Integrating Risk into ADB’s Economic Analysis of Projects

Nigel Rayner
Anneli Lagman-Martin
Keith Ward

June 2002

Asian Development Bank
Integrating Risk into ADB's Economic Analysis of Projects

Nigel Rayner
Anneli Lagman-Martin
Keith Ward

June 2002

Nigel C. Rayner is a Principal Economist and Anneli S. Lagman-Martin is an Economics Analyst with the Economic Analysis and Operations Support Division, Asian Development Bank (ADB); Keith Ward is a staff consultant. The authors thank colleagues at ADB who provided helpful comments on earlier drafts of this paper and during consultations: Xianbin Yao, David Edwards, Stephen Curry, Manabu Fujimura, and Bo Lin.
Foreword

The ERD Technical Note Series deals with conceptual, analytical, or methodological issues relating to project/program economic analysis or statistical analysis. Papers in the Series are meant to enhance analytical rigor and quality in project/program preparation and economic evaluation, and improve statistical data and development indicators. ERD Technical Notes are prepared mainly, but not exclusively, by staff of the Economics and Research Department, their consultants, or resource persons primarily for internal use, but may be made available to interested external parties.
Contents

Abstract vii
Acronyms and Abbreviations ix

I. Introduction 1

II. Risk Analysis in ADB Operations 2
   A. Risk and the Guidelines for the Economic Analysis of Projects 2
   B. ADB Practice of Risk Analysis 3

III. Risk Analysis Techniques 5
   A. Definitions: Risk and Uncertainty 5
   B. Modeling Risk Qualitatively 5
   C. Modeling Risk Quantitatively 7
   D. Risk Analysis and Planning for the Poor 10

IV. Strengthening Risk Analysis of ADB Operations 10
   A. Introduction 10
   B. Appropriate Application of Available Techniques 11
   C. Key Principles to Apply in Risk Analysis 14
   D. Risk Analysis for Supporting Poverty Reduction Objectives 15
   E. Sectors and Projects: Some Typical Risk Analysis Situations 16
   F. Applying Risk Analysis Software 19

References 21
Abstract

Current practice suggests that project economic analysis can be strengthened through the use of quantitative risk analysis to investigate the effect on project outcomes of the expected range and distribution of values for key project parameters. The heightened focus on poverty reduction, which raises the profile of the poor’s vulnerability and exposure to risk, also suggests that poverty analysis can be improved through the use of risk-oriented techniques. The opportunity to improve practice in this area of project economic analysis is offered by the existence of dedicated and easy-to-use software packages for risk analysis.

The paper suggests that, as a general rule, the greater the extent to which risk can be identified and quantified within the scope of routine project economic analysis, the stronger will be overall project design and the lower likelihood of project failure. Also, the more comprehensively the objective circumstances and subjective attitudes of poor project participants can be taken into account in project planning, the greater chance of projects achieving their poverty reduction objectives.

To assist in better integrating risk analysis in project economic analysis, the paper provides a summary of key principles, ways in which risk analysis can be employed specifically to address poverty reduction objectives, and a summary of typical risk circumstances on a sector-by-sector basis. Practical guidance for applying typical risk analysis software is also provided.
Acronyms and Abbreviations

CDF  cumulative distribution function
EIRR  economic internal rate of return
ENPV  economic net present value
EOCC  economic opportunity cost of capital
FIRR  financial internal rate of return
FNPV  financial net present value
FOCC  financial opportunity cost of capital
PBL  policy-based lending
PPTA  project preparatory technical assistance
RRP  Report and Recommendation of the President
UK-DFID  Department for International Development (UK)
WB  World Bank
WTP  willingness-to-pay
I. Introduction

This paper provides guidance to project analysts on the increased integration of risk analysis within the economic analysis of investment operations of the Asian Development Bank (ADB).\(^1\)

ADB last reviewed its own practice (and also that of the World Bank [WB]) with respect to the application of risk analysis in 1985 (Johnson 1985). That paper provided a comprehensive and thorough review of literature and techniques available, but noted that quantitative risk analysis in any form had only been applied in one ADB project and two World Bank projects by that date. A recent review of several projects and programs across all sectors suggests that very little has changed in the practice of ADB and other agencies in dealing with the essentially unknown outcomes of projects.

More recent powerful critiques of project economic analysis practice (e.g., Harberger 1998) have suggested that insufficient account has been taken to date of key variables’ distributions of outcomes as being determinants of eventual project returns. A review of recent ADB postevaluation studies also suggests that many of those variables that appear to explain differences in project performance between the appraisal design and actual outcomes are ones that could (in both principle and practice) be subject to some sort of risk analysis. The existence of dedicated and easy-to-use software packages for risk analysis (usually applied as add-ins to spreadsheets) means that quantitative risk analysis can now quite easily be handled within existing typical project design and appraisal processing. In addition, it is also the case that ADB’s increased lending toward the poorest groups in society raises the profile of these clients’ vulnerability and exposure to risk in the analysis of ADB operations directed toward them. For all these reasons, another review of risk analysis experience and opportunity in the context of encouraging “better practice” in economic analysis of investments is therefore timely.

This paper summarizes existing ADB practice for dealing with unknown outcomes, and explains reasons for this situation (Section II). It then outlines some of the available techniques (both qualitative and quantitative) for dealing with risk (Section III), and suggests circumstances in which they may be applicable. Specifically, it is suggested that:

---

\(^1\) See ADB (2002) Handbook for Integrating Risk Analysis in the Economic Analysis of Projects for a fuller description of current risk analysis practice, more depth regarding the theory and use of various risk analysis techniques, and more detail regarding recommended applications (as well as detailed references and examples of applying risk analysis software to various ADB projects).
(i) the overall analysis of project economic benefits can be strengthened through consideration of the probabilities of particular outcomes; this can be achieved with relatively little additional effort by building on existing practice with the application of dedicated risk analysis software

(ii) there are ways in which poverty analysis in particular might be improved through the use of risk-oriented techniques

Section IV of the paper provides a summary of guidance for practitioners.

II. Risk Analysis in ADB Operations

A. Risk and the Guidelines for the Economic Analysis of Projects

ADB’s Guidelines for the Economic Analysis of Projects (1997) recommend the application of quantitative risk analysis techniques for situations where

(i) projects are very large (from a national point of view); or
(ii) marginal, i.e., where the economic internal rate of return (EIRR) may be just over 10 to 12 percent; or
(iii) where there is considerable uncertainty over the values for key variables.

Quantitative risk analysis is defined as consideration of a range of possible values for key variables (either singly or in combination), which then results in the derivation of a probability distribution of a project’s expected net present value (ENPV) or EIRR (i.e., as opposed to a single point value). The key point for analysts and planners to consider is the likelihood of a project’s ENPV falling below zero (at a 12 percent discount rate) or its EIRR falling below the economic opportunity cost of capital (EOCC). This information should be incorporated into the decision as to whether to accept or reject the project. However, no decision rules are offered in this regard.

There is no fixed criterion for using such a result (ADB 1997, 157), as it is implicitly recognized that actual choices among differentially risky projects will still depend upon particular levels of risk aversion being applied by different decision makers.

Risk analysis is presented in the Guidelines largely as an extension of sensitivity testing, and it is suggested that such analysis should be conducted where sensitivity testing has shown that project returns are highly dependent upon the values that might obtain for a particular variable. The data requirements to undertake some sort of risk analysis (i.e., to allow the construction of some sort of probability distribution) are mentioned, but not described in depth, nor is the use of particular types of software for such analysis.

One reason for the relative paucity of material on risk analysis in the Guidelines is that economic theory suggests (see, for example, Arrow and Lind 1970) that for governments undertaking many independent projects simultaneously, the consequences of risk on any one project can be ignored—risks will be “spread” across all members of society and “pooled” across the portfolio of all projects—and thus the government can be taken to be “risk neutral” as far as individual projects are concerned. However, to the extent that project lending may
tend to become concentrated on specific sections of society (i.e., particular groups—including the poorest in society, individual regions, etc.) the burden of risks becomes more concentrated within society and these general assumptions begin to break down.

B. ADB Practice of Risk Analysis

Given the recommendations in the Guidelines, it is not surprising that ADB’s experience with quantitative risk analysis has been very limited, with the notable exception of a few projects in the transport, agriculture, and power sectors. A review of recent Reports and Recommendation of the President (RRPs) covering all sectors of ADB project and policy lending operations suggest the following main points:

(i) The standard format of an RRP invariably includes a section (usually within the “Financial and Economic Analysis”, but sometimes presented separately and called Risks, Risks and Safeguards, Risks and Assurances, etc.) describing qualitatively the risks a project is expected to face; this text usually (but not always) includes descriptions of the measures that have already been incorporated to mitigate such risks.

(ii) Appendix 1 of the RRP is invariably the “Project Framework”, which identifies and summarizes the risks as previously discussed, and places them in the context of the project’s hierarchy of objectives; however, there is no separate discussion here of risks’ likelihood and seriousness.

