NPVs should be implemented. On the other hand, if there are budget constraints, projects must be prioritized for investment decisions. As mentioned above, when considering alternatives

under budget constraints, the BCR, rather than the NPV, should be used as the primary decision criterion.

Example: Assume that there are five proposed investment projects. Each project’s total capital investment amount and estimated NPV and BCR are as shown in Table 8. If the investment budget available is \$5,000 in total, which of the following proposed projects should be implemented?

Table 8. Hypothetical Case of Selecting Alternatives under Budget Constraint

Budget: \$5,000			
Project	Investment	NPV	BCR
A	\$5,000	\$1,000	1.20
B	\$1,000	\$400	1.40
C	\$500	\$250	1.50
D	\$1,500	\$500	1.33
E	\$2,000	\$460	1.23

Table 9 shows the ranking of the projects by NPV. It is a mistake to prioritize the proposed projects by the size of the NPV until reaching the budget limit. When the NPV decision rule is followed, for example, Project A with the highest NPV of \$1,000 is selected first. Because implementing Project A requires \$5,000 investment and the budget available is also \$5,000, Project A is the only project to be implemented. As a result, the NPV generated becomes \$1,000.

Table 9. Selecting Projects by NPV

Project	Investment	NPV	BCR	Cumulative Investment	Cumulative NPV
A	\$5,000	\$1,000	1.20	\$5,000	\$1,000
D	\$1,500	\$500	1.33	\$8,500	--
E	\$2,000	\$460	1.23	\$7,000	--
B	\$1,000	\$400	1.40	\$9,500	--
C	\$500	\$250	1.50	\$10,000	--

When there are budget constraints, the efficiency of the project must be considered for maximizing the total NPV. Because the project’s efficiency is assessed by the BCR, the proposed projects should be selected by the size of the BCR until reaching the budget limit. Table 10 shows the ranking of the projects by BCR. When the BCR decision rule is followed, Project C with the highest BCR of 1.50 is selected first. Because Project C’s NPV is \$250, the NPV generated is also \$250. Because implementing Project C requires \$500 investment and the budget available is \$5,000, the remaining budget becomes \$4,500. Next, Project B with the second highest BCR of 1.40 is selected. Because Project B generates a NPV of \$400, while implementing it costs \$1,000, the cumulative NPV

becomes \$650 ($=\$250+\400) and the remaining budget becomes \$3,500 ($=\$5,000-\$500-\$1,000$). This process continues until all the budget will be used with the additional selections of Project D and Project E. In this way, the total NPV is maximized at \$1,610, which is 61% ($=(1,610\div 1,000-1)\times 100$) higher than the NPV generated under the NPV decision rule.

Table 10. Selecting Projects by BCR

Project	Investment	NPV	BCR	Cumulative Investment	Cumulative NPV
C	\$500	\$250	1.50	\$500	\$250
B	\$1,000	\$400	1.40	\$1,500	\$650
D	\$1,500	\$500	1.33	\$3,000	\$1,150
E	\$2,000	\$460	1.23	\$5,000	\$1,610
A	\$5,000	\$1,000	1.20	\$10,000	--

Decision rules: When there are budget constraints, the efficiency of the project must be considered.

- Proposed projects should be selected by the size of the BCR until reaching the budget limit → Cumulative NPV is maximized

Chapter III

Step-by-Step Procedures of CBA for Public Investment Projects

3.1. Conducting CBA Using Excel Spreadsheets

Chapter III demonstrates how to apply CBA techniques to public investment projects. The step-by-step examples of CBA procedures are presented using the following three sample cases:

1. Power distribution project
2. Power transmission project
3. Rural infrastructure development project

These analytical samples in Excel have been developed by the SPIMS Project for use in the formulation, assessment, and appraisal of public investment projects in Bangladesh.²

3.2. Standard CBA Procedures and the Structure of the Excel CBA Models

3.2.1. Steps of CBA

As mentioned, the standard CBA of public investment projects consists of the three main stages of (1) financial analysis, (2) economic analysis, and (3) sensitivity analysis, which are closely related to each other. In both financial and economic analysis, there are the following four steps:

1. Identification of project costs and benefits
2. Quantification/measurement of project costs and benefits
3. Construction of cash flow tables of costs and benefits
4. Estimation and interpretation of NPV, BCR, IRR

For a quick review, the major differences between financial and economic analysis are summarized below (also see Table 1):

1. Financial costs and benefits are expenditures and revenues for the project implementing entity, respectively, whereas economic costs and benefits are welfare losses and gains for the society as a whole, which include externalities but exclude transfer payments.
2. Costs and benefits are measured in market prices in financial analysis, whereas these are measured in shadow prices in economic analysis. Financial costs and benefits are adjusted into economic costs and benefits applying conversion

² These Excel CBA models are available upon request from the SPIMS Project/ PIM reform wing of Programming Division. Or see the Planning Commission web site: <https://plancomm.gov.bd/>.

factors.

3. Cash flows of financial costs and benefits are discounted using the financial discount rate to calculate FNPV and FBCR, whereas economic costs and benefits are discounted using the social discount rate to estimate ENPV and EBCR. Similarly, the FIRR is compared to the financial discount rate to interpret the results, whereas the EIRR is compared to the social discount rate.

3.2.2. Excel CBA Models

In accordance with the standard CBA procedures, the Excel CBA models developed by the SPIMS Project are composed of the following 13 worksheets:

Table 11. Structure of Excel CBA Models

Worksheet Name	Description
<i>0.Contents</i>	Table of contents
<i>1.Params*</i>	Setting model parameters & project assumptions/variables
<i>2a.FCosts*</i>	Identifying and quantifying financial costs (1)----DPP format
<i>2b.FCosts*</i>	Identifying and quantifying financial costs (2)----General format
<i>3.FBenefits*</i>	Identifying and quantifying financial benefits
<i>4a.FAnalysis</i>	Constructing financial cash flow tables and estimating financial indicators (1)----Horizontal format
<i>4b.FAnalysis</i>	Constructing financial cash flow tables and estimating financial indicators (2)----Vertical format
<i>5.ECosts</i>	Identifying and quantifying economic costs
<i>6.EBenefits</i>	Identifying and quantifying economic benefits
<i>7a.EAnalysis</i>	Constructing economic cash flow tables and estimating economic indicators (1)----Horizontal format
<i>7b.EAnalysis</i>	Constructing economic cash flow tables and estimating economic indicators (2)----Vertical format
<i>8.Sensitivity</i>	Testing sensitivity of the results to parameters & assumptions
<i>9.Results</i>	Summarizing the results of financial and economic analysis

Sheets *2a.FCosts* through *4b.FAnalysis* are for financial analysis, whereas sheets *5.ECosts* through *7b.EAnalysis* are for economic analysis. *1.Params* and *8.Sensitivity* are actually in one sheet named *1.Params_8.Sensitivity* (due to a functional reason). The structure of the Excel models is broadly consistent with the steps described in the *Development Project Proforma/Proposal (DPP) Manual*³ (although the *DPP Manual* does not specifically refer to sensitivity analysis).

Note that once the Excel model is set up appropriately, what the user of the model needs to do is to enter data in the first four Excel sheets (whose names are asterisked

³ General Economics Division of Planning Commission 2014

(*) in Table 11). All the remaining tasks will be basically taken care of by Excel.

3.3. Step I: Setting Model Parameters and Project Assumptions/Variables

From this section forward, how to conduct CBA will be explained step-by-step using examples from the sample power distribution, power transmission, and rural infrastructure development projects. Please keep in mind, while following explanations and instructions, that our intermediate goal (before the final goal of estimating the values of the performance indicators) is to construct cash flow tables of project costs and benefits (such as Figures 19 and 33, respectively).

3.3.1. Model Parameters

As Table 11 suggests, the first step in conducting CBA using the Excel model is to set values for model parameters and project assumptions. For this step, a statement of the project, its design, and demand for project outputs must be carefully studied. (For a description of each sample project, see Annexures 1-3.)

The common model parameters need to be set for the Excel CBA models are as follows:

- Physical Contingency (%)
- Price Contingency (%)
- Conversion Factors
- Financial Discount Rate (%)
- Economic (Social) Discount Rate (%)
- Exchange Rate (USD/BDT)

Physical contingency is a cash reserve that represents the expected monetary value of additional real resources that may be required beyond the base costs to complete the project. *The physical contingency should be treated as part of the project costs.* The physical contingency rate most commonly used in Bangladesh is 2.0%.

Price contingency is a cash reserve to meet a cost-overrun due to inflation. *Unlike physical contingency, price contingency is not counted as project costs in CBA.* This is because all project costs and benefits in the tables of financial and economic cash flows (i.e., Figures 19 and 33, respectively) are measured in constant prices of the base year, and thus the effect of inflation is eliminated. In the Excel model, the price contingency rate is used to calculate the total initial investment costs that excludes the price contingency. The Excel model can handle the price contingencies for both domestically procured inputs and internationally procured inputs. In Bangladesh, however, no distinction is usually made between domestically and internationally procured inputs in

DPPs.⁴

Conversion factor is the ratio between the financial (or market) value and economic value of project inputs. It is used to transform financial costs into economic costs. In theory, different conversion factors should be set for different types of project inputs⁵. The Excel model can set two conversion factors; that is, the **conversion factor for traded goods**⁶ and the **wage conversion factor for unskilled labor** (though only the conversion factor for traded goods is used for all the three sample projects)⁷.

Discount rate is used to calculate the present values of future streams of costs and benefits occurring over different years (see 2.2.2 Time Value of Money and Discounting in Chapter I). **Financial discount rate** is a market borrowing rate (e.g., weighted average cost of capital: WACC), whereas **economic** (or **social**) **discount rate** more broadly reflects the social view on how future costs and benefits should be valued against present ones. Currently in Bangladesh, the discount rate of 12.0% is used for both financial and economic analysis.⁸

Exchange rate is the ratio of the value of one currency to another. It is used to convert foreign currency costs into local currency costs in the Excel model. However,

⁴ According to the Planning Division's circular*, the physical contingency can be proposed up to 2 % of capital cost, and price contingency can be proposed up to 8% of total cost. *Planning Division's Circular for Instructions on Development Project Formulation, Processing, Approval and Revision (Memo no: 20.00.0000.404.014.61.2020(Part- 1)/133, Date: June 12, 2022)

⁵ Conversion Factor is used to convert a "distorted price" into an "economic price". There are three types of conversion factor: a) to convert a "market price – distorted by taxes" into a "market prices". In general almost all of the goods and services in Bangladesh is affected by VAT and so one strategy is to use $1/(1+VAT\%)$ as a strategy to convert general market prices into "economic price", b) price affected by special tax, subsidy or administrative decisions – such prices are converted using a 'conversion factor' which is listed in the "Handbook for Planning Commission 1987 and DPP manual 2014" for some selected sectors like electricity, rice, etc., and c) prices affected by tax and subsidy at the time of export or import. This conversion factor is known as 'Standard Conversion Factor' which is given by the formula $(X+M)/(X+M+CD+SD-Xsubsidy)$ where X is export amount, M is import amount, amount of (CD is custom duty, SD is supplementary or similar additional duty on imported goods and Xsubsidy is export subsidy) collected on exports and imports.

⁶ If the project uses imported inputs (tradable goods, e.g., gas and oil), border prices are used as economic cost, i.e., import cost plus insurance and freight (CIF). To simplify the case, this model uses "conversion factor for traded goods" for all inputs except "unskilled workers".

⁷ Feasibility study Template of Planning Division's circular* instructs "the value of cost and benefit components into economic price should be converted by using Standard Conversion Factor (SCF) determined by the Government or any standard method can be used for." For Conversion Factors determined by the Government, see Handbook for Planning Commission 1987 and DPP manual 2014. *Planning Division's Circular for Instructions on Development Project Formulation, Processing, Approval and Revision (Memo no: 20.00.0000.404.014.61.2020(Part- 1)/133, Date: June 12, 2022)

⁸ For public investment project, for both financial discount rate and economic discount rate, 12% should be used, according to the Planning Division circular. [Memo no: 20.00.0000.404.014.027.18-177]

because all project costs are reported in terms of the local currency in the DPP, this parameter is not used in the sample projects.

Figure 6 shows a set of model parameters entered in the *1.Params* sheet.

Contingency			
Physical Contingency	(%)		2.0%
Price Contingency, Local currency	(%)		5.0%
Price Contingency, Foreign currency (not used in this sample)	(%)		5.0%
Conversion Factor			
Conversion Factor for Traded Goods			1.15
Wage Conversion Factor for Unskilled Labor (not used in this sample)			1.45
Discount Rate			
Financial Discount Rate	(%)		12.0%
Economic (Social) Discount Rate	(%)		12.0%
Exchange Rate (not used in this sample)	(USD/BDT)		100

Figure 6. Model Parameters [Distribution & Transmission]

EXERCISE 1. Let's check the values of the model parameters entered into beige-colored cells in the *1.Params* sheet of the Excel model. (Remember that the entry of a value on the parameter or assumption/variable should be done only once. The subsequent use of the data should be made by referring to the cells in which the values were first entered.)

3.3.2. Project Assumptions/Variables

In addition to the model parameters, the Excel model requires project assumptions/variables to be specified. For example, the following assumptions/variables need to be set for all projects:

- Project Life (years)
- Construction Period (years)

The **project life** can be divided into (a) the **construction (or investment) period** and (b) the **operating life of the project**. The project life may be determined by considering the technical life of the major investment assets (e.g., machinery) and the market life of the output (i.e., the period for which the benefits will satisfy a need), and it can vary from one type of project to another. In Bangladesh, the project life of 30 years is most commonly used for the CBA of power-sector and rural infrastructure development projects. This is because after 30 years the initial investment cost of the project will be marginal.