(iii) The Financial and Economic Analysis section of an RRP usually argues that “conservative” or “pessimistic” estimates have been used for forecasts of (for example) shipping, road and rail traffic volumes, crop prices, yields and production, fisheries catches, etc., upon which benefits have been estimated. In addition, the fact that certain benefits are identified but not quantified and valued in EIRR calculations is often used to argue that the “base case” EIRR is “conservative” or “understates” real returns—there is thus a “cushion” that supports the likely acceptability of project returns.

(iv) The Financial and Economic Analysis section usually contains a fairly standardized approach to sensitivity testing, in which project aggregate base case costs and benefits streams are changed by 10 or 20 percent each and benefits are delayed by one or two years, and the effects of these on the project base case EIRR are considered (both in isolation and in combination with one another). Sensitivity indicators (SIs) and switching values (SVs) are calculated for key variables.

(v) The project is then usually described in terms of its “robustness”, i.e., in the worst case scenario (when costs changes are highest, benefits most reduced and/or delayed, etc.); its EIRR is still above 12 percent; and (sometimes) the statement is made that, given its ability to survive such adverse circumstances, the project faces no risk.
This format is remarkably similar across projects in all sectors, and the general nature of the practice is very similar to that of the World Bank. In the case of ADB program loans, qualitative discussions of risk are included in the text, and the policy matrix will usually contain a column describing actions planned, many of which deal with management of identified risks. While ADB’s practice in project and program analysis could be argued to be very strong (i.e., it recognizes that risks exist at different levels of objectives achievement, it tends to closely link identified specific risks with those mitigating measures that are already included in project or program design, and it routinely exploits sensitivity testing to demonstrate robustness), it could not be said to incorporate quantitative risk analysis practice in any form.

In particular, the heavy reliance in ADB practice on sensitivity testing to describe unknown outcomes has a number of problems. Firstly, and most fundamentally, it does not take into account the probability of the occurrence of the events it models (the switching values for crop yields may be a fall of 20 percent, or that for traffic flow may be 15,500 vehicles per day, but how likely is it that either or both these will occur in practice?). Secondly, where deviations from project “base case” estimates are modeled in sensitivity testing, it is not clear whether the variations in values being modeled are changes from “expected” values (i.e., the “base case” estimate of the value of the variable is its average value) or deviations from “most likely” (or modal) values. Depending upon the characteristics of particular distributions (in effect the extent of skewness in the data set) mean and modal values may be very different from one another, and what is thus being captured in the base case and its variation is not clear. Thirdly, the identification of appropriate groups of variables to vary together depends on specialist knowledge, and misunderstanding the nature and extent of correlation between variables can lead to erroneous results. Lastly, because the distribution characteristics of different variables that determine project outcomes can differ enormously (the variability in commodity prices is less than input prices for example, the variability in power demand is less than in generation, etc.), the use of standard percentages for variations (e.g., changes of +/– 10 percent or 20 percent are routinely applied for example) in sensitivity testing captures quite differential extents of likely variability; an impression of homogeneous variability is given, which is not warranted by reality.

The exception to ADB’s present standard of risk analysis occurs with the analysis of a few recent agriculture and power projects. In the cases of three power projects, discrete probability distributions containing between three and five possible values (based on project preparatory technical assistance or PPTA mission estimates) for five to six variables in each case (covering capital and other cost elements, commissioning delays, willingness-to-pay [WTP] estimates, foreign exchange, as well as aggregate financial costs and benefits) were used to run a Monte Carlo simulation (see below for description of this technique) that generated expected values for project EIRR, together with estimates of standard deviation (i.e., the square root of variance), minimum, and maximum values. A cumulative distribution function (CDF) was also plotted in each case, indicating the probability of negative or less than acceptable (i.e., below 10 to 12 percent) economic rates of return. Each simulation was run 3,000 times. The models also incorporated estimations of correlation between variables. This approach to risk analysis is
Integrating Risk into ADB's Economic Analysis of Projects

presently pioneering within ADB. Based on feedback from staff, it has been very useful during project design (typically at the fact-finding stage rather than at PPTA) to investigate concerns connected with one or two key variables (typically elements of input or output prices). The main effort in terms of additional work lies in selecting key variables, ensuring the extent of correlations between them is fully modeled, and in designing a "best guess" distribution for each variable. With familiarity of the sector and/or local conditions this exercise may be completed over the course of a few days during normal project preparation, and designing and running a simulation based on several thousand iterations will take only a few hours.

III. Risk Analysis Techniques

A. Definitions: Risk and Uncertainty

This section summarizes some of the main risk analysis techniques available for consideration, and highlights issues associated with their use. The term "risk and uncertainty" tends to be applied generically to the analysis of situations with unknown outcomes. This paper will follow the conventional distinction made in the literature (e.g., Pouliquen 1970, Reutlinger 1970) between them. In essence, risk is taken to be a quantity subject to empirical measurement, while uncertainty is of a nonquantifiable type. Thus in a risk situation it is possible to indicate the likelihood of the realized value of a variable falling within stated limits—typically described by the fluctuations around the average of a probability calculus.

On the other hand, in situations of uncertainty, the fluctuations of a variable are such that they cannot be described by a probability calculus.

Techniques for modeling uncertainty have ranged from game theoretic criteria (now largely abandoned as being "irrational" in various ways) to sensitivity testing, which is widely understood and applied, but whose limitations have already been mentioned in the context of the description of ADB practice. It may also be noted that it is sometimes suggested that uncertainty can be allowed by either applying a different discount rate in calculation of NPV or by using a higher cutoff rate (i.e., greater than 10 to 12 percent) for investment decisions. While there is a large theoretical literature on this point, in essence there is no justification for this approach—apart from any other consideration (e.g., in determining what an appropriate "risk premium" should be). It assumes that risk always increases with time, which is not necessarily true. The discount rate simply measures the decline in the numeraire of project economic worth and says nothing about risks faced by a project.

B. Modeling Risk Qualitatively

As well as the quantitative, probability-based techniques available for risk analysis, other techniques of an essentially qualitative nature can be applied by analysts to provide insight to risks faced by projects. While these techniques do not model risk as properly understood (i.e.,
in that they do not quantify risk), they can be used in the early stages of project analysis both to identify those sources of risk that may be subject to subsequent quantification and also to provide useful material for project design processes.

Current ADB practice of qualitative risk analysis is most notable in relation to social assessments (carried out at various stages of project preparation) and also in situations where a poverty impact ratio (PIR) is not calculated for a particular project because its benefits cannot be reasonably estimated. In such situations, qualitative risk consideration routinely focuses on such issues as, for example, the ability of the target population to cope with risk (e.g., based on socioeconomic status indicators); general societal risks (e.g., institutional, civil) that may compromise overall project success; and risks of benefit leakage to nonpoor groups. Similarly, in the case of policy-based lending (PBL), the use of a poverty impact assessment (PIA) matrix is employed to elicit the relationships and mechanisms between particular policy interventions and ultimate poverty impacts. (Policy-based lending is probably the most inherently uncertain of all lending types in that—while the “why” of the program is likely to be well-understood—the full range of “what” and “how” mechanisms in a sector are likely to be much less clear.)

One of the most useful qualitative risk analysis techniques (not apparently yet employed within ADB) is probably the “risk matrix” that locates each identified risk within a matrix whose dimensions are “probability of occurrence” and “seriousness of impact” (i.e., if the particular event does occur). Table 1 provides an example of a risk (or impact/probability) matrix from a recent UK-DFID project in People’s Republic of China: the numbers 1-10 refer to the 10 different sources of risk to the project, which were identified during preparation and discussed within the logical framework (which itself of course contains a column for the specification of risks and assumptions). The identified risks in this particular case comprised the following:

Risk 1: Inadequate long-term funding for poverty alleviation and environmental improvements by the provincial government in Yunnan
Risk 2: Inadequate state:provincial link
Risk 3: Higher political ranking for economic development rather than reduction of environmental degradation
Risk 4: Abnormal incidence of physical shocks, e.g., earthquakes
Risk 5: High staff turnover leading to skills dissipation
Risk 6: Insufficient priority to sustainable development and the Agenda 21 process from the Yunnan provincial government
Risk 7: Stifling institutional practices that limit the adoption of an integrated approach and subsequent coordination of activities
Risk 8: Insufficient counterpart funding leading to suboptimum choice of pilot projects
Risk 9: Greater priority to environmental benefits than to poverty reduction
Risk 10: Inadequate institutional support to proposed gender improvements
Table 1. Risk Matrix: Impact and Probability Analysis

<table>
<thead>
<tr>
<th>Probability</th>
<th>Impact</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Low</td>
</tr>
<tr>
<td>Low</td>
<td>4</td>
</tr>
<tr>
<td>Medium</td>
<td>8, 10</td>
</tr>
<tr>
<td>High</td>
<td></td>
</tr>
</tbody>
</table>

The format of a risk matrix is also useful for allocating risks among different project participants. Having systematically identified and categorized risks in this way, a further step (during project design and especially in negotiation with host governments and executing agencies) is to assign responsibility for different sorts of risks to different participants in a project. Thus, responsibility for construction costs may rest with a contractor; that for farmer adoption rates with an agricultural extension agency. By attributing different risks’ management clearly to particular participants, it becomes possible to design appropriate systems of rewards and penalties for performance. The format of a risk matrix can also be adapted to clearly separate those risks that are subject to control by management and those that are not.