For reference, Table 12 presents the project life periods by sector recommended by the European Commission.⁹

Table 12. European Commission's Reference Project Life Periods by Sector

Sector	Project Life (Years)
Railways	30
Roads	25-30
Ports and Airport	25
Urban Transport	25-30
Water Supply/Sanitation	30
Water Management	25-30
Buildings	20
Energy	15-25
Broadband	15-20
Business Infrastructure	10-15
Other Sectors	10-15

There are other project assumptions/variables that need to be specified to estimate the financial and economic cash flows of costs and benefits. These are, for example, the assumptions/variables related to the supply of and the demand for project outputs, the prices of inputs and outputs, and the number of beneficiaries, etc.

⁹ Source: European Commission. 2014. *Guide to Cost-Benefit Analysis of Investment Projects: Economic Appraisal Tool for Cohesion Policy 2014-2020*. Brussels.

Figures 7-9 shows a set of project assumptions/variables for each of the sample projects.

<u>Project Life & Construction Period</u>		
Project Life	(years)	30
Construction Period	(years)	5
<u>Demand</u>		
Growth in Capacity Utilization/Growth of Demand for Electricity	(%)	9.0%
Existing Customers	(#)	100,000
<u>Capacity</u>		
Initial Capacity Utilization after Construction	(%)	80.0%
Total Capacity to be Increased per hour	(MVA/hour)	595
Total Capacity to be Increased per year	(MVA/year)	5,212,200
System Loss	(%)	5.25%
Additional Supply of Electricity to Meet Demand per year	(MVA/year)	4,938,560
<u>Price & Costs</u>		
Average Sales Rate per kWh	(BDT/kWh)	8.05
Average Cost of Input (Purchase rate + Wheeling charge) per kWh	(BDT/kWh)	6.75
Cost of Electricity Produced Privately per kWh	(BDT/kWh)	12.00
<u>Service Improvement</u>		
Reduction in Load Shedding per day	(mins/day)	12
Reduction in Load Shedding per year	(hrs/year)	73.0
<u>Allocation Benefits among Generation/Transmission/Distribution</u>		
Percent of Indirect Benefits Attributable to the Project	(#)	33.3%

Figure 7. Project Assumptions/Variables [Distribution]

<u>Project Life & Construction Period</u>		
Project Life	(years)	30
Construction Period	(years)	6
<u>Capacity</u>		
Incremental Load Flow/Total Capacity to be Increased	(MW/hour)	1,398.63
Load Factor	(%)	90.0%
Gross Annual Energy (considering the Load Factor)	(mil.kWh/year)	11,026.80
Transmission Loss	(%)	2.77%
Wheeled Energy/Additional Supply of Electricity to Meet Demand	(mil.kWh/year)	10,721.36
Percent of Electricity Transmitted to Commercial Customers	(%)	39.18%
<u>Price & Costs</u>		
Wheeling Charge	(BDT/kWh)	0.2791
Revenues from Wheeling Charge	(lakh)	29,923.31
Average Sales Rate for Residential	(BDT/kWh)	7.49
Average Sales Rate for Commercial	(BDT/kWh)	9.80
Cost of Electricity Produced Privately for Residential	(BDT/kWh)	12.00
Cost of Electricity Produced Privately for Commercial	(BDT/kWh)	12.00
<u>Service Improvement</u>		
Existing Total Customers	(#)	1,332,805
Percent of Existing Total Customers who Benefit from Cost Savings	(%)	1.0%
Avg. Cost Savings per Customer	(BDT/year)	1,000
<u>Allocation Benefits among Generation/Transmission/Distribution</u>		
Percent of Indirect Benefits Attributable to the Project	(#)	33.3%

Figure 8. Project Assumptions/Variables [Transmission]

<i>Project Life & Construction Period</i>		
Project Life	(years)	30
Construction Period	(years)	5
<i>Demand</i>		
Growth in Capacity Utilization/Growth of Demand	(%)	0%
<i>Capacity</i>		
Initial Capacity Utilization after Construction	(%)	100%
<i>Population & Households</i>		
Total Population	(#)	35,000
Annual Population Growth Rate	(%)	1.37%
Avg. Household Size	(#/HH)	5.2
Total Households	(#)	6,731
Percent of Agricultural Households in Total Households	(%)	45.0%
Agricultural Households	(#)	3,029
Percent of MSME Households in Total Households	(%)	7.5%
MSME Households	(#)	505
Percent of Students in Total Population	(%)	20.0%
Students	(#)	7,000
Student Dropout Rate	(%)	10.0%
Reduction in Student Dropouts	(%)	10.0%
Percent of Female Population	(%)	50.0%
Percent of Females Aged 15 to 44	(%)	50.0%
Percent of Women Giving Birth per year	(%)	8.0%
Maternal Mortality Rate	(#/100,000 births)	173
Reduction in Maternal Deaths	(%)	70.0%
Population in Negatively Affected Areas	(#)	13,000
Annual Population Growth Rate in Negatively Affected Areas	(%)	1.37%
Avg. Household Size for Negatively Affected Areas	(#/HH)	5.2
Households in Negatively Affected Areas	(#)	2,500
<i>Income</i>		
Avg. Monthly Income for Agricultural Households	(BDT/month)	12,000
Avg. Monthly Income for MSME Households	(BDT/month)	25,000
Increase in Agricultural Income	(%)	20.0%
Increase in MSME Income	(%)	25.0%
Increase in Personal Income due to Avoidance of Dropout	(USD/life)	209,000
Working Life of a Person	(years)	35
Purchasing Power Parity (PPP) from USD to BDT	(BDT/USD)	32.81
Increase in Personal Income due to Avoidance of Dropout	(BDT/year)	195,923
Total Statistical Value of Life in Bangladesh	(BDT/life)	1,909,355
Annual Statistical Value of Life in Bangladesh	(BDT/year)	54,553
Avg. Monthly Income for Households in Negatively Affected Areas	(BDT/month)	23,000
Loss of Income in Negatively Affected Areas	(%)	4.0%
<i>Depreciation (for the Calculation of Salvage Value)</i>		
Annual Depreciation Rate for Total Initial Investment	(%)	10.0%

Figure 9. Project Assumptions/Variables [Rural Infrastructure]

EXERCISE 2. Let's check the values of the project assumptions/variables entered in the *1.Params* sheet, by referring to the project descriptions in Annexures 1-3.

3.4. Step II: Identifying and Quantifying Financial Costs

Once the parameters and the assumptions/variables are set, we can start preparing cash flow tables for financial analysis. **Financial analysis** focuses on the ability of the project to generate sufficient incremental cash flows to cover its capital and recurrent costs.

3.4.1. Identification of Financial Costs

The second step in conducting CBA using the Excel model is to identify financial costs and quantify them.

Financial costs are project expenditures, and they can be classified into three components:

- Initial investment costs
- Salvage (or residual) value of investment assets
- Operating costs

3.4.2. Total Initial Investment Costs

Initial investment costs include the capital costs of all the fixed assets (e.g., land, buildings, machinery, equipment) and non-fixed assets (e.g., technical costs such as design/planning, project management and technical assistance, construction supervision) during construction. There are two ways to enter data and calculate total initial investment costs using the Excel model. One way is to enter the estimated costs of the following initial investment items directly into the *2b.FCosts* sheet in the beige-colored cells (see Table 10):

- Materials & equipment costs
- Labor costs
 - Skilled workers
 - Unskilled workers
- Land acquisition/compensation costs
- Consultant costs
- General/administrative costs (overhead costs)
- Taxes, subsidies (transfers)

Item	Local Currency (BDT)			Foreign Currency (USD)	Total (BDT)
	GOB	Project Aid	Own Funds		
Materials & Equipment Costs	0	0	0	0	0
Labor Costs	0	0	0	0	0
Skilled Workers	0	0	0	0	0
Unskilled Workers	0	0	0	0	0
Land Acquisition/Compensation Costs	0	0	0	0	0
Consultant Costs	0	0	0	0	0
General/Administrative Costs (Overhead Costs)	0	0	0	0	0
Taxes, Subsidies (Transfers)	0	0	0	0	0
Base Costs (w/o Contingencies)	0	0	0	0	0
Physical Contingency (2%)	0	0	0	0	0
Price Contingency, Local currency (5%) / Foreign currency (5%)	0	0	0	0	0
Total Initial Investment Costs (w/ Contingencies)	0	0	0	0	0
Total Initial Investment Costs (BC + Physical Contingency)	0	0	0	0	0

Figure 10. Total Initial Investment Costs (1) [Distribution, Transmission & Rural Infra]

The other way, which has been employed by all the three sample cases, is to enter cost data into the *2a.FCosts* sheet, which is based on the *Detailed Estimated Cost* form (Annexure V(a) of the *DPP Manual*) used in Bangladesh (see Figure 11).

Detailed Estimated Cost													(Taka in Lac)		
Economic Code	Economic Sub-code	Economic Sub-code Description (In Detail)	Unit	Unit Cost	Quantity	GOB (FE)	Project Aid				Own Fund (FE)	Others	Total	% of Total Project Cost	
							RPA		DPA						
							Through GOB	Special Account*	Through PD	Through DP					
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	
(a) Revenue:															
														0.00	0%
														0.00	0%
														0.00	0%
Sub total of Revenue						0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0%	
(b) Capital:															
														0.00	0%
		Taxes (Transfers)												0.00	0%
		Subsidies, <i>negative costs</i> (Transfers)												0.00	0%
Sub total of Capital						43,349.99	0.00	0.00	0.00	119,567.45	59,376.36	0.00	222,293.80	93%	
(c) Physical Contingency (2%)						867.00	0.00	0.00	0.00	2,391.35	1,187.53	0.00	4,445.88	2%	
(d) Price Contingency (5%)						2,167.50	0.00	0.00	0.00	5,978.37	2,968.82	0.00	11,114.69	5%	
Total (a+b+c+d)						46,384.49	0.00	0.00	0.00	127,937.17	63,532.71	0.00	237,854.37	100%	

Figure 11. *Detailed Estimated Cost* Format [Distribution]

The cost data entered in the *2a.FCosts* sheet will be taken over by the *2b.FCosts* sheet. Figure 12 shows the calculation of total initial investment costs for the sample power distribution project. The sum of total initial investment costs entered through the *Detailed Cost Estimate* format is BDT 237,854 lakh, of which BDT 4,446 lakh is physical contingency and BDT 11,115 lakh is price contingency. Because the effect of inflation should not be considered, the price contingency is excluded from the total initial investment costs. As a result, the final total initial investment costs become BDT 226,740 lakh (=237,854-11,115), including rounding errors.

<i>Data either from above Table or Detailed Estimated Cost (2a.FCosts)*</i>	GOB	PA	OF	FC	Total
Taxes, Subsidies (Transfers)	0	0	0	0	0
Base Costs (w/o Contingencies)	43,350	119,567	59,376	0	222,294
Physical Contingency	867	2,391	1,188	0	4,446
Price Contingency	2,167	5,978	2,969	0	11,115
Total Initial Investment Costs (w/ Contingencies)	46,384	127,937	63,533	0	237,854
Total Initial Investment Costs (BC + Physical Contingency)	44,217	121,959	60,564	0	226,740

Figure 12. Total Initial Investment Costs (2) [Distribution]

EXERCISE 3. Let's check how the Excel calculates the total initial investment costs during construction using the *2a.FCosts* sheet and the *2b.FCosts* sheet.

Next, the total initial investment costs must be distributed across the construction years in which they actually arise. Because the construction period of the power distribution project is five years, we need to specify how much investment will be made in each of these five years (see the project description in Annexure 1). Remember that the sum of each allocation must add up to the total initial investment costs minus the price contingency (i.e., BDT 226,740 lakh), as shown in Figure 13.

Item	1	2	3	4	5	Total
Annual Initial Investment Breakdowns during Construction (%)	0.5%	35.6%	39.5%	23.7%	0.6%	100%
Annual Initial Investment Costs (BDT)	1,230	80,626	89,656	53,815	1,413	226,740

Figure 13. Total Initial Investment Costs (3) [Distribution]

EXERCISE 4. Let's check how the Excel allocates the total initial investment costs across the construction years.

3.4.3. Salvage Value

Salvage (or residual) value is the remaining value of investment assets at the end of the project life, which is treated as a negative investment cost. Figure 14 shows the estimation of salvage value for the sample power distribution project. It is assumed that among the initial investments of BDT 4,700 lakh (made for the overhead and underground line construction), 10% of them can be salvaged at the end of the project. The salvage value of investment is thus BDT 470 lakh.

If there is land acquisition, it must be taken into consideration that land may appreciate rather than depreciate as land has no definitive useful life.

In the model of this handbook, the salvage (or residual) value is included to show the calculation of the salvage (or residual) value. However, in many cases, where the project life is more than 30 years, and so, the salvage (or residual) value is very marginal, it often happens that the calculation of the salvage (or residual) value is not included in the CBA calculation.

Item	
Investment I -- Buildings	
Costs of Fixed Investment	0
Salvage (Residual) Value (%)	10%
Investment II -- Equipment (Overhead & underground line construction)	
Costs of Fixed Investment	4,700
Salvage (Residual) Value (%)	10%
Investment III -- Land	
Costs of Fixed Investment	0
Salvage (Residual) Value (%)	100%
Salvage Value of Investment	470

Figure 14. Salvage Value [Distribution]

EXERCISE 5. There are different ways of estimating salvage value. Check how the Excel model for the sample rural infrastructure development project calculates the salvage value applying the declining depreciation method. The declining depreciation method denotes that $(\text{salvage value}) = (\text{total costs of fixed assets}) \div (1 + (\text{depreciation rate}))^t$, where $t = (\text{years of project life})$.

3.4.4. Operating Costs

Operating costs are the costs to operate and maintain (O&M) the new or rehabilitated/upgraded services. These costs are classified into fixed and variable costs. To get annual operating costs during operation, we need to enter the estimated costs of the following O&M items in the *2b.FCosts* sheet:

- Input purchase
- Spares & maintenance
- Labor costs
 - Skilled workers
 - Unskilled workers
- Insurance
- General/administrative costs (overhead costs)

Note that as mentioned in Section I, depreciation and depreciation charges, which appear in financial statements, are not counted as project costs, because they do not entail cash outlays. In addition, the payment of interest and the repayment of principal are also omitted from financial and economic cash flows, despite that they entail cash outlays. This is because in financial analysis for public investment, *the financial sustainability of the project should be assessed, independent of its financing mode*. In addition, *debt service is only a transfer of resources within a society*, therefore, the payment of interest and the repayment of principal should not be counted as economic

costs. This is because in economic analysis for public investment that it is important to assess project quality independently of the funding method.

Figure 15 shows the calculation of annual operating costs for the sample power distribution project. The estimated annual operating costs are composed of the costs of input purchase and the costs of spares and maintenance in this specific example. The costs of input purchase (BDT 351,824 lakh) are calculated by multiplying the annual total (electricity) capacity to be increased by the average cost of input, which are both from project assumption/variable values we set in the *1.Params* sheet. Because the unit for the additional supply of electricity is mega-volt ampere (MVA) per year, and one MVA is equal to 1,000 kW, it is multiplied by 1,000 to convert into kW. Furthermore, to show the monetary value in lakh, the estimated amount is divided by 100,000 (i.e., BDT 351,824 lakh=5,212,200 MVA per year×BDT 6.75 kWh×1,000÷100,000).

Additionally, based on the information from similar power distribution projects, the costs of spares and maintenance are assumed as 1% of the costs of input purchase (BDT 3,518 lakh). The sum of the annual operating costs thus becomes BDT 355,342 lakh.

Item	Local Currency (BDT)	Foreign Currency (USD)	Total (BDT)
Input Purchase (e.g., electricity purchase, wheeling charge)	351,824	0	351,824
Spares & Maintenance	3,518	0	3,518
Labor Costs	0	0	0
Skilled Workers	0	0	0
Unskilled Workers	0	0	0
Insurance	0	0	0
General/Administrative Costs (Overhead Costs)	0	0	0
Annual Operating Costs (Operation & Maintenance Costs)	355,342	0	355,342

Figure 15. Operating Costs (1) [Distribution]

Then, these annual operating costs will be allocated into the years in which they arise. The Excel automatically generates a stream of operating costs as shown in Figure 16 (where years 1-4 and years 10-29 are omitted for space reasons).

	5	6	7	8	9	30
Annual Operating Cost Levels after Construction (cumulative %)	0%	80%	87%	95%	100%	100%
Annual Operating Costs after Construction (BDT)	0	284,273	309,858	337,745	355,342	355,342

Figure 16. Operating Costs (2) [Distribution]

Note that the initial capacity utilization is set at 80% (in Year 6) and is assumed to grow 9% annually until it reaches 100% (in Year 9) (which are specified as the project assumption/variables of “Initial Capacity Utilization after Construction” and “Growth in Capacity Utilization/Growth of Demand for Electricity” in the *1.Params* sheet).

EXERCISE 6. Check how the Excel estimates the annual operating costs and allocates them.

3.5. Step III: Identifying and Quantifying Financial Benefits

3.5.1. Identification of Financial Benefits

The third step in conducting CBA using the Excel model is to identify financial benefits and quantify them. **Financial benefits** are project revenues, which can be calculated by multiplying the sales quantity by the sales price.

In terms of financial benefits, public investment projects can be classified into the following two types:

- Revenue-generating
- Non-revenue-generating

For non-revenue-generating projects, such as the sample rural infrastructure development project, this step of identifying and quantifying financial benefits should be skipped.

3.5.2. Revenues

The Excel model automatically calculates the annual revenues based on the project assumptions/variables entered in in the *1.Params* sheet.

The upper table of Figure 17 shows the calculation of annual revenues for the sample power distribution project. The annual revenues of BDT 397,554 lakh is calculated by multiplying the additional supply of electricity (MVA per year) by the average sales rate (BDT per kWh) ($=4,938,560 \times 8.05 \times 1,000 \div 100,000$).

Item					
Revenue Source I					
Additional Supply of Electricity to Meet Demand per year	4,938,560				
Average Sales Rate per kWh	8.05				
Revenue Source II					
Additional Supply of Electricity to Meet Demand per year					
Average Sales Rate per kWh					
Revenue Source III					
Additional Supply of Electricity to Meet Demand per year					
Average Sales Rate per kWh					
Annual Revenues	397,554	(lakh)			
	1	2	3	4	5
Annual Revenue Generation during Construction (cumulative %)	0%	0%	0%	0%	0%
Annual Revenues during Construction (BDT), if any	0	0	0	0	0

Figure 17. Annual Revenues (1) [Distribution]

If the project becomes partially operational during construction, the Excel automatically generates a cash inflow in the lower table of Figure 17 (but no revenues generated during construction for the sample power distribution project).

As shown in Figure 18 (where years 1-4 and years 10-29 are omitted for space reasons), Excel then generates a stream of annual revenues after construction.

	5	6	7	8	9	30
Annual Revenue Generation after Construction (cumulative %)		80%	87%	95%	100%	100%
Annual Revenues after Construction (BDT)	n/a	318,043	346,667	377,867	397,554	397,554

Figure 18. Annual Revenues (2) [Distribution]

Note that because the initial capacity utilization was set at 80% (in Year 6) and was assumed to grow 9% annually until it reaches 100% (in Year 9) in the *2b.FCosts* sheet, the annual revenues generated for the years 6-8 are automatically adjusted accordingly.

EXERCISE 7. Check how the Excel estimates and generates a stream of annual revenues.

3.6. Step IV: Constructing Financial Cash Flow Tables and Estimating Financial Indicators

The fourth step in conducting CBA using the Excel model is to construct cash flow tables of financial costs and benefits and estimate financial indicators. This step is all taken care of by Excel, and what we need to do is carefully check the cash flow tables and interpret the results of the performance indicators.

3.6.1. Constructing Cash Flow Tables of Financial Costs and Benefits

As shown in Figure 19 (where years 13-28 are omitted for space reasons), Excel generates the tables of financial cash flows in the *4a.FAnalysis* sheet, based on the previous steps. The upper table of Figure 19 indicates the cash flows of financial costs and benefits **before discounting**, expressed in constant (real) values (in terms of the base year price), for the sample power distribution project. The table automatically calculates net benefits by subtracting total costs from total benefits for each year of the project life. As explained below, Excel calculates FNPV, FBCR, and FIRR directly from these before-discounting data.

The lower table of Figure 19, on the other hand, indicates financial cash flows **after discounting** with a financial discount rate of 12%. A series of figures (labeled "DF") listed between the upper and lower tables are discount factors for the corresponding years. For example, the discount factor for Year 10 is 0.322 ($=1 \div 1.12^{10}$). Therefore, by multiplying the net benefits of BDT 42,212 lakh for Year 10 (in the upper table) by this discount factor of 0.322, we will get the present value of the net benefits, which is BDT 13,591 lakh ($=42,212 \times 0.322$) (in the lower table).

3.6.2. Estimating and Interpreting FNPV, FBCR, and FIRR

The Excel model calculates FNPV, FBCR, and FIRR, applying the following Excel functions:

- FNPV → `=NPV(rate, value1, [value2], ...)`
e.g.) `=NPV(0.12, C5:L5)`
- FBCR → `=NPV(Total benefits)/NPV(Total costs)`
e.g.) `=NPV(0.12, C4:L4)/NPV(0.12, C3:L3)`
- FIRR → `=IRR(values, [guess])`
e.g.) `=IRR(C5:L5)`

We can also calculate FNPV and FBCR manually by using the figures in the lower table of Figure 19. For example, the present value of the total benefits (BDT 1,698,025 lakh) minus the present value of the total costs (BDT 1,681,903 lakh) equals the present value of the net benefits (BDT 16,122 lakh), which is consistent with the Excel's estimation on FNPV. Similarly, the present value of the total benefits (BDT 1,698,025 lakh) divided by the present value of the total costs (BDT 1,681,903 lakh) equals 1.01, which is consistent with the Excel's estimation on FBCR.

Note that the *4b.FAnalysis* sheet shows the financial cash flow tables in vertical (or portrait) format (as in Figure 20), whereas the *4a.FAnalysis* sheet shows the cash flow tables in horizontal (or landscape) format (as in Figure 19).

EXERCISE 8. Check which cells the Excel refers to when it calculates FNPV and FIRR using its functions. How does the Excel calculate BCR?

At Constant Prices/Before Discounting (lakh)	Total	Year															Salvage
		1	2	3	4	5	6	7	8	9	10	11	12	29	30		
Total Costs	8,975,664	1,230	80,626	89,656	53,815	1,413	284,273	309,858	337,745	355,342	355,342	355,342	355,342	355,342	355,342		
Initial Investment Costs	226,740	1,230	80,626	89,656	53,815	1,413	--	--	--	--	--	--	--	--	--		
Operating Costs (Operation & Maintenance Costs)	8,749,395	0	0	0	0	0	284,273	309,858	337,745	355,342	355,342	355,342	355,342	355,342	355,342		
Salvage Value	(470)	--	--	--	--	--	--	--	--	--	--	--	--	--	--	(470)	
Total Benefits	9,788,766	0	0	0	0	0	318,043	346,667	377,867	397,554	397,554	397,554	397,554	397,554	397,554		
Net Benefits	813,102	(1,230)	(80,626)	(89,656)	(53,815)	(1,413)	33,770	36,809	40,122	42,212	42,212	42,212	42,212	42,212	42,682		
Financial Discount Rate (12%)	DF	0.893	0.797	0.712	0.636	0.567	0.507	0.452	0.404	0.361	0.322	0.287	0.257	0.037	0.033		
Present Values (lakh)		Year															Salvage
Total		1	2	3	4	5	6	7	8	9	10	11	12	29	30		
Total Costs	1,681,903	1,098	64,274	63,815	34,200	802	144,022	140,164	136,410	128,140	114,411	102,152	91,207	13,284	11,861		
Initial Investment Costs	164,190	1,098	64,274	63,815	34,200	802	--	--	--	--	--	--	--	--	--		
Operating Costs (Operation & Maintenance Costs)	1,517,729	0	0	0	0	0	144,022	140,164	136,410	128,140	114,411	102,152	91,207	13,284	11,861		
Salvage Value	(16)	--	--	--	--	--	--	--	--	--	--	--	--	--	--	(16)	
Total Benefits	1,698,025	0	0	0	0	0	161,131	156,815	152,614	143,362	128,002	114,287	102,042	14,862	13,270		
Net Benefits	16,122	(1,098)	(64,274)	(63,815)	(34,200)	(802)	17,109	16,651	16,205	15,222	13,591	12,135	10,835	1,578	1,425		
FNPV	16,122	(lakh)	16,122														
FBCR	1.01		1.01														
FIRR	13.0%																

Figure 19. Cash Flows of Financial Costs and Benefits (1) ---- Horizontal format [Distribution]

At Constant Prices/Before Discounting (lakh)								Present Values (lakh)								
	Total Costs	Initial Investment Costs	Operating Costs (Operation & Maintenance Costs)	Salvage Value	Total Benefits	Net Benefits	Financial Discount Rate (12%)		Total	Total Costs	Initial Investment Costs	Operating Costs (Operation & Maintenance Costs)	Salvage Value	Total Benefits	Net Benefits	
Total	8,975,664	226,740	8,749,395	(470)	9,788,766	813,102	DF	Total	1,681,903	164,190	1,517,729	(16)	1,698,025	16,122		
Year	1	1,230	1,230	0	--	0	(1,230)	0.893	Year	1	1,098	1,098	0	--	0	(1,098)
	2	80,626	80,626	0	--	0	(80,626)	0.797		2	64,274	64,274	0	--	0	(64,274)
	3	89,656	89,656	0	--	0	(89,656)	0.712		3	63,815	63,815	0	--	0	(63,815)
	4	53,815	53,815	0	--	0	(53,815)	0.636		4	34,200	34,200	0	--	0	(34,200)
	5	1,413	1,413	0	--	0	(1,413)	0.567		5	802	802	0	--	0	(802)
	6	284,273	--	284,273	--	318,043	33,770	0.507		6	144,022	--	144,022	--	161,131	17,109
	7	309,858	--	309,858	--	346,667	36,809	0.452		7	140,164	--	140,164	--	156,815	16,651
	8	337,745	--	337,745	--	377,867	40,122	0.404		8	136,410	--	136,410	--	152,614	16,205
	9	355,342	--	355,342	--	397,554	42,212	0.361		9	128,140	--	128,140	--	143,362	15,222
	10	355,342	--	355,342	--	397,554	42,212	0.322		10	114,411	--	114,411	--	128,002	13,591
	11	355,342	--	355,342	--	397,554	42,212	0.287		11	102,152	--	102,152	--	114,287	12,135
	12	355,342	--	355,342	--	397,554	42,212	0.257		12	91,207	--	91,207	--	102,042	10,835
	13	355,342	--	355,342	--	397,554	42,212	0.229		13	81,435	--	81,435	--	91,109	9,674
	14	355,342	--	355,342	--	397,554	42,212	0.205		14	72,710	--	72,710	--	81,347	8,637
	15	355,342	--	355,342	--	397,554	42,212	0.183		15	64,920	--	64,920	--	72,632	7,712
	16	355,342	--	355,342	--	397,554	42,212	0.163		16	57,964	--	57,964	--	64,850	6,886
	17	355,342	--	355,342	--	397,554	42,212	0.146		17	51,754	--	51,754	--	57,901	6,148
	18	355,342	--	355,342	--	397,554	42,212	0.130		18	46,208	--	46,208	--	51,698	5,489
	19	355,342	--	355,342	--	397,554	42,212	0.116		19	41,258	--	41,258	--	46,159	4,901
	20	355,342	--	355,342	--	397,554	42,212	0.104		20	36,837	--	36,837	--	41,213	4,376
	21	355,342	--	355,342	--	397,554	42,212	0.093		21	32,890	--	32,890	--	36,797	3,907
	22	355,342	--	355,342	--	397,554	42,212	0.083		22	29,366	--	29,366	--	32,855	3,489
	23	355,342	--	355,342	--	397,554	42,212	0.074		23	26,220	--	26,220	--	29,335	3,115
	24	355,342	--	355,342	--	397,554	42,212	0.066		24	23,411	--	23,411	--	26,192	2,781
	25	355,342	--	355,342	--	397,554	42,212	0.059		25	20,902	--	20,902	--	23,385	2,483
	26	355,342	--	355,342	--	397,554	42,212	0.053		26	18,663	--	18,663	--	20,880	2,217
	27	355,342	--	355,342	--	397,554	42,212	0.047		27	16,663	--	16,663	--	18,643	1,979
	28	355,342	--	355,342	--	397,554	42,212	0.042		28	14,878	--	14,878	--	16,645	1,767
	29	355,342	--	355,342	--	397,554	42,212	0.037		29	13,284	--	13,284	--	14,862	1,578
	30	355,342	--	355,342	--	397,554	42,682	0.033		30	11,861	--	11,861	--	13,270	1,425
Salvage				(470)				Salvage				(16)				
	FNPV	16,122	(lakh)													
	FBCR	1.01														
	FIRR	13.0%														

Figure 20. Cash Flows of Financial Costs and Benefits (2) ---- Vertical format [Distribution]

3.7. Step V: Identifying and Quantifying Economic Costs

From this section forward, we start preparing cash flow tables for economic analysis. **Economic analysis** assesses if the project generates economic benefits above economic costs from a perspective of the society as a whole.