C. Modeling Risk Quantitatively

Because of the conceptual shortcomings of all approaches to modeling uncertainty, and the limitations of simple qualitative categorization and description of risk, attempts are sometimes made in project economic analysis to more properly capture the impacts of unknown outcomes through modeling risk quantitatively.

While the Guidelines do not themselves provide a specific detailed methodology for the application of risk techniques, it is suggested in principle that the results of sensitivity testing be used to consider which variable(s) may be appropriate to base a risk analysis upon (i.e., those with major impacts on project outcomes). Having identified particular variables, it is necessary to specify a number of possible data points (i.e., values above and below the “base case”, upper and lower limits to data values, etc.), together with the frequency (or likelihood) of each of these values occurring. From such data points and associated frequency estimates, a probability distribution can be constructed for the variable(s) in question. The use of values for these key variables (i.e., those determining project outcomes) is to derive a cumulative distribution function for a project’s ENPV (or EIRR), such that the probability of negative ENPV (or EIRR<EOCC) being generated is explicitly identified.

Figure 1 shows such a chart. The probability of project ENPV being negative as a result of variability in underlying factors is thus clearly identified, and provides further information to decisionmakers as to the relative attractiveness of the project.

Quantitative risk analysis in practice typically involves the choice of several variables to be varied simultaneously, as project returns are generally subject to more than one source of
risk. The procedure is usually referred to as simulation, being based either on either “Monte Carlo” or some other type of sampling. It involves random generation of values for individual variables according to their respective probability of occurrence, combined with other randomly generated values for the other variables under review, and these figures collectively used to calculate an estimate of the project NPV. This process is repeated a large number of times (usually at least 1,000 times, and typically more than this; the number is specified by the analyst and in effect is equivalent to implementing the project again and again in different circumstances). An average (or “expected”) ENPV is produced together with an associated probability distribution. The analysis of risk in this form is invariably undertaken by some kind of computer software, and various specialized packages now exist to address such tasks. However, despite the recent overcoming of computational constraints to the application of such techniques, two major practical considerations remain regarding the extent to which such techniques can reasonably be used in project preparation situations.

First is the issue of data availability, and the degree to which a situation can reasonably be defined as risk (as opposed to uncertain) through the construction of a meaningful probability distribution of outcomes. The actual situation with data availability is likely to vary enormously both between project situations and also across different sources of variability within any one project environment. At one extreme, large volumes of reliable cross-sectional or time series data may be available from historical sources for the variable concerned (e.g., for rainfall, for commodity prices, for traffic flows). At the other extreme are a few data points (e.g., “most likely” values, absolute minimum possible, maximum possible, etc.), which are the expectations of experts/analysts involved in preparing the project. Other possibilities lying within these bounds include the forecasting or specification of power-generation theoretical capabilities adjusted for a set of likely different operating conditions, forecasts of trade flows and commodity prices (e.g., based on World Bank publications taking into account world supply and demand factors), etc. Risk analysis software typically has capabilities to fit probability distributions of different types to raw data sets supplied by the analyst. Such routines will fit distribu-
tions to data and also provide a measure of the “goodness” of the particular resulting fit. Experience from a few actual ADB projects and from case studies (as presented in the Handbook) clearly suggest that meaningful results can be obtained with the use of very simple distributions (e.g., triangular, including a “most likely” value, a minimum value, and a maximum value) applied to only a handful of key variables.

Second is the extent of covariance between those variables that are to be selected for risk analysis. Statistical complexities can arise depending upon the relationships between the selected variables. Where variables are in fact statistically independent of one another there is no problem, as it is appropriate to treat them independently. Where variables may be related in some way, however, the extent of covariance between them needs to be taken account of when specifying the distribution of individual variables in some type of simulation. Failure to take appropriate account of covariance can lead to erroneous estimates of outcomes. Again, typical risk analysis software will allow the easy construction of risk matrices to specify the extent of correlation. Because of the need to ensure proper handling of data in the development of variables’ distributions within a project risk analysis model, a number of principles to be followed in this regard are suggested later (in Section IV).

The result of quantitative risk analysis as described is to identify projects (or alternative designs of the same project) that now have two essential characteristics—i.e., their economic return (as measured by their expected ENPV, EIRR, etc.); and their degree of risk (as measured by their variability in general—captured by the distribution’s measures of dispersion, such as variance and coefficient of variation, and also by the probability of the return falling below some unacceptable level in particular). This quantitative measure of risk adds to the information available to the decisionmaker, although in itself does not necessarily provide any guide as to whether any individual project is acceptable or as to which project among several possible ones actually should be undertaken.

In some cases, the expected higher returns of project A as compared to project B (or alternative designs of the same project) have to be weighed against the increased degree of risk of the project. How should a decision be made between the alternative designs/projects? As mentioned, the traditional view taken toward public sector investment was that governments with large project portfolios could afford to ignore the riskiness of investments as long as the expected values were acceptable—i.e., they could afford to be “risk-neutral”. This is because, with a large number of investments spread across all of society, the costs of any individual project failures could be absorbed within the portfolio as a whole. Exceptions to this view were very large projects, or projects somehow correlated with national circumstances (such that good performance of the project in bad years for the economy as a whole were worth more in terms of a disproportionate contribution to national income); or particular affected groups (e.g., in one region, one type of student, etc.) such that the impact on particular individuals could not be ignored. In fact, there is no answer to the question of project choice in such circumstances without reference to knowledge about the extent of decisionmakers’ risk-aversion (i.e., the rate at which they are prepared to trade off levels of expected income against levels of variability of outcomes). This issue becomes particularly important when planning for the poor.
D. Risk Analysis and Planning for the Poor

Poverty is usually associated with vulnerability to external shocks, cultural factors, and trends. In addition, any situation (e.g., a proposed project) involving the possibility of uncertain and/or negative outcomes for the poor is potentially disastrous for them—even if it would not necessarily be so for less poor populations. For example, for the poor in natural resource-based situations who have less financial reserves to cope with bad seasons, the consequences of failure may actually be catastrophic (e.g., property or soil loss through flooding) and/or nonreversible (e.g., loss of land to debt). For these sorts of reasons, the poor are usually considered to be more risk-averse than most sections of society. Although estimating welfare functions has proved very difficult in practice, empirical studies have tended to demonstrate that individuals generally become very risk-averse indeed when considering outcomes involving sums of money they are not used to dealing with, and/or when the possibilities for losses are involved (i.e., they are said to exhibit a “focus of loss”).

These considerations imply that, when considering investments affecting poor people, quantitative risk analysis can most usefully show how likely it is that financial and/or economic returns may be very low or negative (i.e., FNPV or ENPV < 0, FIRR < F0CC or EIRR < EOCC) for particular groups affected by the project—typically the poor (e.g., farmers, processors, traders) who are its target population. However, it remains the case that making decisions about whether or not it is appropriate to accept or impose such risks necessarily involves some knowledge about risk aversion among the project target population.

What emerges from consideration of the sorts of qualitative analysis of risk encapsulated in the techniques currently employed by ADB (e.g., in social assessments, PIAs, etc.) is that project target population/beneficiaries’ situations and views are being quite thoroughly canvassed, but more could perhaps be done to explicitly document the extent of risk aversion among such groups, as an input to planning for them (and in situations requiring choosing among various design alternatives). In other words, as well as “objective” data that may be available from other sources upon which to estimate expected values and their variance for key variables affecting project outcomes (including private incomes), it should be possible for project planners to gather (in the application of quite intensive and participatory data-gathering exercises) some “subjective” information about how those expected to benefit from project or policy interventions may view choices among such options. Accordingly, an approach to risk analysis combining both objective and subjective approaches is outlined in Section IV.

IV. Strengthening Risk Analysis of ADB Operations

A. Introduction

This section provides practical guidance on applying analysis of risk to ADB projects. It begins with an overview of available techniques, followed by a summary of key principles to follow (from identifying key variables to consider as sources of risk, through developing ap-
Integrating Risk into ADB’s Economic Analysis of Projects

appropriate distributions and determining correlation between variables, to interpreting results of a risk analysis). Ways in which risk analysis can be employed specifically to address poverty reduction objectives are considered, and then a summary of typical risk circumstances (likely analytical concerns, key variables, data issues, etc.) on a sector-by-sector basis is provided. The section concludes with some guidance for applying typical risk analysis software (e.g., @RISK).