3.7.1. Identification of Economic Costs

The fifth step in conducting CBA using the Excel model is to identify economic costs and quantify them. Economic costs are estimated on the basis of financial costs we have already measured. However, because economic costs (and benefits) are estimated from a perspective of the society as a whole (as opposed to a perspective of the project implementing entity), the following items are treated differently in between financial and economic analysis (also see Table 1).

- **Transfer payments** (e.g., taxes, subsidies) included in financial analysis must be excluded in economic analysis
- **Externalities** (e.g., pollution) excluded in financial analysis must be included in economic analysis
- Other **indirect** (or **intangible**) **costs**, which do not entail actual expenditures but reduce the economic welfare of the society, must be included in economic analysis

In addition, because financial prices deviate from economic prices due to government interventions and/or market distortions, financial costs must be converted into economic costs to evaluate them in non-distorted, economic prices.

3.7.2. Tangible Expenditures

The financial costs estimated in the previous steps are tangible or actual expenditures. If there are any transfer payments included in the total initial investment costs, they must be excluded from the calculation of economic costs before conversion, as they simply transfer resources from one party to another within a society.

Figure 21 shows the conversion of financial costs into economic costs for the sample power distribution project. To remove the effects of price distortions, the Conversion Factor for traded goods of 1.15 is applied to the financial costs (of total initial investment costs, salvage value, and operating costs). (Note that the breakdowns of initial investment costs during construction and the operating costs after construction, automatically generated by Excel, are omitted in Figure 21 for space reasons.)

Conversion Factor							
Shadow Price Factor (SPF) [=1/Conversion Factor for Traded Goods]		0.87					
Shadow Wage Rate Factor (SWRF) [=1/Conversion Factor for Unskilled Labor]		0.69					
Financial Costs				Economic Costs			
Item	Local Currency (BDT)	Foreign Currency (USD)	Total (BDT)	Item	Local Currency (BDT)	Foreign Currency (USD)	Total (BDT)
Materials & Equipment Costs	0	0	0	Materials & Equipment Costs [=LC*SPF+FC*(Exchange Rate)]	0	0	0
Labor Costs	0	0	0	Labor Costs	0	0	0
Skilled Workers	0	0	0	Skilled Workers [=LC*SPF+FC*(Exchange Rate)]	0	0	0
Unskilled Workers	0	0	0	Unskilled Workers [=LC*SWRF+FC*(Exchange Rate)]	0	0	0
Land Acquisition/Compensation Costs	0	0	0	Land Acquisition/Compensation Costs [=LC*SPF+FC*(Exchange Rate)]	0	0	0
Consultant Costs	0	0	0	Consultant Costs [=LC*SPF+FC*(Exchange Rate)]	0	0	0
General/Administrative Costs (Overhead Costs)	0	0	0	General/Administrative Costs (Overhead Costs) [=LC*SPF+FC*(Exchange Rate)]	0	0	0
Taxes, Subsidies (Transfers)	0	0	0	Taxes, Subsidies (Transfers)	--	--	--
Base Costs (w/o Contingencies)	0	0	0	Base Costs (w/o Contingencies) - Transfers	0	0	0
Physical Contingency (2%)	0	0	0	Physical Contingency [=LC*SPF+FC*(Exchange Rate)]	0	0	0
Price Contingency, Local currency (5%) / Foreign currency (5%)	0	0	0	Price Contingency	--	--	--
Total Initial Investment Costs (w/ Contingencies)	0	0	0	Total Initial Investment Costs (w/ Contingencies)	--	--	--
Total Initial Investment Costs (BC + Physical Contingency)	0	0	0	Total Initial Investment Costs (BC + Physical Contingency) - Transfers	0	0	0
Cost Data				Cost Data			
Taxes, Subsidies (Transfers)	0	0	0	Taxes, Subsidies (Transfers)	--	--	--
Base Costs (w/o Contingencies)	222,294	0	222,294	Base Costs (w/o Contingencies) - Transfers	193,299	0	193,299
Physical Contingency	4,446	0	4,446	Physical Contingency	3,866	0	3,866
Price Contingency	11,115	0	11,115	Price Contingency	--	--	--
Total Initial Investment Costs (w/ Contingencies)	237,854	0	237,854	Total Initial Investment Costs (w/ Contingencies)	--	--	--
Total Initial Investment Costs (BC + Physical Contingency)	226,740	0	226,740	Total Initial Investment Costs (BC + Physical Contingency) - Transfers	197,165	0	197,165
Financial Costs				Economic Costs			
Item				Item			
Salvage Value of Investment	470			Salvage Value of Investment [=TC*SPF]	409 (lakh)		
Financial Costs				Economic Costs			
Item	Local Currency (BDT)	Foreign Currency (USD)	Total (BDT)	Item	Local Currency (BDT)	Foreign Currency (USD)	Total (BDT)
Input Purchase (e.g., electricity purchase, wheeling charge)	351,824	0	351,824	Input Purchase [=LC*SPF+FC*(Exchange Rate)]	305,933	0	305,933
Spares & Maintenance	3,518	0	3,518	Spares & Maintenance [=LC*SPF+FC*(Exchange Rate)]	3,059	0	3,059
Labor Costs	0	0	0	Labor Costs	0	0	0
Skilled Workers	0	0	0	Skilled Workers [=LC*SPF+FC*(Exchange Rate)]	0	0	0
Unskilled Workers	0	0	0	Unskilled Workers [=LC*SWRF+FC*(Exchange Rate)]	0	0	0
Insurance	0	0	0	Insurance [=LC*SPF+FC*(Exchange Rate)]	0	0	0
General/Administrative Costs (Overhead Costs)	0	0	0	General/Administrative Costs (Overhead Costs) [=LC*SPF+FC*(Exchange Rate)]	0	0	0
Annual Operating Costs (Operation & Maintenance Costs)	355,342	0	355,342	Annual Operating Costs (Operation & Maintenance Costs)	308,993	0	308,993

Figure 21. Conversion of Financial Costs into Economic Costs [Distribution]

Excel converts financial costs into economic costs by applying the **Shadow Price Factor**, which is the inverse of the Conversion Factor for traded goods.

- $(\text{Economic costs}) = (\text{Financial costs}) \times (\text{Shadow price factor})$
where $(\text{Shadow price factor}) = 1 \div (\text{Conversion factor for traded goods})$

If the conversion factor for traded goods is 1.15, the shadow price factor is 0.87 ($= 1 \div 1.15$). Thus, the operating costs of BDT 355,342 lakh become BDT 308,993 lakh ($= 355,342 \times 0.87$) after conversion.

Figure 22 illustrates the concept of converting project costs evaluated in distorted prices into those in non-distorted prices, using a simplified example of the economy with one product. In the ideal world where there is no government intervention or market distortion, the price of product X is BDT 100. However, in the real world, a 15% duty is levied on project X. Therefore, the conversion factor for traded goods and the shadow price factor are used to estimate the economic costs.

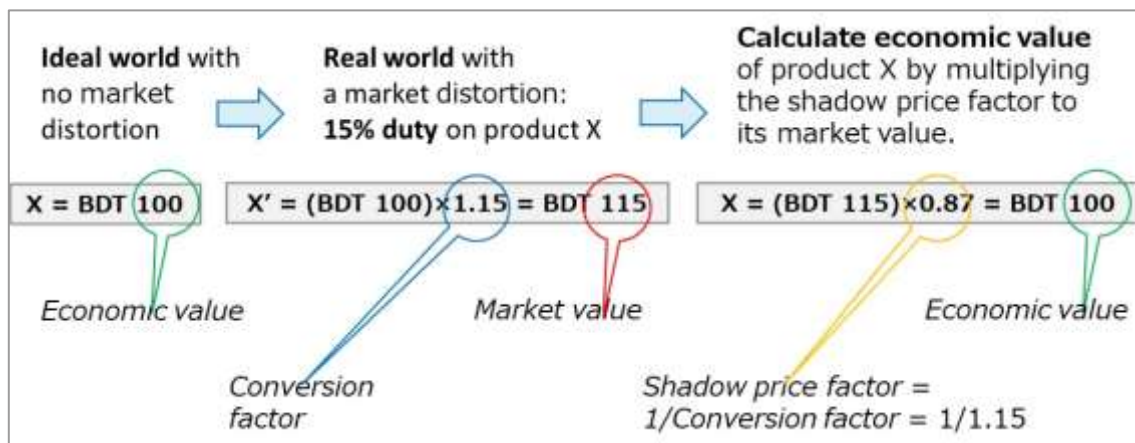


Figure 22. A Simplified Example: Conversion Factor and Shadow Price Factor

EXERCISE 9. Check how Excel converts financial costs into economic costs using the conversion factor for trade goods/shadow price factor.

3.7.3. Indirect Costs

If there are any (negative) externalities or other unintended welfare losses due to a project, they also must be counted as economic costs. For example, the project might negatively affect the economic welfare of some segments of population, even though its overall impact on the entire society is positive. In fact, the sample rural infrastructure development project is expected to decrease the average household income of some population who live in certain areas, because a number of people and businesses currently visiting these areas for purchasing some goods and services will be diverted to other, newly accessible areas after the project completion.

The Excel model estimates these losses of income based on a set of project assumptions/variables specified in the *1.Params* sheet. More specifically, as shown in Figure 23 (where years 2-4 and years 8-28 are omitted for space reasons), it is estimated that approximately 13,000 people live in negatively affected areas at the start of the project. Because the average household size is 5.2, it translates into about 2,500 households living in the negatively affected areas in Year 1. With the annual population growth of 1.37%, by Year 6, there will be 2,676 households in the negatively affected areas $(=(13,000 \times (1+0.0137)^5) \div 5.2, \text{ or } 2,500 \times (1+0.0137)^5)$. It is also assumed that the average monthly household income in the negatively affected areas is BDT 23,000 (or the average annual household income of BDT 276,000). Thus, the total sum of the annual household incomes earned by all the households living in the negatively affected areas will be BDT 7,386 lakh $(=2,676 \times 276,000 \div 10^5)$ in Year 6 if there were no project. Because the loss of household income due to the project is estimated to be 4%, the loss of the total annual household incomes earned by all the households living in the negatively

affected areas will be BDT 295 lakh ($=7,386 \times 0.04$) in Year 6. The loss of the total annual household incomes for other years can be calculated in a similar manner.

	1	5	6	7	29	30
Population in Negatively Affected Areas	13,000	13,728	13,916	14,107	19,031	19,292
Households in Negatively Affected Areas	2,500	2,640	2,676	2,713	3,660	3,710
Total Annual Income Earned by Households in NAA without the Project	6,900	7,286	7,386	7,488	10,101	10,240
Indirect Costs	1	5	6	7	29	30
Decrease in Total Annual Income for Households in NAA due to the Project	0	0	295	300	404	410

Figure 23. Indirect Costs [Rural Infrastructure]

EXERCISE 10. Check the various assumptions on which the Excel model’s calculation of indirect costs is based.

3.8. Step VI: Identifying and Quantifying Economic Benefits

3.8.1. Identification of Economic Benefits

The sixth step in conducting CBA using the Excel model is to identify economic benefits and value them in monetary terms. Sources of **economic benefits** may fall into the following categories:

- Consumer’s surplus
 - Incremental outputs (benefits)
 - Non-incremental outputs (benefits)
- Producer’s (or Supplier’s) surplus
 - Revenue
- Indirect benefits

Incremental outputs (benefits) are the additional outputs of goods and/or services supplied by the project that meet additional demand. In the sample power distribution project and the sample power transmission project, the incremental outputs refer to the additional outputs of electricity distributed and transmitted by the respective project.

Non-incremental outputs (benefits), on the other hand, are the project outputs that replace existing, less reliable supply with new, more reliable ones. In short, non-incremental outputs refer to resource cost savings. As illustrated in Figure 24, both incremental outputs and non-incremental outputs represent an increase in **consumer’s surplus**, owing to the project.

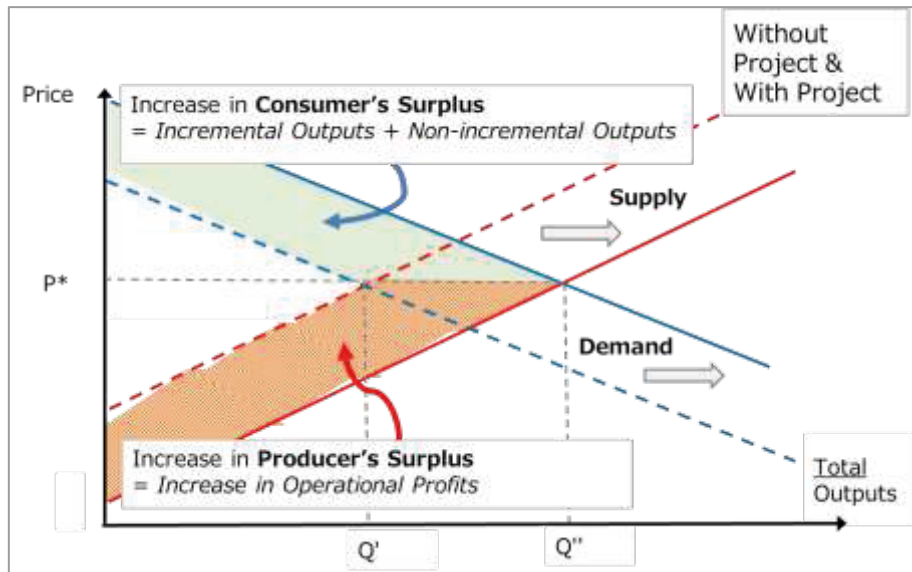


Figure 24. Increases in Consumer's Surplus and Provider's Surplus

Revenues are basically the same as financial benefits estimated in Step III. But the financial benefits must be re-evaluated in terms of economic prices to convert them into economic benefits. An increase in revenues is expected to increase operational profits, which represent **producer's surplus** (see Figure 24¹⁰).

Note that for non-revenue-generating projects, such as the sample rural infrastructure development project, neither incremental outputs nor non-incremental outputs usually can be calculated, as the project outputs are not transacted in markets. In that case, project benefits must be measured either by estimating consumers' willingness to pay (WTP) for the project outputs (using stated or revealed preference methods) or by estimating the indirect impact of the project outputs on the economic welfare of the society (i.e., **indirect benefits**)¹¹, which is explained below. In general, estimating WTP for project benefits is not recommended as it is known to be unreliable.

3.8.2. Incremental Outputs (Benefits)

For the sample power distribution and power transmission projects, the Excel model automatically calculates the incremental outputs based on the project assumptions/variables entered in the *1.Params* sheet. The valuation of the incremental outputs can be

¹⁰ The supply curve is actually vertical for projects like the sample power distribution project and the sample power transmission project, because the market is monopolistic and the supply is fixed, regardless of the price.

¹¹ For example, the impact of rural roads on household incomes may be estimated using a sample of villages with and without access to rural roads.

understood graphically as the estimation of the light blue-colored area of the triangle in Figure 25.

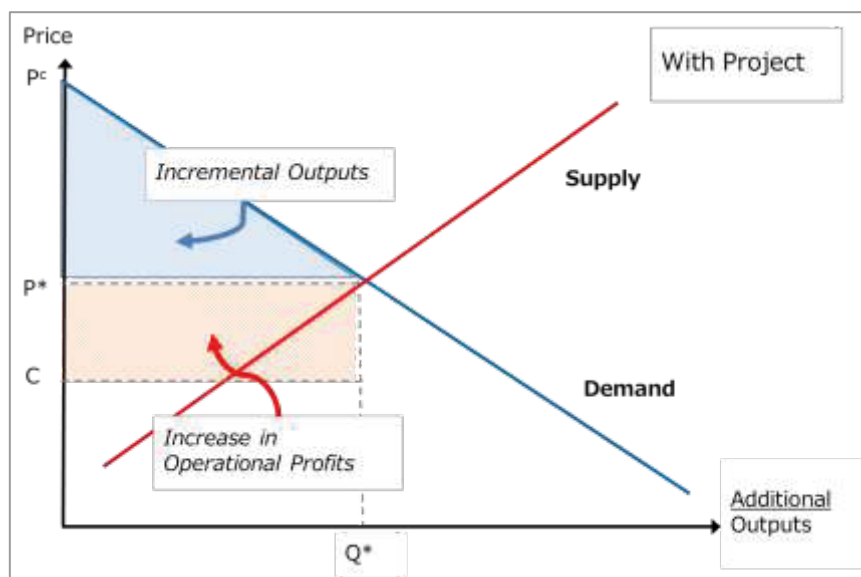


Figure 25. Consumer's Surplus and Provider's Surplus

Figure 26 shows the calculation of incremental outputs using the sample power distribution project. First, the difference between the cost of electricity produced privately (i.e., choke price) and the average sales rate (market clearing price) is calculated (i.e., $12.00 - 8.05 = 3.95$ per kWh). Note that the cost of electricity produced privately corresponds to P^c and the average sales rate corresponds to P^* in Figure 25. This difference is the height of the triangle. Second, to calculate the area of the triangle, the height is multiplied by the base of the triangle (i.e., additional supply of electricity of 4,938,560 MVA per year) and divided by two (i.e., $3.95 \times 4,938,560 \div 2 \times 1,000 \div 100,000 = 97,537$, after converting MVA into kW and BDT into BDT lakh). Finally, to avoid triple counting of incremental outputs with generation and transmission projects, the estimated incremental outputs are simply divided by three (i.e., $97,537 \div 3 = 32,512$). As a result, the incremental outputs attributable to the power distribution project becomes BDT 32,512 lakh.

Item	
Additional Supply of Electricity to Meet Demand per year (a)	4,938,560
Average Sales Rate per kWh (b)	8.05
Cost of Electricity Produced Privately per kWh (c)	12.00
Total Annual Incremental Outputs [=0.5*a*(c-b)]	97,537
Indirect Benefits Attributable to Generation/Transmission (66.7%)	65,024
Annual Incremental Outputs Attributable to Distribution	32,512

Figure 26. Incremental Outputs (1) [Distribution]

The Excel example for the power transmission project calculates incremental outputs in a similar fashion but estimates incremental outputs for residential customers and commercial customers separately (see Figure 27).

Item	
<i>Residential Customers</i>	
Wheeled Energy/Additional Supply of Electricity to Meet Demand (a)	6,521
Average Sales Rate for Residential (b)	7.49
Cost of Electricity Produced Privately for Residential (c)	12.00
Annual Incremental Outputs for Residential [=0.5*a*(c-b)]	147,042
<i>Commercial Customers</i>	
Wheeled Energy/Additional Supply of Electricity to Meet Demand (a)	4,201
Average Sales Rate for Residential (b)	9.80
Cost of Electricity Produced Privately for Commercial (c)	12.00
Annual Incremental Outputs for Commercial [=0.5*a*(c-b)]	46,207
Total Annual Incremental Outputs	193,249
Indirect Benefits Attributable to Generation/Distribution (66.7%)	128,833
Annual Incremental Outputs Attributable to Transmission	64,416

Figure 27. Incremental Outputs (2) [Transmission]

EXERCISE 11. Check how Excel calculates the area of the triangle in Figure 25 for the estimation of incremental outputs.

3.8.3. Non-Incremental Outputs (Benefits)

As mentioned, non-incremental outputs refer to cost savings to be enjoyed by the existing customers. In the sample power distribution project, for example, the non-incremental outputs are expected to be materialized through a reduction in load shedding. Without the project, the existing customers have to produce electricity privately during load shedding (e.g., using a generator). With the project, this existing, less reliable supply of electricity will be replaced by the new, more reliable supply.

The Excel model automatically calculates the non-incremental outputs for the power distribution project by multiplying the number of the existing customers by the average cost savings per customer. The amount of the average cost savings per customer is estimated as the estimated reduction in the time of load shredding per year times the difference between the cost of producing electricity privately and the average sales rate. The sum of total annual cost savings, therefore, is estimated to be BDT 288 lakh (=100,000×73.0×(12.0-8.05)÷100,000). Then, to avoid triple counting of non-incremental outputs with generation and transmission projects, the non-incremental

outputs attributable to distribution are calculated by simply dividing the total non-incremental outputs by three (i.e., $288 \div 3 = 96$) (see Figure 28).

Item	
Average Sales Rate per kWh (b)	8.05
Cost of Electricity Produced Privately per kWh (c)	12.00
Existing Customers (d)	100,000
Reduction in Load Shedding per year (e)	73.0
Total Annual Cost Savings (Reliability Benefits) [(c-b)*d*e]	288
Indirect Benefits Attributable to Generation/Transmission (66.7%)	192
Annual Non- incremental Outputs Attributable to Distribution	96

Figure 28. Non-Incremental Outputs (1) [Distribution]

The non-incremental outputs for the sample power transmission project, on the other hand, are more generically estimated, assuming that a certain percentage of total population in the project area will enjoy a certain amount of cost savings. Specifically, the Excel model calculates (based on the project assumptions/variables we set in the *1.Params* sheet) that 1% of a total of 1,332,805 customers will be able to achieve an annual saving of BDT 1,000 owing to the project. As a result, the total annual cost savings are estimated to be BDT 133 lakh ($=1,332,805 \times 0.01 \times 1,000 \div 100,000$), and the estimated non-incremental outputs attributable to distribution are estimated to be BDT 44 lakh ($=133 \div 3$) (see Figure 29).

Item	
Existing Total Customers (c)	1,332,805
Percent of Existing Total Customers who Benefit from Cost Savings (d)	1.00%
Avg. Cost Savings per Customer (e)	1,000
Total Annual Cost Savings (Reliability Benefits) [c*d*e]	133
Indirect Benefits Attributable to Generation/Distribution (66.7%)	89
Annual Non-incremental Outputs Attributable to Transmission	44

Figure 29. Non-Incremental Outputs (2) [Transmission]

EXERCISE 12. Check how the Excel model calculates the non-incremental outputs.

3.8.4. Revenue

Similar to the conversion of financial costs into economic costs, the financial benefits/revenues estimated for financial analysis must be converted into economic benefits by evaluating them in economic prices. Excel will automatically convert financial benefits/revenues into economic benefits by applying the shadow price factor.

Figures 30 and 31 show examples for the sample power distribution project and the sample power transmission project, respectively. To remove the effects of price distortions, the conversion factor for trade goods of 1.15, or the shadow price factor of 0.87 is applied. For the power distribution project, the incremental revenues evaluated in economic prices becomes BDT 345,699 lakh ($=397,554 \times (1 \div 1.15) = 397,554 \times 0.87$), and that for the power transmission project becomes BDT 26,020 lakh ($=29,923 \times (1 \div 1.15) = 29,923 \times 0.87$).

Conversion Factor			
Shadow Price Factor (SPF) [=1/Conversion Factor for Traded Goods]		0.87	
Shadow Wage Rate Factor (SWRF) [=1/Conversion Factor for Unskilled Labor]		0.69	
Financial Benefits/Revenues			Economic Benefits/Revenues
Item		→	Item
Revenue Source I			Revenue Source I
Additional Supply of Electricity to Meet Demand per year	4,938,560		Additional Supply of Electricity to Meet Demand per year
Average Sales Rate per kWh	8.05		Average Sales Rate per kWh
Revenue Source II			Revenue Source II
Additional Supply of Electricity to Meet Demand per year			Additional Supply of Electricity to Meet Demand per year
Average Sales Rate per kWh			Average Sales Rate per kWh
Revenue Source III			Revenue Source III
Additional Supply of Electricity to Meet Demand per year			Additional Supply of Electricity to Meet Demand per year
Average Sales Rate per kWh			Average Sales Rate per kWh
Annual Revenues	397,554 (lakh)		Annual Revenues [=LC*SPF] 345,699

Figure 30. Revenue (1) [Distribution]

Financial Benefits/Revenues			Economic Benefits/Revenues	
Item		→	Item	
Revenue Source I			Revenue Source I	
Incremental Load Flow/Total Capacity to be Increased	1398.63 (MW/hour)		Incremental Load Flow/Total Capacity to be Increased	
Load Factor	90.0% (%)		Load Factor	
Gross Annual Energy (considering the Load Factor)	11026.80 (mil.kWh/year)		Gross Annual Energy (considering the Load Factor)	
Transmission Loss	2.77% (%)		Transmission Loss	
Wheeled Energy/Additional Supply of Electricity to Meet Demand (a)	10721.36 (mil.kWh/year)		Wheeled Energy/Additional Supply of Electricity to Meet Demand (a)	
Wheeling Charge (b)	0.28 (BDT/Wh)		Wheeling Charge (b)	
Revenues from Wheeling Charge (a)*(b)	29,923 (lakh)		Revenues from Wheeling Charge (a)*(b) [=LC*SPF]	26,020
Revenue Source II			Revenue Source II	
Wheeled Energy/Additional Supply of Electricity to Meet Demand (a)			Wheeled Energy/Additional Supply of Electricity to Meet Demand (a)	
Wheeling Charge (b)			Wheeling Charge (b)	
Revenues from Wheeling Charge (a)*(b)			Revenues from Wheeling Charge (a)*(b) [=LC*SPF]	
Revenue Source III			Revenue Source III	
Wheeled Energy/Additional Supply of Electricity to Meet Demand (a)			Wheeled Energy/Additional Supply of Electricity to Meet Demand (a)	
Wheeling Charge (b)			Wheeling Charge (b)	
Revenues from Wheeling Charge (a)*(b)			Revenues from Wheeling Charge (a)*(b) [=LC*SPF]	
Annual Revenues	29,923 (lakh)		Annual Revenues [=LC*SPF] 26,020	

Figure 31. Revenue (2) [Transmission]

EXERCISE 13. Confirm that the way the Excel model converts financial revenues into economic revenues is identical to the way it converts financial costs into economic costs.