B. Appropriate Application of Available Techniques

What is fundamentally suggested in this paper is that, as a general rule, the greater the extent to which risk can be identified and quantified within the scope of routine project economic analysis, the stronger will be overall project design (assuming mitigating measures are put in place once the scale and impacts of known risk are clear) and the lower the likelihood of project failure (in the sense of EIRR<EOCC). Also, the more comprehensively the objective circumstances and subjective attitudes of poor project participants are taken account in project planning, the greater the chance of projects achieving poverty reduction objectives. As a specific operational corollary of these points, there is a greater chance of quantitative risk analysis becoming more understood and acceptable by ADB project analysts through the much wider use of dedicated commercial software used as add-ons to existing spreadsheet packages.

A pragmatic approach to the use of risk analysis is warranted. Each project is unique, and the sources of uncertainty and risk it faces will be similarly unique to its own individual circumstances, and the extent to which risk can be quantitatively dealt with will also vary. It would not be appropriate to advocate hard and fast guidelines about application of particular risk analysis techniques to certain sorts of projects. Nevertheless, similar types of projects are likely to face similar analytical issues and similar types of risk analysis techniques will therefore be appropriate to use across a number of project types.

Tables 2a and 2b summarize the major approaches to risk analysis, outlining their main features, the type and form of results that come from such analyses, the circumstances in which their application may be likely, and also some possible constraints to their application. The tables classify the techniques according to whether they are essentially qualitative or quantitative in nature. What is apparent from the tables is that there are a number of techniques for dealing with risk in project design and analysis. They range from:

(i) simple risk identification (and linking these risks with specific mitigating measures),
(ii) subjective quantification of likelihood of event occurrence and seriousness of impact in that event,
(iii) description of the nature of exposure to risk on the part of project participants and some estimation of their attitudes toward risk in particular circumstances, and
(iv) probabilistic-based estimates of project returns depending on the behavior of key variables (such estimates may derive from more or less sophisticated and data-intensive techniques).
## Table 2a. Qualitative Risk Analysis Techniques

<table>
<thead>
<tr>
<th>Type of Risk Analysis Technique</th>
<th>Main Features</th>
<th>Likely Applications</th>
<th>Possible Constraints/Limitations</th>
</tr>
</thead>
<tbody>
<tr>
<td>Logical Framework “Risks and Assumptions” Elaboration</td>
<td>Expansion of consideration of risks within existing ADB Project Framework</td>
<td>Textual summary of how each risk may prevent achievement of objectives at different levels of the project’s objective hierarchy. Each identified risk is described in more detail than before and linked to at least one specific mitigation measure</td>
<td>Any project for which the Project Framework is completed</td>
</tr>
<tr>
<td>Risk Matrix Construction (and “Risk Annex” Preparation)</td>
<td>Construction of 3x3 (or more) cell matrix showing approximate probability of risk occurrence (high, medium, low) against seriousness of impact (high, medium, low) Allocation of risks among different project participants</td>
<td>Risk Matrix, with individual risks numbered and discussed (along with identified mitigating measures) in a separate “Risk Annex” to the RRP Demonstration that “killer” risks have been dealt with (i.e., that most likely / most serious is not a “killer”) Responsibilities and rewards for managing different sorts of risks assigned to those agents best able to deal with them</td>
<td>Any project Particularly applicable to those involving physical constructions</td>
</tr>
<tr>
<td>Poverty and Risk Vulnerability Assessment</td>
<td>Assessment of the nature and extent of target group’s exposure to risk (catastrophic or not, controllable at micro level or not, reversible or not, insurable or not, etc.)</td>
<td>Part of the Initial Social Assessment prior to PPTA, particularly the social and economic assessment during PPTA; should show how proposed project will contribute to risk exposure reduction Part of (modified) Poverty Impact Assessment Matrix in PBL</td>
<td>Any project, but especially Poverty Intervention ones PBL</td>
</tr>
</tbody>
</table>
### Table 2b. Quantitative Risk Analysis Techniques

<table>
<thead>
<tr>
<th>Type of Risk Analysis Technique</th>
<th>Main Features</th>
<th>Type and Form of Results</th>
<th>Likely Applications</th>
<th>Possible Constraints/ Limitations</th>
</tr>
</thead>
<tbody>
<tr>
<td>Risk Aversion/ “Focus of Loss” Estimation</td>
<td>Quantification of extent of target group’s attitude to risk (especially any risk or risk reduction implied by the proposed project) and especially toward possible losses of incomes</td>
<td>Application of (for example) interview-based ELCE (equally-likely certain equivalent) technique to derive estimate of risk aversion over typical income levels of those affected by proposed project intervention</td>
<td>New technology being introduced, especially where it is desirable to estimate likely attitudes to uptake of new but risky technologies (e.g., in agriculture) and negative outcomes</td>
<td>Relatively demanding in terms of consultant/staff and interviewee time</td>
</tr>
<tr>
<td>Simplified Probabilistic Analysis (Harberger, ADB power, WB Mexico irrigation examples)</td>
<td>Indicates likelihood of project EIRR/ ENPV being acceptable, based on consideration of key variables as determinants of project performance</td>
<td>Estimate of expected EIRR/ ENPV, plus CDF of project EIRR/ ENPV, with measures of variance, minimum/maximum values</td>
<td>Any project, where key variables can be identified and simplified, and probability distributions constructed</td>
<td>Results will only be as good as the distributions are realistic; statistical complexities with co-variance; availability of software (@RISK, RISKMASTER, etc.)</td>
</tr>
<tr>
<td>Spreadsheet-based Applications (e.g., Clarke and Low)</td>
<td>Use of standard spreadsheet functions (to generate random numbers and counts of observations of key variables) to produce distribution of project outcomes</td>
<td>Estimate of expected EIRR/ ENPV, plus CDF of project EIRR/ ENPV, with measures of variance, minimum/maximum values</td>
<td>No inherent advantages; likely to be used only in situations where risk analysis software is unavailable</td>
<td>Fairly extensive familiarity with EXCEL or LOTUS required; developing nonuniform distributions by writing formulae is complex</td>
</tr>
<tr>
<td>“Monte Carlo” Simulation with Continuous Distributions</td>
<td>Classic risk analysis technique based on continuous distributions for key variables</td>
<td>Estimate of expected EIRR/ ENPV, plus CDF of project EIRR/ ENPV, with measures of variance, minimum/maximum values</td>
<td>Where historical / cross-sectional data exist for key variables such that continuous distributions can be fitted</td>
<td>Demanding in terms of data and staff time; experience may suggest that results add little to analysis over and above use of simplified distributions</td>
</tr>
</tbody>
</table>
These risk analysis techniques are of course likely to be applicable in different circumstances. The suggested elaboration of risk analysis within the existing Project Framework and the construction of a risk matrix could be applied in any project situation, while the use of continuous probability distributions based on historical observations will probably remain relatively rare (for data intensity reasons, if not software ones), for example. It is also important to note that the use of the individual techniques is not mutually exclusive. For example, the risk matrix technique can identify those risks that are considered most serious and/or likely to occur so that they can then be further investigated through quantitative techniques. It is also of course the case that such variables can be identified after sensitivity testing techniques have been applied.

C. Key Principles to Apply in Risk Analysis

Table 3 suggests some principles that can be applied to risk analysis for the purpose of overall project design, specifically in relation to the estimation of a project’s overall economic benefits. They are applicable from the very earliest stages of project design to the making of a final investment decision.

Table 3. Principles in Applying Risk Analysis in Project Design

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Identify any risk facing the proposed project as soon as possible (i.e., pre-PPTA); include description of expected risks in first draft of the Project Framework</td>
</tr>
<tr>
<td>2</td>
<td>Construct “Risk Matrix” for proposed project, ranking risks according to their relative likelihood of occurrence and their expected scale of impact</td>
</tr>
<tr>
<td>3</td>
<td>Identify “key” variables (e.g., quantities, unit costs, output mixtures, output prices, uptake/adoption rates, price and income elasticities of demand, etc.), which are sources of risk and determinants of project returns</td>
</tr>
<tr>
<td>4</td>
<td>Decide which of these variables may be subject to quantitative description</td>
</tr>
<tr>
<td>5</td>
<td>Identify data sources for each variable (i.e., “objective” historical or forecasts, “subjective best guesses”, expert-Delphi, etc.)</td>
</tr>
<tr>
<td>6</td>
<td>Construct probability distributions of key variables</td>
</tr>
<tr>
<td>7</td>
<td>Perform simplified probabilistic analysis (e.g., using @RISK, RISKMASTER, etc.) to generate CDF of expected EIRR/ENPV, minimum/maximum expected values, etc.</td>
</tr>
<tr>
<td>8</td>
<td>Consider whether the derivation of distributions from primary/empirical sources is justified; if so, derive such distributions and perform probability-based analysis using them</td>
</tr>
<tr>
<td>9</td>
<td>On the basis of results from 7 and 8, decide whether risk of EIRR&lt;EOCC or ENPV&lt;0 is “acceptable”</td>
</tr>
<tr>
<td>10</td>
<td>If extent of risk is regarded as “acceptable”, re-design may not be necessary (but check individual distributions to see if any high values are “pulling up” the expected value of the distribution—i.e., see if positive skewness is occurring causing average values to be substantially higher than the most likely values)</td>
</tr>
<tr>
<td>11</td>
<td>If extent of risk is regarded as “not acceptable”, possible re-design may be necessary (in particular, to see what can be done about any low values in distributions, to investigate any negative skewness, and to truncate distribution)</td>
</tr>
</tbody>
</table>
Because of possible statistical issues arising when developing distributions for key variables from raw historical, forecast, or subjective data, Table 4 suggests some principles to apply in such circumstances.