3.8.5. Indirect Benefits

As mentioned, neither incremental outputs nor non-incremental outputs usually can be calculated for non-revenue-generating projects, such as the sample rural infrastructure development project, because the project outputs are not transacted in markets. Thus, the Excel model tries to approximate the impact of the project on the

economic welfare of the society through the estimation of indirect benefits¹². The Excel model for the sample rural infrastructure development project, for example, estimates the following indirect benefits:

- **Commercial benefits** – for those who will enjoy higher demands for their products and services owing to better access to markets and distribution channels
 - Agricultural households
 - MSME (micro, small, medium-sized enterprises) households
- **Educational benefits** – for those who will avoid dropping out of school and complete high school education owing to better access to schools
- **Health benefits** – for the pregnant women whose lives will be saved owing to better access to maternal health services

First, an increase in total annual income earned by all agricultural households is calculated by multiplying the total annual income earned by all agricultural households (without the project) by the estimated percentage increase in total income owing to the project. As demonstrated in Figure 32 (where years 2-4 and years 8-28 are omitted for space reasons), the Excel model first estimates the total annual income earned by all agricultural households by multiplying the average annual income for agricultural households by the number of agricultural households. In the sample rural infrastructure development project, the percentage of agricultural households in total households is estimated to be 45%, and the total population is expected to grow 1.37% annually during the project life. Because the total population in Year 1 is 35,000, it grows to 37,464 by Year 6 ($=35,000 \times (1+0.0137)^5$). Given that the average household size is 5.2, the number of households becomes 7,205 in Year 6 ($=37,464 \div 5.2$), of which 3,242 ($=7,205 \times 0.45$) are agricultural households. The average monthly income of BDT 12,000 for agricultural households means the average annual income of BDT 144,000 ($=12,000 \times 12$). Thus, the total annual income earned by all agricultural households (in lakh) in Year 6, can be obtained by multiplying this by the number of agricultural households in Year 6; that is, $(144,000 \times 3,242) \div 100,000 = 4,668.48$ or BDT 4,668.48 lakh. Because agricultural income is expected to increase by 20% due to the project, an increase in total annual income earned by all agricultural households will be BDT 933.70 lakh in Year 6. A stream of incomes for subsequent years can be calculated in a similar manner.

¹² Another way of measuring project benefits for non-revenue-generating projects is to estimate consumers' willingness to pay (WTP) for the project outputs (using stated or revealed preference methods). However, estimating WTP for project benefits is known to be less reliable.

Using the same analytical framework, an increase in total annual income earned by all MSME households can be calculated.

Indirect Benefits	1	5	6	7	29	30
Population	35,000	36,958	37,464	37,977	51,230	51,932
Households	6,731	7,107	7,205	7,303	9,852	9,987
Agricultural Households	3,029	3,198	3,242	3,286	4,433	4,494
MSME Households	505	533	540	548	739	749
High School Students	7,000	7,392	7,493	7,595	10,246	10,386
Student Dropouts	700	739	749	760	1,025	1,039
Reduction in Student Dropouts	0	0	75	76	103	104
Female Population	17,500	18,479	18,732	18,989	25,615	25,966
Female Population from Age 15 to 44	8,750	9,240	9,366	9,495	12,808	12,983
Women Giving Birth	700	739	749	760	1,025	1,039
Maternal Deaths	1	1	1	1	2	2
Reduction in Maternal Deaths	0	0	1	1	1	1
Total Annual Income for Agricultural Households	4,361.76	4,605.12	4,668.48	4,731.84	6,383.52	6,471.36
Total Annual Income for MSME Households	1,515.00	1,599.00	1,620.00	1,644.00	2,217.00	2,247.00
Commercial Benefits	1	5	6	7	29	30
Increase in Total Annual Income for Agricultural Households	0	0	933.70	946.37	1,276.70	1,294.27
Increase in Total Annual Income for MSME Households	0	0	405.00	411.00	554.25	561.75
Increase in Total Annual Income for Agricultural/MSME Households	0	0	1,338.70	1,357.37	1,830.95	1,856.02
Educational Benefits	1	5	6	7	29	30
Increase in Total Annual Income for Those Who Avoided Dropout	0	0	29.39	59.56	201.80	203.76
Health Benefits	1	5	6	7	29	30
Total Value Obtained from Saving Maternal Lives	0	0	0.55	0.55	0.55	0.55

Figure 32. Indirect Benefits [Rural Infrastructure]

Second, education benefits are estimated on the assumptions that the project will reduce the high school dropout rate, which will in turn contribute to an increase in income earned by those who avoid dropping out of school and complete high school education. The Excel model estimates that 20% of total population (i.e., 35,000 in Year 1) are high school-aged students. Thus, the number of high school-aged students is 7,000 ($=35,000 \times 0.20$) in Year 1. Because the population is expected to grow 1.37% annually, the number of high school-aged students becomes 7,493 ($=7,000 \times (1+0.0137)^5$) by Year 6. The Excel model further assumes that the annual dropout rate is initially 10% but will decrease by 10% to 9% ($=0.10 \times 0.9$), as a result of the project. Thus, in Year 6, the number of students dropping out of school will be 749 ($=7,493 \times 0.10$) without the project. But with project, that number will decrease by 75 ($=749 \times 0.10$). Furthermore, the model estimates that an increase in annual personal income due to the avoidance of dropout is the BDT 195,923 (see the *1.Params* sheet for details). Thus, the increase in total annual income earned by those who avoid dropout would be BDT 146.94 lakh ($=195,923 \times 75 \div 100,000$) in Year 6. The model, at the same time, assumes that only 20% of that full potential effects will materialize in the first year after project completion. As a result, the educational benefits in Year 6 is BDT 29.39 lakh ($=146.94 \times 0.20$). A stream of increased incomes for subsequent years can be calculated in a similar manner (see Figure 32).

Finally, the health benefits are estimated on the assumptions that the project will reduce the maternal mortality of pregnant women through the provision of better access to maternal health services and that the estimated monetary value of a woman's life saved is BDT 54,553 per year. The Excel model estimates that 50% of total population (i.e., 35,000 in Year 1) are women, of which 50% are aged from 15 to 44. Thus, the number of reproductive-aged women is about 8,750 ($=35,000 \times 0.50 \times 0.50$) in Year 1. Because the population is expected to grow 1.37% annually, the number of reproductive-aged women becomes 9,366 ($=8,750 \times (1+0.0137)^5$) by Year 6. The Excel model further assumes that 8% of reproductive-aged women give birth every year and that the maternal mortality rate is 173 deaths per every 100,000 births without the project but will decrease by 70% to 52 deaths per every 100,000 births with the project. Therefore, in Year 6, the number of maternal deaths will be about 1.3 ($=9,366 \times 0.08 \times 0.000173$) without the project. But with project, that number will decrease to about 0.7 ($=9,366 \times 0.08 \times 0.000052$). (These numbers are rounded to the nearest integer in the model.) Furthermore, with the estimated monetary value of BDT 54,553 per year for a woman's life, the health benefits enjoyed by pregnant women whose lives are saved will be BDT 0.55 lakh ($=1 \times 54,553 \div 100,000$) in Year 6. Again, a stream of increased incomes for subsequent years can be calculated in a similar manner. Note that the health benefits expected from the sample rural infrastructure development project are very small compared to the commercial and educational benefits (see Figure 32).

In theory, there are two other potential sources for the project benefits of an infrastructure development project, which would be more direct than the indirect benefits explained. One is **cost savings**, arising mainly from spending less on fuel expenditures, and the other is **travel time savings**, resulting in a reduction in opportunity cost (by being able to spend more time on productive activities).¹³ However, the sizes of these benefits are usually very small for rural infrastructure development projects, as contrary for urban infrastructure development projects. This is because rural infrastructure development projects usually have little to do with the resolution of traffic congestion. As a result, the Excel model for the sample rural infrastructure development project does not take into account the benefits from the cost and travel time savings.

EXERCISE 14. Check how the Excel model estimates indirect benefits. Confirm that estimation relies heavily on the assumptions/variables that come from outside the Excel model.

¹³ Note that the cost savings and travel time savings are not mutually exclusive to the indirect benefits, such as commercial, educational, and health benefits estimated above.

3.9. Step VII: Constructing Economic Cash Flow Tables and Estimating Economic Indicators

3.9.1. Constructing Cash Flow Tables of Economic Costs and Benefits

The seventh step in conducting CBA using the Excel model is to construct cash flow tables of economic costs and benefits and estimate economic indicators.

Figure 33 (where years 13-28 are omitted for space reasons) shows economic cash flows for the sample rural infrastructure development project. The upper table illustrates the cash flows of economic costs and benefits **before discounting**. The lower table, on the other hand, shows economic cash flows **after discounting** with a social discount rate of 12%. A series of figures (labeled “DF”) listed between the upper and lower tables are discount factors for the corresponding years.

3.9.2. Estimating and Interpreting ENPV, EBCR, and EIRR

The Excel model calculates ENPV, EBCR, and EIRR, applying Excel functions, such as **NPV()** and **IRR()**, to a (before-discounting) cash flow of net benefits. We can also manually calculate ENPV and EBCR from the lower table of Figure 33. For example, the present value of the total benefits (BDT 7,142 lakh) minus the present value of the total costs (BDT 4,611 lakh) equals the present value of the net benefits (BDT 2,531 lakh), which is consistent with the Excel’s estimation of ENPV. Similarly, the present value of the total benefits (BDT 7,142 lakh) divided by the present value of the total costs (BDT 4,611 lakh) equals 1.55, which is again consistent with the Excel’s estimation of EBCR.

Note that the *7b.EAnalysis* sheet shows the economic cash flow tables in vertical (or portrait) format (as in Figure 34), whereas the *7a.EAnalysis* sheet shows the cash flow tables in horizontal (or landscape) format (as in Figure 33).

EXERCISE 15. Double-check how the Excel calculates ENPV, EBCR, and EIRR.

At Constant Prices/Before Discounting (lakh)	Total	Year															Salvage
		1	2	3	4	5	6	7	8	9	10	11	12	29	30		
Total Costs	14,710	166	414	1,242	1,863	455	378	382	386	391	395	399	403	487	492		
Initial Investment Costs	4,139	166	414	1,242	1,863	455	--	--	--	--	--	--	--	--	--		
Operating Costs (Operation & Maintenance Costs)	2,069	0	0	0	0	0	83	83	83	83	83	83	83	83	83		
Salvage Value	(237)	--	--	--	--	--	--	--	--	--	--	--	--	--	--	(237)	
Decrease in Income for HHs in Negatively Affected	8,739	0	0	0	0	0	295	300	304	308	312	316	321	404	410		
Total Benefits	43,659	0	0	0	0	0	1,369	1,417	1,467	1,518	1,570	1,590	1,612	2,033	2,060		
Increase in Income for Agricultural/MSME HHs	39,601	0	0	0	0	0	1,339	1,357	1,376	1,395	1,414	1,433	1,453	1,831	1,856		
Increase in Income for Those Who Avoided Dropout	4,044	0	0	0	0	0	29	60	91	122	155	157	159	202	204		
Value Obtained from Saving Maternal Lives	14	0	0	0	0	0	1	1	1	1	1	1	1	1	1		
Net Benefits	28,949	(166)	(414)	(1,242)	(1,863)	(455)	990	1,035	1,080	1,127	1,175	1,191	1,209	1,546	1,805		
Economic Discount Rate (12%)	DF	0.893	0.797	0.712	0.636	0.567	0.507	0.452	0.404	0.361	0.322	0.287	0.257	0.037	0.033		
Present Values (lakh)	Total	Year															Salvage
		1	2	3	4	5	6	7	8	9	10	11	12	29	30		
Total Costs	4,611	148	330	884	1,184	258	192	173	156	141	127	115	104	18	16		
Initial Investment Costs	2,804	148	330	884	1,184	258	--	--	--	--	--	--	--	--	--		
Operating Costs (Operation & Maintenance Costs)	368	0	0	0	0	0	42	37	33	30	27	24	21	3	3		
Salvage Value	(8)	--	--	--	--	--	--	--	--	--	--	--	--	--	--	(8)	
Decrease in Income for HHs in Negatively Affected	1,447	0	0	0	0	0	150	135	123	111	100	91	82	15	14		
Total Benefits	7,142	0	0	0	0	0	693	641	592	547	505	457	414	76	69		
Increase in Income for Agricultural/MSME HHs	6,556	0	0	0	0	0	678	614	556	503	455	412	373	68	62		
Increase in Income for Those Who Avoided Dropout	583	0	0	0	0	0	15	27	37	44	50	45	41	8	7		
Value Obtained from Saving Maternal Lives	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0		
Net Benefits	2,531	(148)	(330)	(884)	(1,184)	(258)	502	468	436	406	378	342	310	58	60		
ENPV	2,531	(lakh)	2,531														
EBCR	1.55		1.55														
EIRR	20.4%																

Figure 33. Cash Flows of Economic Costs and Benefits (1) [Rural Infrastructure]