Table 4. Principles to Apply in Data Handling for Probabilistic Risk Analysis

1. Identify those variables for which future values are unknown and which are likely to affect project returns (i.e., the key variables)
2. Explain fully the general nature of the data set used for modeling the values (its origin—i.e., from objective or subjective sources, whether it is based on historical observations or projections, the number of observations the data set contains, its extent of completeness/any missing data points, etc.)
3. If the data derives from subjective sources, explain the method by which it was elicited (e.g., from visual techniques, from subjective questioning, from an expert-based Delphic process, etc.)
4. Explain the statistical nature of those variables’ assigned probability distributions (i.e., whether they are triangular, uniform, normal, logarithmic, exponential, etc.)
5. Clarify the goodness of fit of the distribution (if one has been fitted using @RISK or similar software)
6. Make explicit any correlation considered to exist between variables used in the risk analysis (i.e., its extent and the technical, real-world basis for the assumption, etc.)
7. Explain and justify the extent of any variable disaggregation

In addition to modeling the technical variables that explain a project’s performance, there may also be doubt about the values used in estimating the project’s economic costs and benefits (i.e., the derivation of specific conversion factors such as the shadow wage rate factor, or general conversion factors such as the standard conversion factor or shadow exchange rate factor). Sometimes such factors are included within existing sensitivity testing exercises, but there is of course no reason why they could not more routinely be subject to a simplified probabilistic analysis. In such circumstances, the derivation and treatment of probability distributions is identical to that for technical variables.

D. Risk Analysis for Supporting Poverty Reduction Objectives

In addition to more fully considering the likely distribution of overall economic benefits, it has been suggested that risk analysis could be useful in ensuring that poverty reduction objectives were better targeted. This involves not only considering the distribution of financial and economic outcomes at individual, household, farm, etc., level—in a way identical to describing project economic benefits and enterprise/financial institution profitability—but also considering what the target groups’ attitudes toward risk are, given the context of their vulnerability. Table 5 therefore summarizes how these various techniques can be employed to support poverty reduction. It can be seen that they attempt to merge project participants’ subjective circumstance and attitudes to risk with typical probability-based risk descriptions. In addition,
distribution analysis (i.e., analysis of benefits by groups participating in the project) can also be approached in terms of risk analysis.

Again, the primary focus of this type of poverty analysis is not as an add-on to eventual project description, but should be used as early as possible in project preparation so that redesign can take place to more closely pursue ADB’s poverty reduction objectives.

Table 5. Application of Risk Techniques for Poverty Analysis

<table>
<thead>
<tr>
<th>Step</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Describe textually the nature and extent of vulnerability. This can be approached in terms of consequences of loss (catastrophic or not), reversibility, and ability of households to exercise control, possibilities for insurance, etc., as part of Initial Social Assessments and Poverty Impact Assessment Matrix (in PBL).</td>
</tr>
<tr>
<td>2</td>
<td>Estimate risk aversion/focus of loss for participants. Estimate quantitatively to the extent possible participants’ attitude to risks at different income levels; in particular, investigate “focus of loss” for project situations (e.g., where new technology is being introduced) where possible very low or negative outcomes may have to be considered. These estimates can be derived through interview-based techniques offering participants choices between specific but certain outcomes on one hand, compared to higher but risky outcomes on the other.</td>
</tr>
<tr>
<td>3</td>
<td>Estimate income/welfare impacts at individual/household/farm level. Estimate the distribution of individual, household, or farm incomes (based on probabilistic analysis of output quantities and prices, etc.), with focus on the likelihood that returns may be negative or unacceptable. (This analysis should include possibilities that “benefits leakage” will occur.)</td>
</tr>
<tr>
<td>4</td>
<td>Calculate distribution of poverty impact ratio (PIR). Based on the calculation of financial and economic benefits and their distribution between groups, the PIR can be calculated and so can its distribution (as long as its estimation is directly linked within the same spreadsheet as the rest of the project economic analysis). A consideration of the likelihood that the project PIR may be below an acceptable level (i.e., in relation to the proportion of the share of the poor in total population) should be provided.</td>
</tr>
<tr>
<td>5</td>
<td>Justify the imposition/acceptance of any particular level of risk. On the basis of steps 1-4, justify the project design in terms of its level of risk implied for the project. This is likely to differ across project situations; for example, a 25 percent chance of negative returns for farmers on an irrigation scheme may be acceptable if their resource base is relatively stable, but would perhaps be unacceptable to impose upon very poor communities in degraded watersheds.</td>
</tr>
</tbody>
</table>

E. Sectors and Projects: Some Typical Risk Analysis Situations

Any proposed ADB project may be able to show, for example, how its expected EIRR/ENPV has a particular probability of being acceptable (i.e., EIRR>E0CC, ENPV>0) depending upon values for certain key variables, or that its expected cost-effectiveness is similarly dependent on unknown but probabilistically described outcomes. It is also the case that projects will share similar overall concerns to ensure financial, environmental, and institutional sustainability, and so the kinds of approaches to risk analysis already suggested above to address such
issues could equally apply to water supply, transport, power, or agriculture projects. The treatment of similar sorts of variables (e.g., capital costs) across many projects is also likely to be broadly similar.

However, each project design will encompass different sets of variables, many of whose actual outcomes will be unknown. The analysis of risk in a project can be as unique as each individual proposed project itself. What may be left for consideration, therefore, are fairly typical “technical” issues as they occur across different sectors and as are frequently faced by analysts. Table 6 attempts to indicate some of these typical project economic analysis technical concerns on a sector-by-sector/ project type basis, and to indicate how risk analysis could be applied in considering some key variables for such projects. The table is not exhaustive in its content; it is meant to be indicative and general only.

Table 6. Project Types and Some Possible Risk Analysis Considerations

<table>
<thead>
<tr>
<th>Sector / Project Type</th>
<th>Examples of Likely Analytical Concerns</th>
<th>Potential Key Variables To Investigate</th>
<th>Possible Variable and Data Characteristics</th>
</tr>
</thead>
<tbody>
<tr>
<td>Agriculture: Plantation/ Estate</td>
<td>Realized tree crop yields and production; factory/ mill throughput; future prices as determinants of farmers' and/or estates incomes</td>
<td>Price projections; tree crop yield estimates, machinery operating capacity/ efficiency</td>
<td>Use of WB commodity price projections for exports; more “subjective” estimates for locally consumed items; yield estimates for new crops may be based only on research trials and need some adjustment; machinery estimates based on design characteristics plus subjective experience</td>
</tr>
<tr>
<td>Agriculture: Irrigation</td>
<td>Scheme maintenance; realized new and existing crop yields; crop prices; adoption/uptake rates; household and farm incomes</td>
<td>Operating/water supply costs; yields and prices (as above); willingness-to-pay estimates for water demand; adoption/uptake of new varieties</td>
<td>Cost estimates derived from similar schemes; WTP estimates from interviews with target groups and extent of doubt about this can be derived at same time; adoption rates can be modeled with triangular distribution as a minimum</td>
</tr>
<tr>
<td>Forestry</td>
<td>Volume of harvestable wood in 7-20 years time, and price of output (e.g., pulp/wood) at that point</td>
<td>Wood and by-product yields/losses to theft/ harvest efficiency, etc., as determinants of production in future periods</td>
<td>Considerable doubt about point estimates of volumes and prices when wood is harvested a long time in the future; current real prices plus considerable variation should be considered</td>
</tr>
<tr>
<td>Fisheries</td>
<td>Impact of new culture technologies from aquaculture; future stocks and landings from capture; fish prices; determinants of fishermen's incomes</td>
<td>Harvest yields and fish stocks; commodity price projections and local variety</td>
<td>Data on yields from new technologies may be from research only—possibly exclude extreme values; fish stocks well modeled but sometimes highly mobile; price estimates may be based on comprehensive data for commodities (e.g., for tuna) or guesses for local varieties</td>
</tr>
</tbody>
</table>
Table 6. continued.