At Constant Prices/Before Discounting (lakh)											Present Values (lakh)											
	Total Costs	Initial Investment Costs	Operating Costs (Operation & Maintenance Costs)	Salvage Value	Decrease in Income for HHs in Negatively Affected	Total Benefits	Increase in Income for Agricultural/MSME HHs	Increase in Income for Those Who Avoided Dropout	Value Obtained from Saving Maternal Lives	Net Benefits	Economic Discount Rate (12%)		Total Costs	Initial Investment Costs	Operating Costs (Operation & Maintenance Costs)	Salvage Value	Decrease in Income for HHs in Negatively Affected	Total Benefits	Increase in Income for Agricultural/MSME HHs	Increase in Income for Those Who Avoided Dropout	Value Obtained from Saving Maternal Lives	Net Benefits
Total	14,710	4,139	2,069	(237)	8,739	43,659	39,601	4,044	14	28,949	DF	Total	4,611	2,804	368	(8)	1,447	7,142	6,556	583	2	2,531
Year	1	166	166	0	--	0	0	0	0	(166)	0.893	1	0	148	0	--	0	0	0	0	0	(148)
	2	414	414	0	--	0	0	0	0	(414)	0.797	2	330	330	0	--	0	0	0	0	0	(330)
	3	1,242	1,242	0	--	0	0	0	0	(1,242)	0.712	3	884	884	0	--	0	0	0	0	0	(884)
	4	1,863	1,863	0	--	0	0	0	0	(1,863)	0.636	4	1,184	1,184	0	--	0	0	0	0	0	(1,184)
	5	455	455	0	--	0	0	0	0	(455)	0.567	5	258	258	0	--	0	0	0	0	0	(258)
	6	378	--	83	--	295	1,369	1,339	29	990	0.507	6	192	--	42	--	150	693	678	15	0	502
	7	382	--	83	--	300	1,417	1,357	60	1,035	0.452	7	173	--	37	--	135	641	614	27	0	468
	8	386	--	83	--	304	1,467	1,376	91	1,080	0.404	8	156	--	33	--	123	592	556	37	0	436
	9	391	--	83	--	308	1,518	1,395	122	1,127	0.361	9	141	--	30	--	111	547	503	44	0	406
	10	395	--	83	--	312	1,570	1,414	155	1,175	0.322	10	127	--	27	--	100	505	455	50	0	378
	11	399	--	83	--	316	1,590	1,433	157	1,191	0.287	11	115	--	24	--	91	457	412	45	0	342
	12	403	--	83	--	321	1,612	1,453	159	1,209	0.257	12	104	--	21	--	82	414	373	41	0	310
	13	408	--	83	--	325	1,634	1,473	161	1,226	0.229	13	93	--	19	--	74	374	337	41	0	281
	14	412	--	83	--	329	1,658	1,493	165	1,246	0.205	14	84	--	17	--	67	339	305	34	0	255
	15	417	--	83	--	334	1,681	1,513	167	1,264	0.183	15	76	--	15	--	61	307	277	30	0	231
	16	421	--	83	--	339	1,703	1,534	168	1,282	0.163	16	69	--	14	--	55	278	250	27	0	209
	17	426	--	83	--	343	1,727	1,556	170	1,301	0.146	17	62	--	12	--	50	251	227	25	0	189
	18	431	--	83	--	348	1,749	1,576	172	1,319	0.130	18	56	--	11	--	45	227	205	22	0	171
	19	435	--	83	--	353	1,773	1,598	174	1,338	0.116	19	51	--	10	--	41	206	186	20	0	155
	20	440	--	83	--	357	1,799	1,620	178	1,359	0.104	20	46	--	9	--	37	186	168	18	0	141
	21	445	--	83	--	362	1,823	1,642	180	1,378	0.093	21	41	--	8	--	34	169	152	17	0	128
	22	450	--	83	--	367	1,848	1,665	182	1,398	0.083	22	37	--	7	--	30	153	138	15	0	115
	23	455	--	83	--	372	1,872	1,688	184	1,417	0.074	23	34	--	6	--	27	138	125	14	0	105
	24	460	--	83	--	377	1,899	1,710	188	1,439	0.066	24	30	--	5	--	25	125	113	12	0	95
	25	465	--	83	--	383	1,925	1,734	190	1,459	0.059	25	27	--	5	--	23	113	102	11	0	86
	26	471	--	83	--	388	1,950	1,757	192	1,479	0.053	26	25	--	4	--	20	102	92	10	0	78
	27	476	--	83	--	393	1,978	1,782	196	1,502	0.047	27	22	--	4	--	18	93	84	9	0	70
	28	481	--	83	--	399	2,005	1,806	198	1,524	0.042	28	20	--	3	--	17	84	76	8	0	64
	29	487	--	83	--	404	2,033	1,831	202	1,546	0.037	29	18	--	3	--	15	76	68	8	0	58
	30	492	--	83	--	410	2,060	1,856	204	1,805	0.033	30	16	--	3	--	14	69	62	7	0	60
Salvage				(237)								Salvage				(8)						
	ENPV	2,531	(lakh)																			
	EBCR	1.55																				
	EIRR	20.4%																				

Figure 34. Cash Flows of Economic Costs and Benefits (2) [Rural Infrastructure]

3.10. Step VIII: Testing the Sensitivity of the Results to Parameters and Variables

3.10.1. Conducting Sensitivity Analysis

The eighth step in conducting CBA using the Excel model is to test the sensitivity of the results to project assumptions and variables. **Sensitivity analysis** assesses the impact of changing values of the different assumptions/variables on project outcomes.

The main steps of sensitivity analysis are as follows:

1. Select the project assumptions/variables to which the investment decision may be sensitive
2. Determine the possible extent of variation of the assumptions/variables from the base scenario
3. Simulate the effects of different values of these assumptions/variables on NPV, BCR, and IRR

EXERCISE 16. Simulate the impact of changing values of total benefits on financial and economic NPV, BCR, and IRR, as follows:

1. Go to Excel's *8.Sensitivity* sheet and find the "Change in Total Benefits" table for sensitivity analysis.
2. Clear all the data values except the top row and select the entire circled area of the table, as shown in Figure 35.

Parameter/Assumption	Value	Financial Analysis			Economic Analysis			
		NPV	BCR	IRR	NPV	BCR	IRR	
Change in Total Benefits	(%)	100%	16,122	1.01	13.0%	153,295	1.10	21.5%
		80%						
		90%						
		100%						
		110%						
		120%						

Figure 35. Sensitivity Analysis (1) [Distribution]

3. In the Excel menu bar, choose the **Data** tab → **What-If Analysis** → **Data Table**.
4. In the **Data Table** pop-up box, enter the red-circled "Level of Total Benefits" cell of "100%" into the **Column input cell** (see Figure 36).

Level of Total Benefits	(%)	100%
Level of Total Costs	(%)	100%

Figure 36. Sensitivity Analysis (2)

5. Excel automatically simulates the effects on financial and economic NPV, BCR, IRR, as shown in Figure 37.

Parameter/Assumption	Value	Financial Analysis			Economic Analysis			
		NPV	BCR	IRR	NPV	BCR	IRR	
Change in Total Benefits	(%)	100%	16,122	1.01	13.0%	153,295	1.10	21.5%
		80%	(323,483)	0.81	n/a	(169,869)	0.88	n/a
		90%	(153,680)	0.91	-7.3%	(8,287)	0.99	11.4%
		100%	16,122	1.01	13.0%	153,295	1.10	21.5%
		110%	185,925	1.11	21.9%	314,877	1.22	28.8%
		120%	355,727	1.21	28.6%	476,459	1.33	34.8%

Figure 37. Sensitivity Analysis (3) [Distribution]

In a similar manner, sensitivity analysis can be done for total costs and all other assumptions/variables.

3.11. Step IX: Summarizing the Results of Financial and Economic Analysis

3.11.1. Reporting Financial and Economic NPV, BCR, and IRR

The ninth and final step in conducting CBA using the Excel model is to summarize and report the results of financial and economic analysis. Excel displays the financial and economic NPV, BCR, and IRR in the format consistent with the specifications of the *Development Project Proforma/Proposal (DPP) Manual*.

Figures 38-40 show a summary of the results of NPV, BCR, and IRR for each of the sample projects.

Indicator	Value
(i) Financial Net Present Value (FNPV)	16,122
(ii) Financial Benefit-Cost Ratio (FBCR)	1.01
(iii) Financial Internal Rate of Return (FIRR)	13.0%
(i) Economic Net Present Value (ENPV)	153,295
(ii) Economic Benefit-Cost Ratio (EBCR)	1.10
(iii) Economic Internal Rate of Return (EIRR)	21.5%

Figure 38. Summary of the Results [Distribution]

Indicator	Value
(i) Financial Net Present Value (FNPV)	2,330
(ii) Financial Benefit-Cost Ratio (FBCR)	1.02
(iii) Financial Internal Rate of Return (FIRR)	12.2%
(i) Economic Net Present Value (ENPV)	290,903
(ii) Economic Benefit-Cost Ratio (EBCR)	3.54
(iii) Economic Internal Rate of Return (EIRR)	34.3%

Figure 39. Summary of the Results [Transmission]

Indicator	Value
(i) Financial Net Present Value (FNPV)	(3,781)
(ii) Financial Benefit-Cost Ratio (FBCR)	0.00
(iii) Financial Internal Rate of Return (FIRR)	n/a
(i) Economic Net Present Value (ENPV)	2,531
(ii) Economic Benefit-Cost Ratio (EBCR)	1.55
(iii) Economic Internal Rate of Return (EIRR)	20.4%

Figure 40. Summary of the Results [Rural Infrastructure]

In the end, what is most important in the CBA of public investment projects is that we all follow the appropriate logic and framework (including reasonable parameters and assumptions) of the CBA, as well as its analytical process, in a consistent manner.

Reference

ADB (2013) Cost-Benefit Analysis for Development – A Practical Guide

ADB (2017) Guidelines for the Economic Analysis of Projects

European Union (2014) Guide to Cost-Benefit Analysis of Investment Projects

General Economics Division, Planning Commission (2014) Development Project Proforma/ Proposal (DPP) Manual (Instructions for Preparing Development Project Proposal)

Annexures

Description of Power Distribution Project

1. Project Outline (Sheet "0.Contents")

The project is designed to increase the supply of electricity to about 200,000 new customers in rapidly growing urban areas and to improve the service of electricity supply to 100,000 existing customers by establishing new service connections, and updating the existing distribution facilities, respectively.

The following Table shows the planned outputs of the proposed project.

Outputs	Total
Installation of grid substations	2 Nos.
Construction of overhead & underground electricity distribution lines	113.88 Km
Construction of underground transmission lines	66.55 km
Installation of ring main units (RMU) and distribution transformers	2 Nos.

2. Project duration (Sheet "1.Params_8.Sensitivity")

The estimated construction period of the project is for 5 years. The project life is 30 years.

3. Project Cost (Sheet "2a.FCosts" and "2b.FCosts")

Direct Cost 1: Investment Cost

The investment cost is the cost to deliver the outputs. The estimated total cost, as an investment of the project is BDT 237,854 lakh. Here, physical contingency is BDT 4,446 lakh and price contingency is BDT 11,115 lakh.

Item	Description	BDT (Lakh)***
(a) Revenue*		-
(b) Capital		222,294
(c) Physical Contingency**	2% of (b)	4,446
(d) Price Contingency**	5% of (a+b)	11,115
Total (a+b+c+d)		237,854

*To make the model simple, cost for Revenue is not counted.

** The parameter is set in sheet "1.Params_8.Sensitivity".

*** The total and the sum of a+b+c+d do not exactly match. This is due to rounding to the nearest whole number.

Table below shows annual initial investment cost excluding the price contingency.

Year 1	Year 2	Year 3	Year 4	Year 5	Total
0.5%	35.6%	39.5%	23.7%	0.6%	100%
1,230	80,626	89,656	53,815	1,413	226,740

Direct Cost 2: Operation and maintenance cost

For the cost of operation and maintenance of the facilities developed by the proposed project, this model assumes BDT 355,342 lakh per annum as the annual operation and maintenance cost. BDT 355,342 lakh per annum comes from the cost of Input Purchase (e.g., electricity purchase, wheeling charge) and the cost of Spares & Maintenance. The Cost of Inputs Purchase is estimated as [total capacity to be increased] X [average cost of input]. The cost of Spares & Maintenance is assumed to be 1% of the cost of Inputs Purchase.

The distribution company will purchase electricity from the gridline and will distribute electricity to its customers using a tariff rate fixed by the Bangladesh Energy Regulatory Commission.

Indirect cost

No significant indirect costs of the project, such as negative environmental impacts, are expected.

4. Project Benefit (Sheet “1.Params_8.Sensitivity”, “3.FBenefits”, “6.EBenefits”)

This model considers the following consumer’s surplus and producer’s surplus as direct benefits shown in the Table below.

Category	Sub-category	Description
Consumer’s surplus	Incremental outputs	Additional output of electricity transmitted to new customers.
Consumer’s surplus	Non-incremental outputs	Output of electricity transmitted to existing customers that displaces unreliable services of electricity supply with more reliable ones.
Producer’s surplus		Increase in operational revenues

The proposed project used the following data and information for benefit calculation.

- General Information (Sheet “1.Params_8.Sensitivity”)
 - The number of Existing consumers is 100,000 in the project area and additional 200,000 new consumers eventually will be added after completion of the project.
 - This project considered the purchase price from BPDB at BDT 6.75 per kWh including the wheeling charge and the average sales price is BDT 8.05 per kWh. In addition, it is also considered that Cost of Electricity Production Privately per kWh is about BDT 12.00, which is a choke price and the wheeling charge is about BDT 0.29.

- This project is considering the Conversion Factor for traded goods at 1.15.
- Financial Benefit (Sheet "3.FBenefits")
 - This project is targeting to increase the total Capacity about 595 MVA per hour, and thus 5,212,200 MVA per year. Assuming the system loss is 5.25%, Additional Supply of Electricity to Meet Demand per year is 4,938,560 MVA/Year.
 - Assuming Average Sales Rate per kWh is BDT 8.05 per kWh, Annual Revenues is BDT 397,554 Lakh.
 - Initial Capacity of Utilization after Project Completion is about 80% and annual Growth in Capacity Utilization/Growth of Demand for Electricity is at 9%.
- Economic Benefit: Incremental Outputs (Sheet "6.EBenefits")
 - Additional Supply of Electricity to Meet Demand per year is 4,938,560 MAV/Year.
 - Assuming Average Sales Rate per kWh is BDT 8.05 per kWh, and Cost of Electricity Produced Privately per kWh is BDT 12.00 per kWh, the difference of these is BDT 3.95 per kWh.
 - Total Annual Incremental Outputs is [Additional Supply of Electricity to Meet Demand per year] x [The difference], which is BDT 97,537 Lakh.
- Economic Benefit: Non-Incremental outputs (Sheet "6.EBenefits")
 - This project is targeting to reduce the load shedding about 12 minutes per day. Thus, Reduction in Load Shedding per year is 73 hours per year.
 - The number of Existing consumers is 100,000 in the project area.
 - Assuming Average Sales Rate per kWh is BDT 8.05 per kWh, and Cost of Electricity Produced Privately per kWh is BDT 12.00 per kWh, the difference of these is BDT 3.95 per kWh.
 - Total Annual Cost Savings (Reliability Benefits) is [Reduction in Load Shedding per year] x [The number of Existing consumers] x [The difference], which is BDT 288 Lakh.
- Economic Benefit: Increase in operational revenues (Sheet "6.EBenefits")
 - Financial benefit: BDT 397,544 lakh per year is converted into Economic Benefit: BDT 345,699 lakh per year using the Conversion Factor for traded goods at 1.15.