<table>
<thead>
<tr>
<th>Sector / Project Type</th>
<th>Examples of Likely Analytical Concerns</th>
<th>Potential Key Variables To Investigate</th>
<th>Possible Variable and Data Characteristics</th>
</tr>
</thead>
<tbody>
<tr>
<td>Environment and Natural Resources: Various</td>
<td>Extent of identification, quantification, and valuation of indirect, nonuse, and option impacts of total economic value (TEV)</td>
<td>Quantities of particular biophysical impacts; alternative methodologies for benefit estimation</td>
<td>Knowledge of the extent of physical impacts may be reasonably well known, but estimates of impacts’ economic value can vary widely based on both primary and secondary techniques—consider wide range of possible values</td>
</tr>
<tr>
<td>Transport: Rural Roads</td>
<td>Construction costs in difficult or unknown environment, traffic composition mixtures, extent of generated traffic and vehicle operating cost (VOC) savings</td>
<td>Construction cost estimates; traffic volumes by types of vehicles; VOCs</td>
<td>Construction costs likely to be reasonably well known from similar projects in the same country; traffic forecasts modeled with several scenarios and associated probabilities; VOCs less well known but triangular distribution as a minimum</td>
</tr>
<tr>
<td>Transport: Highway/Toll Roads</td>
<td>Construction costs, price elasticity of demand for new road use; currency depreciation for loan repayment and sustainability of road authority</td>
<td>Contractor's/analysts' estimates allow for several states of costs; price elasticity of demand for road use; foreign exchange projections</td>
<td>Construction costs likely to be reasonably well known from similar projects in the same country; WTP demand estimates and foreign exchange projections can be modeled with simplified probability distributions</td>
</tr>
<tr>
<td>Transport: Railways and Ports/Shipping</td>
<td>Future passenger and/or freight volumes; extent of maintenance, operating costs</td>
<td>Costs estimates; passenger and freight forecasts</td>
<td>Costs based on simplified distribution estimate; forecasts of traffic demands can be modeled continuously if necessary</td>
</tr>
<tr>
<td>Energy: Rural Electrification</td>
<td>Operating costs; consumer price elasticity of demand</td>
<td>Capital and operating costs; consumers' demand schedules</td>
<td>Costs based on simplified distribution estimate; distribution of WTP estimates can be derived at the same time as averages</td>
</tr>
<tr>
<td>Energy: Power Generation/Transmission</td>
<td>Costs of inputs; poor maintenance of equipment; consumer demands for power</td>
<td>Costs of equipment; input prices; operating efficiency; consumer demands</td>
<td>All subject to simplified probability distribution analysis (e.g., ADB/WB power)</td>
</tr>
</tbody>
</table>
Table 6. continued.

<table>
<thead>
<tr>
<th>Sector / Project Type</th>
<th>Examples of Likely Analytical Concerns</th>
<th>Potential Key Variables To Investigate</th>
<th>Possible Variable and Data Characteristics</th>
</tr>
</thead>
<tbody>
<tr>
<td>Urban: Water Supply and Sanitation/Wastewater/Solid Waste etc.</td>
<td>Construction costs; value to consumers; willingness of authorities to pursue policy reforms (e.g., charges for service provision)</td>
<td>WTP estimates; probability of success of implementing institutional reforms</td>
<td>Distribution of WTP estimates can be derived at the same time as averages/point estimates; quantitative institutional reform analysis may be considered</td>
</tr>
<tr>
<td>Health: Primary Care</td>
<td>Service uptake rates; extent of cost recovery from rural poor; benefit estimation methodology (if applied in EIRR calculation)</td>
<td>Use of services and consumer demand/ability to pay; estimated WTP</td>
<td>Economic values, for example, DALY (disability-adjusted life year), may be contentious</td>
</tr>
<tr>
<td>Education: Secondary and Postsecondary</td>
<td>Nature of beneficiaries’ ultimate employment and the income differentials arising from such employment</td>
<td>Employment rates; income differentials</td>
<td>Can be extensively modeled with continuous distributions if necessary</td>
</tr>
<tr>
<td>Education: Teacher Training</td>
<td>Numbers ultimately failing to find or accept work as teachers after training</td>
<td>Policies such as school construction/funding programs; on-going institutional changes; employment rates</td>
<td>Institutional aspects can potentially be investigated quantitatively; modeling of employment through discrete or continuous distributions</td>
</tr>
</tbody>
</table>

F. Applying Risk Analysis Software

The more routine undertaking of quantitative risk analysis depends upon the successful application of dedicated software for this purpose. ADB has evaluated various commercially-available packages and concluded that @RISK is most generally appropriate for major analytic purposes. This section therefore considers some points for practitioners in its application.

(i) The use of @RISK is extremely simple and user-friendly. It can be applied to any existing spreadsheet, and primarily involves the substitution of point values in cells by user-specified distributions (in input cells). This results in output cells (e.g., EIRR or ENPV estimates) with distributions generated for each, which can then be represented and analyzed both numerically and graphically.

(ii) The usual considerations of designing spreadsheets with as many individual variables specified separately therefore apply, and make the application of @RISK quite possible for any or all variables affecting project outcomes.

(iii) There is a wide range of distribution types (more than 30—e.g., triangular, normal, Pareto, binary, lognormal, etc.) to choose from, and users can specify central tendency, dispersion, and cut-off characteristics where appropriate. All specified distributions can be represented graphically.

(iv) Distributions of various forms can easily be fitted from existing historical or time-series data, and several alternative and complementary measures of goodness of fit are provided (e.g., Chi-square, Kolmogorov-Smirnov, Anderson-Darling statistics).
(v) Users can specify estimated covariance between variables in the form of an easy to use correlation matrix.

(vi) Typically, several thousand simulations can be processed in minutes using @RISK on a fairly standard personal computer.

(vii) Alternative sampling methods for these simulations can be used, including standard Monte Carlo random sampling and stratified Latin Hypercube sampling techniques.

(viii) The typical time taken to apply @RISK in this manner is very short—typically a couple of hours for the tasks specified above, once some form of spreadsheet model for EIRR/PIR estimation has been set up.

(ix) For most practitioners, the major issue involved in applying @RISK (or any such product) will be in correctly specifying distributions for existing or forecast data and determining appropriate extents of covariance among variables such that results for EIRR/ENPV distributions will be meaningful. While it is easy to quickly generate attractive and precise outputs from such software, the general adage applied to the use of powerful computer programs of “rubbish in, rubbish out” still applies.

(x) @RISK will most typically be applied to demonstrate the probability that the project EIRR and/or ENPV will be unacceptable. However, it can also be used to directly generate distributions for measures of distribution and poverty impact (i.e., the poverty impact ratio or PIR), if such calculations are in cells (that @RISK will designate as outputs), which are dependent upon variables for which distributions have been substituted for point values. For this reason, it is good practice in project economic analysis to ensure that the PIR calculation (where undertaken) is seamlessly linked to the spreadsheet containing the EIRR/ENPV calculations.

(xi) For projects expected to be very large, marginal, or particularly uncertain (e.g., perhaps because they are new sorts of lending, involve several countries, involve new technologies, etc.), the analysis of risk can be expected to figure larger than in other situations. For this reason, requirements for analysis of risk should be identified prior to PPTA and included in the PPTA scope of work. The use of a dedicated risk analysis package such as @RISK should be specified, in the same way that (for example) COSTAB is specified for financial cost estimation.

(xii) Because @RISK is so easy to use, it should be applied very early in project design, specifically to investigate which variables are key determinants of project outcomes and which describe how such variables’ distributions may be collected.

(xiii) Undertaking some form of risk-based analysis in the early stages of project design and presenting risk analysis results in a PPTA report would probably average less than a few days’ work for an economist and/or other staff.
As experience with the application of @RISK within ADB accumulates, a number of issues may be expected to emerge. Firstly, any extended application of quantitative (i.e., probability-based) risk analysis will require expansion of most project analysts’ statistical skills if errors in the interpretation of results (i.e., following application of typical risk analysis software) are to be avoided. This means that some form of essentially technical/statistical support needs to be made available within ADB upon which project analysts can draw as needed.

Secondly, in such a context, it may be useful to develop some “typical” project-based or sector-based models of anticipated statistical issues (e.g., that have something to do with expected correlations between typical determinant variables) or expected distribution characteristics for particular variables. It may also be possible to develop models for expected distributions of cost items across sectors (increasing evidence suggests that capital cost estimates for projects across a range of sectors may be lognormally distributed, for example).

References


ADB, 2000a. Draft Report and Recommendation of the President to the Board of Directors on a Proposed Loan to the Philippines for the proposed Transmission Interconnection Project. Manila.


PUBLICATIONS FROM THE ECONOMICS AND RESEARCH DEPARTMENT

ERD TECHNICAL NOTE SERIES (TNS)
(Published in-house; Available through ADB Office of External Relations; Free of Charge)

No. 1 Contingency Calculations for Environmental Impacts with Unknown Monetary Values
—David Dole
February 2002

No. 2 Integrating Risk into ADB’s Economic Analysis of Projects
—Nigel Rayner, Anneli Lagman-Martin, and Keith Ward
June 2002

ERD WORKING PAPER SERIES (WPS)
(Published in-house; Available through ADB Office of External Relations; Free of Charge)

No. 1 Capitalizing on Globalization
—Barry Eichengreen, January 2002

No. 2 Policy-based Lending and Poverty Reduction: An Overview of Processes, Assessment and Options
—Richard Bolt and Manabu Fujimura
January 2002

No. 3 The Automotive Supply Chain: Global Trends and Asian Perspectives
—Francisco Veloso and Rajiv Kumar
January 2002

No. 4 International Competitiveness of Asian Firms: An Analytical Framework
—Rajiv Kumar and Doren Chadee
February 2002

No. 5 The International Competitiveness of Asian Economies in the Apparel Commodity Chain
—Gary Gereffi
February 2002

No. 6 Monetary and Financial Cooperation in East Asia—the Chiang Mai Initiative and Beyond
—Pradumna B. Rana
February 2002

No. 7 Probing Beneath Cross-national Averages: Poverty, Inequality, and Growth in the Philippines
—Arsenio M. Balisacan and Ernesto M. Pernia
March 2002

No. 8 Poverty, Growth, and Inequality in Thailand
—Anil B. Deolalikar
April 2002

No. 9 Microfinance in Northeast Thailand: Who Benefits and How Much?
—Brett E. Coleman
April 2002

No. 10 Poverty Reduction and the Role of Institutions in Developing Asia
—Anil B. Deolalikar, Alex B. Brilliantes, Jr., Raghav Gaiha, Ernesto M. Pernia, Mary Racelis with the assistance of Marita Concepcion Castro-Guevara, Liza L. Lim, Pilipinas F. Quising
May 2002

No. 11 The European Social Model: Lessons for Developing Countries
—Assar Lindbeck
May 2002

No. 12 Costs and Benefits of a Common Currency for ASEAN
—Srinivasa Madhur
May 2002

No. 13 Monetary Cooperation in East Asia: A Survey
—Raul Fabella
May 2002

No. 14 Toward A Political Economy Approach to Policy-based Lending
—George Abonyi
May 2002

No. 15 A Framework for Establishing Priorities in a Country Poverty Reduction Strategy
—Ron Duncan and Steve Pollard
June 2002
No. 1 ASEAN and the Asian Development Bank
—Seiji Naya, April 1982

No. 2 Development Issues for the Developing East and Southeast Asian Countries and International Cooperation
—Seiji Naya and Graham Abbott, April 1982

No. 3 Aid, Savings, and Growth in the Asian Region
—J. Malcolm Dowling and Ulrich Hiemenz, April 1982

No. 4 Development-oriented Foreign Investment and the Role of ADB
—Kiyoshi Kojima, April 1982

No. 5 The Multilateral Development Banks and the International Economy's Missing Public Sector
—John Lewis, June 1982

No. 6 Notes on External Debt of DMCs
—Evelyn Go, July 1982

No. 7 Grant Element in Bank Loans
—Dal Hyun Kim, July 1982

No. 8 Shadow Exchange Rates and Standard Conversion Factors in Project Evaluation
—Peter Warr, September 1982

No. 9 Small and Medium-Scale Manufacturing Establishments in ASEAN Countries: Perspectives and Policy Issues
—Mathias Bruch and Ulrich Hiemenz, January 1983

No. 10 A Note on the Third Ministerial Meeting of GATT
—Jungsoo Lee, January 1983

No. 11 Macroeconomic Forecasts for the Republic of China, Hong Kong, and Republic of Korea
—J. Malcolm Dowling, January 1983

No. 12 ASEAN: Economic Situation and Prospects
—Seiji Naya, March 1983

No. 13 The Future Prospects for the Developing Countries of Asia
—Seiji Naya, March 1983

No. 14 Energy and Structural Change in the Asia-Pacific Region, Summary of the Thirteenth Pacific Trade and Development Conference
—Seiji Naya, March 1983

No. 15 A Survey of Empirical Studies on Demand for Electricity with Special Emphasis on Price Elasticity of Demand
—Wisarn Pupphavesa, June 1983

No. 16 Determinants of Paddy Production in Indonesia: 1972-1981—A Simultaneous Equation Model Approach
—T.K. Jyaraman, June 1983

No. 17 The Philippine Economy: Economic Forecasts for 1983 and 1984
—J. Malcolm Dowling, E. Go, and C.N. Castillo, June 1983

No. 18 Economic Forecast for Indonesia

No. 19 Relative External Debt Situation of Asian Developing Countries: An Application of Ranking Method
—Jungsoo Lee, June 1983

No. 20 New Evidence on Yields, Fertilizer Application, and Prices in Asian Rice Production
—William James and Teresa Ramirez, July 1983

No. 21 Inflationary Effects of Exchange Rate Changes in Nine Asian LDCs
—Pradumna B. Rana and J. Malcolm Dowling, December 1983

No. 22 Effects of External Shocks on the Balance of Payments, Policy Responses, and Debt Problems of Asian Developing Countries
—Seiji Naya, December 1983

No. 23 Changing Trade Patterns and Policy Issues: The Prospects for East and Southeast Asian Developing Countries
—Seiji Naya and Ulrich Hiemenz, February 1984

No. 24 Small-Scale Industries in Asian Economic Development: Problems and Prospects
—Seiji Naya, February 1984

No. 25 A Study on the External Debt Indicators Applying Logit Analysis
—Jungsoo Lee and Clarita Barretto, February 1984

No. 26 Alternatives to Institutional Credit Programs in the Agricultural Sector of Low-Income Countries
—Jennifer Sour, March 1984

No. 27 Economic Scene in Asia and Its Special Features
—Kedar N. Kohli, November 1984

No. 28 The Effect of Terms of Trade Changes on the Balance of Payments and Real National Income of Asian Developing Countries
—Jungsoo Lee and Lutgardia Labios, January 1985

—Yoshihiro Iwasaki, February 1985

No. 30 Sources of Balance of Payments Problem in the 1970s: The Asian Experience
—Pradumna Rana, February 1985

No. 31 India’s Manufactured Exports: An Analysis of Supply Sectors
—Ifzal Ali, February 1985

No. 32 Meeting Basic Human Needs in Asian Developing Countries
—Jungsoo Lee and Emma Banaria, March 1985

No. 33 The Impact of Foreign Capital Inflow on Investment and Economic Growth in Developing Asia
—Evelyn Go, May 1985

No. 34 The Climate for Energy Development in the Pacific and Asian Region: Priorities and Perspectives
—V.V. Desai, April 1986

No. 35 Impact of Appreciation of the Yen on Developing Member Countries of the Bank
—Jungsoo Lee, Pradumna Rana, and Ifzal Ali, May 1986

No. 36 Smuggling and Domestic Economic Policies in Developing Countries
—A.H.M.N. Chowdhury, October 1986

No. 37 Public Investment Criteria: Economic Internal Rate of Return and Equalizing Discount Rate
—Ifzal Ali, November 1986

No. 38 Review of the Theory of Neoclassical Political Economy: An Application to Trade Policies
—M.G. Quibria, December 1986

No. 39 Factors Influencing the Choice of Location: Local and Foreign Firms in the Philippines
—E.M. Pernia and A.N. Herrin, February 1987

No. 40 A Demographic Perspective on Developing Asia and Its Relevance to the Bank
—E.M. Pernia, May 1987

No. 41 Emerging Issues in Asia and Social Cost Benefit Analysis
—I. Ali, September 1988
### STATISTICAL REPORT SERIES (SR)

| No. 1 | Estimates of the Total External Debt of the Developing Member Countries of ADB: 1981-1983 |
| No. 2 | Multivariate Statistical and Graphical Classification Techniques Applied to the Problem of Grouping Countries |
| No. 3 | Gross National Product (GNP) Measurement Issues in South Pacific Developing Member Countries of ADB |
| No. 4 | Estimates of Comparable Savings in Selected DMCs |
| No. 5 | Keeping Sample Survey Design and Analysis Simple |
| No. 6 | External Debt Situation in Asian Developing Countries |
| No. 7 | Study of GNP Measurement Issues in the South Pacific Developing Member Countries. Part II: Factors Affecting Intercountry Comparability of Per Capita GNP |
| No. 8 | Survey of the External Debt Situation in Asian Developing Countries, 1985 |
| No. 9 | A Survey of the External Debt Situation in Asian and Pacific Developing Countries: 1987-1988 |
| No. 10 | A Survey of the External Debt Situation in Asian and Pacific Developing Countries, 1989-1992 |
| No. 11 | A Survey of the External Debt Situation in Asian and Pacific Developing Countries: 1988-1989 |
| No. 12 | A Survey of the External Debt Situation in Asian Developing Countries: 1989-1992 |
| No. 14 | A Survey of the External Debt Situation in Asian and Pacific Developing Countries: 1988-1989 |
| No. 15 | A Survey of the External Debt Situation in Asian Developing Countries: 1989-1992 |
| No. 16 | Recent Trends and Prospects of External Debt Situation and Financial Flows to Asian and Pacific Developing Countries |
| No. 17 | Purchasing Power Parity in Asian Developing Countries: A Co-Integration Test |
| No. 18 | Capital Flows to Asian and Pacific Developing Countries: Recent Trends and Future Prospects |