Note: The sample model in this Handbook is only a template for CBA calculations, and is intended to show how to carry out a CBA step by step. As the actual values of the project assumptions and variables to be used for a particular project will vary from project to project, their estimated values must ultimately be obtained from project-specific data sources, such as the project's feasibility study.

Description of Power Transmission Project

1. Project Outline (Sheet “0.Contents”)

The project is designed to ensure uninterrupted and reliable power transmission for some economic zones in XXX Division and for XXX Hi-Tech City in XXX District and to meet the growing demand of electricity in the southern areas of XXX Division by constructing new substations and expansion of transmission facilities in the project area.

The following Table shows the planned outputs of the proposed project.

Outputs	Total
Construction of 230 kV GIS grid substation	2 Nos.
Construction of 132 kV GIS grid substations	2 Nos.
Construction of 230 kV transmission lines	113.88 Km
Construction of 132 kV transmission lines	66.55 km
Extensions of 230 kV GIS bay at the existing XXX substation	2 Nos.

2. Project duration (Sheet “1.Params_8.Sensitivity”)

The estimated construction period of the project is for 6 years. The project life is 30 years.

3. Project Cost (Sheet “2a.FCosts” and “2b.FCosts”)

Direct Cost 1: Investment Cost

The investment cost is the cost to deliver the outputs. The estimated total cost, as an investment of the project is Tk. 200,816 lakh. Here, physical contingency is Tk. 3,753 lakh and price contingency is Tk. 9,384 lakh.

Item	Description	Taka (Lakh)
(e) Revenue*		-
(f) Capital		187,679
(g) Physical Contingency**	2% of (b)	3,753
(h) Price Contingency**	5% of (a+b)	9,384
Total (a+b+c+d)		200,816

*To make the model simple, cost for Revenue is not counted.

** The parameter is set in sheet “1.Params_8.Sensitivity”.

Table below shows annual initial investment cost excluding the price contingency.

Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Total
8.6%	15.5%	25.7%	21.5%	18.2%	10.4%	100%
16,516	29,766	49,271	41,189	34,803	19,887	191,433

Direct Cost 2: Operation and maintenance cost

For the cost of operation and maintenance of the facilities developed by the proposed

project, this model assumes Tk. 496 lakh per annum as the annual operation and maintenance cost, which is taken from a similar type of the existing substation of the transmission company.

Indirect cost

No significant indirect costs of the project, such as negative environmental impacts, are expected.

4. Project Benefit (Sheet “1.Params_8.Sensitivity”)

This model considers the following consumer’s surplus and producer’s surplus as direct benefits shown in the Table below.

Category	Sub-category	Description
Consumer’s surplus	Incremental outputs	Additional output of electricity transmitted to new customers.
Consumer’s surplus	Non-incremental outputs	Output of electricity transmitted to existing customers that displaces unreliable services of electricity supply with more reliable ones.
Producer’s surplus		Increase in operational revenues

This model assumes that from the fourth year, electricity will be partially transmitted.

5. Assumptions and variables used in the model (Sheet “1.Params_8.Sensitivity)

To capture the costs and benefits described in sections 3 and 4 above, the model used the following assumptions and variables.

- General Information
 - This project is considering the Conversion Factor for traded goods at 1.15.
- Financial Benefit (Sheet “3.FBenefits”)
 - This project is targeting to increase the total Capacity about 1,398.63 MWA per hour.
 - Considering Load Factor is 90.0%, Gross Annual Energy (considering the Load Factor) is [Incremental Load Flow/Total Capacity to be Increased] x [Load Factor], which is 11,026.80 mil.kWh/year.
 - Considering Transmission Loss is 2.77%, Wheeled Energy/Additional Supply of Electricity to Meet Demand is [Gross Annual Energy (considering the Load Factor)] x [Transmission Loss], which is 10,721.36 mil.kWh/year.
- Considering Wheeling Charge is BDT 0.2791 per kWh, Revenues from Wheeling Charge is [Wheeled Energy/Additional Supply of Electricity to Meet Demand] x [Wheeling Charge], which is 29,923.31 Lakh BDT.

- Economic Benefit: Increment Outputs (Sheet “6.EBenefits”)
 - Percent of Electricity Transmitted to Residential and Commercial Customers is 61.82% and 39.18%, respectively.
 - Residential Consumer: Wheeled Energy/Additional Supply of Electricity to Meet Demand for Residential Consumer is [Wheeled Energy/Additional Supply of Electricity to Meet Demand] x [Percent of Electricity Transmitted to Residential Customers], which is 6,521 mil.kWh/year. Considering Average Sales Rate for Residential Consumers is BDT 7.49 per kWh, and Cost of Electricity Produced Privately for Residential is BDT 12.00 per kWh, the difference between them is BDT 4.51 per kWh. Annual Incremental Outputs for Residential Consumer is [Wheeled Energy/Additional Supply of Electricity to Meet Demand for Residential Consumer] x [the difference] x 0.5, which is 147,042 Lakh BDT.
 - Commercial Consumer: Wheeled Energy/Additional Supply of Electricity to Meet Demand for Commercial Consumer is [Wheeled Energy/Additional Supply of Electricity to Meet Demand] x [Percent of Electricity Transmitted to Commercial Customers], which is 4,201 mil.kWh/year. Considering Average Sales Rate for Commercial Consumers is BDT 9.80 per kWh, and Cost of Electricity Produced Privately for Commercial is BDT 12.00 per kWh, the difference between them is BDT 2.20 per kWh. Annual Incremental Outputs for Commercial Consumer is [Wheeled Energy/Additional Supply of Electricity to Meet Demand for Commercial Consumer] x [the difference] x 0.5, which is 46,207 Lakh BDT.
- Economic Benefit: Non-Incremental outputs (Sheet “6.EBenefits”)
 - The number of Existing Total Customers is 1,332,805. Assuming the Percent of Existing Total Customers who Benefit from Cost Savings is 1 % and the Average Cost Savings per Customer is 1,000 BDT per Year, Total Annual Cost Savings (Reliability Benefits) is [The number of Existing Total Customers] x [the Percent of Existing Total Customers who Benefit from Cost Savings] x [the Average Cost Savings per Customer], which is 133 Lakh BDT.
- Economic Benefit: Increase in operational revenues (Sheet “6.EBenefits”)
 - Financial benefit: 29,923 lakh BDT per year is converted into Economic Benefit: 26,020 lakh BDT per year using the Conversion Factor for traded goods at 1.15.

Note: The sample model in this Handbook is only a template for CBA calculations, and is intended to show how to carry out a CBA step by step. As the actual values of the project assumptions and variables to be used for a particular project will vary from project to project, their estimated values must ultimately be obtained from project-specific data sources, such as the project’s feasibility study.

Description of Rural Infrastructure Development Project

1. Project Outline (Sheet "0.Contents")

The objectives of the project are to enhance the economic activities and improve access to education and healthcare service for the of the people living in 100 square kilometer area of the project area by connecting the rural people with proposed road network, including improved growth centers/ markets/ ghat.

The following Table shows the planned outputs of the proposed project.

Outputs	Total
Construction of Union Road	50.50 km
Construction of Village Road	100.00 km
Rehabilitation of Village Road	150.00 km
Construction of Bridges/ Culverts	500 meters
Construction of Growth Center Market (GCM) construction	25 Nos.
Construction of Ghat	10 Nos.

2. Project duration (Sheet "1.Params_8.Sensitivity")

The estimated construction period of the project is for 5 years. The project life is 30 years.

3. Project Cost (Sheet "2a.FCosts" and "2b.FCosts")

Direct Cost 1: Investment Cost

The investment cost is the cost to deliver the outputs. The estimated total cost, as an investment of the project is BDT 5,188 lakh. Here, physical contingency is BDT 97 lakh and price contingency is BDT 242 lakh.

Item	Description	BDT (Lakh)
(i) Revenue*		-
(j) Capital		4,849
(k) Physical Contingency**	2% of (b)	97
(l) Price Contingency**	5% of (a+b)	242
Total (a+b+c+d)		5,188

*To make the model simple, cost for Revenue is not counted.

** The parameter is set in sheet "1.Params_8.Sensitivity".

Table below shows annual initial investment cost excluding the price contingency.

Year 1	Year 2	Year 3	Year 4	Year 5	Total
4%	10%	30%	45%	11%	100%
198	495	1,484	2,226	544	4,946

Direct Cost 2: Operation and maintenance cost

As the cost of operation and maintenance of the facilities developed by the proposed project, this model assumes that 2% of the total initial investment amount is required every year to maintain the road network and other facilities associated with the project. Thus, BDT 99 lakh per annum is taken as the annual operation and maintenance cost.

Indirect cost

The indirect costs in the form of a decrease in income/welfare loss/external cost are also expected for some segment of population.

4. Project Benefit (Sheet "1.Params_8.Sensitivity", "6.EBenefits")

This model considers the indirect benefits show in the Table below, because the model assumes that no consumer's surplus and producer's surplus can be calculated here as the project outputs are not transacted in markets. ^{14 15}

Category	Description
Commercial benefits	Agricultural and Micro, Small and Medium Enterprise (MSME) households will enjoy higher demands of their products and services owing to improved access to markets and distribution channels.
Educational benefits	For young citizens, who will get benefitted by not dropping out of school and finish high school education owing to improved and easy access to schools.
Health benefits	For the pregnant women, whose lives will be saved owing to improved access to maternal health services.

The proposed project used the following data and information for benefit calculation.

- General Information (Sheet "1.Params_8.Sensitivity", "6.EBenefits")
 - Nearly 35,000 people will be benefitted through this project. Average Household size for both project area and negatively affected area is 5.2. Thus, the number of households in the project areas is 6731.

¹⁴ Note that for non-revenue-generating projects, neither incremental outputs nor non-incremental outputs usually can be calculated, as the project outputs are not transacted in markets. In that case, project benefits must be measured either by estimating consumers' willingness to pay (WTP) for the project outputs (using stated or revealed preference methods) or by estimating the indirect impact of the project outputs on the economic welfare of the society (i.e., indirect benefits).

¹⁵ In case of road projects, travel time and cost saving is commonly used as economic benefit. To capture this benefit, surveys are often required. Some Rural Infrastructure Development Projects include not only road construction but also market construction and others, so counting only travel time and cost saving as economic benefit results may underestimate the results of economic analysis.

- Annual Population growth rate for both project area and negatively affected area is 1.37%
- Population in negatively affected area is 1300 people.
- Commercial benefits (Agriculture) (Sheet "6.EBenefits")
 - Approximately 45% of all households, or 3,029 households, are dependent on agricultural income.
 - Average monthly income for agricultural households is BDT 12,000 per month.
 - Total Annual Income for Agricultural Households is [The number of agricultural households] x [Average monthly income for agricultural households] X 12month, which is BDT 4,361.76 Lakh.
 - It is expected that because of improved condition, rural households engaged in agricultural activities will also see a rise of their income by 20% per year.
 - Increase in Total Annual Income for Agricultural Households is [Total Annual Income for Agricultural Households] X [Increase in Agricultural Income], which is BDT 933.70 Lakh in year 6, considering the Annual Population growth rate.
- Commercial benefits (MSME) (Sheet "6.EBenefits")
 - Approximately 7.5% of all households, or 505 households, are dependent on Micro, Small and Medium Enterprise (MSME) income.
 - Average monthly income for MSME households is BDT 25,000 per month.
 - Total Annual Income for MSME Households is [The number of MSME households] x [Average monthly income for MSME households] X 12month, which is BDT 1,515.00 Lakh.
 - It is expected that because of improved condition, rural households engaged in MSME will also see a rise of their income by 25% per year.
 - Increase in Total Annual Income for MSME Households is [Total Annual Income for Agricultural Households] X [Increase in MSME Income], which is BDT 405.00 Lakh in year 6, considering the Annual Population growth rate.
- Education Benefit (Sheet "6.EBenefits")
 - Nearly 20% of the population, or 7,000 persons are high school going and that 10% of them or 700 persons dropped out from education and among them 10% of student dropout will be reduced due to the intervention of the project.
 - Increase in Personal Income due to reduced High School Dropout is USD 209,000 for life, which is equivalent to BDT 195,923, by considering working life of a person: 35 years and using PPP exchange rate: BDT 32.81 per USD. (PPP exchange rate is used because a reasonably reliable estimate on personal income was available only in USD from a US study.)
 - Increase in Total Annual Income for Those Who Avoided Dropout is [Reduction in Student Dropouts] x [Increase in Personal Income due to Avoidance of

Dropout]. Assuming 20% of the program benefits materialized and considering the Annual Population growth rate, Increase in Total Annual Income for Those Who Avoided Dropout in year 6 is BDT 29.39 Lakh.

- Health Benefits
 - Percentage of Female Population in the project area is 50%, or 17,500 persons, and among them, Percentage of Female aged between 15 to 44 years is around 50% or 8,750 persons.
 - It is assumed that 8% of the female population of the project area, or 700 persons are experiencing complicated pregnancy cases per year. (or Women Giving Birth per year)
 - Maternal Mortality in the project area is considered 173 deaths per 100,000 births. Thus, maternal death in Year 1 is 1.
 - Due to better communication to health facilities, the project assumes that the maternal mortality will be dropped by 70% in the project area.
 - Total Statistical Value of Life in Bangladesh is BDT 1,909,355 per life, or BDT 54,553 per year, considering working life of a person: 35 years.
 - Total Value Obtained from Saving Maternal Lives is [Annual Statistical Value of Life in Bangladesh] × [Reduction in Maternal Deaths], which is BDT 0.55 lakh in year 6, considering the Annual Population growth rate.

The model refers to the following source of information to set the assumptions.

- Increase in personal income due to avoidance of dropout
(<https://academiccommons.columbia.edu/doi/10.7916/D8CF9QG9>)
- Purchasing power parity (PPP)
(<https://data.worldbank.org/indicator//PA.NUS.PPP?locations=BD>)
- Health cost saved due to delivery
(<https://onlinelibrary.wiley.com/doi/full/10.1111/mcn.13098>)

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