### OCCASIONAL PAPERS (OP)

| No. 1 | Poverty in the People's Republic of China: Recent Developments and Scope for Bank Assistance |
| No. 2 | The Eastern Islands of Indonesia: An Overview of Development Needs and Potential |
| No. 3 | Rural Institutional Finance in Bangladesh and Nepal: Review and Agenda for Reforms |
| No. 4 | Fiscal Deficits and Current Account Imbalances of the South Pacific Countries: A Case Study of Vanuatu |
| No. 5 | Reforms in the Transitional Economies of Asia |
| No. 6 | Environmental Challenges in the People's Republic of China and Scope for Bank Assistance |
| No. 7 | Sustainable Development Environment and Poverty Nexus |
| No. 8 | Intermediate Services and Economic Development: The Malaysian Example |
| No. 9 | Interest Rate Deregulation: A Brief Survey |
| No. 10 | Some Aspects of Land Administration in Indonesia: Implications for Bank Operations |
| No. 11 | Demographic and Socioeconomic Determinants of Contraceptive Use among Urban Women in the Melanesian Countries in the South Pacific: A Case Study of Port Vila Town in Vanuatu |
| No. 12 | Managing Development through Institution Building |
| No. 13 | Growth, Structural Change, and Optimal Poverty Interventions |
| No. 14 | Private Investment and Macroeconomic Environment in the South Pacific Island Countries: A Cross-Country Analysis |
| No. 15 | The Rural-Urban Transition in Viet Nam: Some Selected Issues |
| No. 16 | A New Approach to Setting the Future Transport Agenda |
| No. 17 | Adjustment and Distribution: The Indian Experience |
| No. 18 | Tax Reforms in Viet Nam: A Selective Analysis |
| No. 19 | Surges and Volatility of Private Capital Flows to Asian Developing Countries: Implications for Multilateral Development Banks |
| No. 20 | The Millennium Round and the Asian Economies: An Introduction |
| No. 21 | Information Technology: Next Locomotive of Growth? |

---

27
SPECIAL STUDIES, COMPLIMENTARY (SSC)
(Published in-house; Available through ADB Office of External Relations; Free of Charge)

1. Improving Domestic Resource Mobilization Through Financial Development: Overview September 1985
5. Financing Public Sector Development Expenditure in Selected Countries: Overview January 1988
7. Financing Public Sector Development Expenditure in Selected Countries: Bangladesh June 1988
8. Financing Public Sector Development Expenditure in Selected Countries: India June 1988
11. Financing Public Sector Development Expenditure in Selected Countries: Pakistan June 1988
12. Financing Public Sector Development Expenditure in Selected Countries: Philippines June 1988
13. Financing Public Sector Development Expenditure in Selected Countries: Thailand June 1988
17. Foreign Trade Barriers and Export Growth September 1988
18. The Role of Small and Medium-Scale Industries in the Industrial Development of the Philippines April 1989
19. The Role of Small and Medium-Scale Manufacturing Industries in Industrial Development: The Experience of Selected Asian Countries January 1990
23. Export Finance: Some Asian Examples September 1990
27. Guidelines for the Economic Analysis of Projects February 1997
28. Investing in Asia 1997

SPECIAL STUDIES, ADB (SS, ADB)
(Published in-house; Available commercially through ADB Office of External Relations)

1. Rural Poverty in Developing Asia
   Edited by M.G. Quibria
   Vol. 1: Bangladesh, India, and Sri Lanka, 1994 $35.00 (paperback)
   Vol. 2: Indonesia, Republic of Korea, Philippines, and Thailand, 1996 $35.00 (paperback)
2. External Shocks and Policy Adjustments: Lessons from the Gulf Crisis
   Edited by Naved Hamid and Shahid N. Zahid, 1995 $15.00 (paperback)
3. Gender Indicators of Developing Asian and Pacific Countries
   Asian Development Bank, 1993 $25.00 (paperback)
   Edited by Ernesto Pernia, 1994 $20.00 (paperback)
5. Indonesia-Malaysia-Thailand Growth Triangle: Theory to Practice
   Edited by Myo Thant and Min Tang, 1996 $15.00 (paperback)
6. Emerging Asia: Changes and Challenges
   Asian Development Bank, 1997 $30.00 (paperback)
7. Asian Exports
   Edited by Dilip Das, 1999 $35.00 (paperback)
   $55.00 (hardbound)
8. Mortage-Backed Securities Markets in Asia
   Edited by S.Ghon Rhee & Yutaka Shimomoto, 1999 $35.00 (paperback)
9. Corporate Governance and Finance in East Asia:
   A Study of Indonesia, Republic of Korea, Malaysia, Philippines and Thailand
   Vol. 1, 2000 $10.00 (paperback)
   Vol. 2, 2001 $15.00 (paperback)
10. Financial Management and Governance Issues
    Asian Development Bank, 2000
    Cambodia $10.00 (paperback)
    People's Republic of China $10.00 (paperback)
    Mongolia $10.00 (paperback)
    Pakistan $10.00 (paperback)
    Papua New Guinea $10.00 (paperback)
    Uzbekistan $10.00 (paperback)
    Viet Nam $10.00 (paperback)
    Selected Developing Member Countries $10.00 (paperback)
11. Guidelines for the Economic Analysis of Projects
    Asian Development Bank, 1997 $10.00 (paperback)
    Asian Development Bank, 1999 $15.00 (hardbound)
    Asian Development Bank, 2000 $10.00 (paperback)
1. Informal Finance: Some Findings from Asia
   Prabhu Ghate et. al., 1992
   $15.00 (paperback)
2. Mongolia: A Centrally Planned Economy in Transition
   Asian Development Bank, 1992
   $15.00 (paperback)
3. Rural Poverty in Asia, Priority Issues and Policy Options
   Edited by M.G. Quibria, 1994
   $25.00 (paperback)
4. Growth Triangles in Asia: A New Approach to Regional Economic Cooperation
   Edited by Myo Thant, Min Tang, and Hiroshi Kakazu
   1st ed., 1994 $36.00 (hardbound)
   Revised ed., 1998 $55.00 (hardbound)
5. Urban Poverty in Asia: A Survey of Critical Issues
   Edited by Ernesto Pernia, 1994
   $18.00 (paperback)
   Edited by M.G. Quibria, 1995
   $15.00 (paperback)
   $36.00 (hardbound)
7. From Centrally Planned to Market Economies: The Asian Approach
   Edited by Pradumna B. Rana and Naved Hamid, 1995
   Vol. 1: Overview $36.00 (hardbound)
   Vol. 2: People's Republic of China and Mongolia $50.00 (hardbound)
8. Financial Sector Development in Asia
   Edited by Shahid N. Zahid, 1995
   $50.00 (hardbound)
9. Financial Sector Development in Asia: Country Studies
   Edited by Shahid N. Zahid, 1995
   $55.00 (hardbound)
    Christine P.W. Wong, Christopher Heady, and Wing T. Woo, 1995
    $15.00 (paperback)
    Edited by M.G. Quibria and J. Malcolm Dowling, 1996
    $50.00 (hardbound)
12. The Bangladesh Economy in Transition
    Edited by M.G. Quibria, 1997
    $20.00 (hardbound)
13. The Global Trading System and Developing Asia
    Edited by Arvind Panagariya, M.G. Quibria, and Narhari Rao, 1997
    $55.00 (hardbound)
14. Rising to the Challenge in Asia: A Study of Financial Markets
    Asian Development Bank, 1999
    Vol. 1 $20.00 (paperback)
    Vol. 2 $15.00 (paperback)
    Vol. 3 $25.00 (paperback)
    Vols. 4-12 $20.00 (paperback)

SERIALS
(Co-published with Oxford University Press; Available commercially through Oxford University Press Offices, Associated Companies, and Agents)
1. Asian Development Outlook (ADO; annual)
   $36.00 (paperback)
2. Key Indicators of Developing Asian and Pacific Countries (KI; annual)
   $35.00 (paperback)

JOURNAL
(Published in-house; Available commercially through ADB Office of External Relations)
1. Asian Development Review (ADR; semiannual)
   $5.00 per issue; $8.00 per year (2 issues)