1 Introduction and Background

Introduction

The purpose of this Handbook is to support the development of a practical and operationally relevant methodological framework for the analysis of risk in project design and project economic analysis.

The Handbook is divided into five parts. Following a brief introduction, including a summary of the reasons why risk analysis may be undertaken, Part II outlines the available technical approaches to modeling risk within conventional project economic analysis. The classic distinction between "risk" and "uncertainty" is explained, and then some typical techniques for dealing with uncertainty are outlined. This is followed by a summary of the nature and practice of sensitivity analysis in dealing with uncertain outcomes, as it is applied by, for example, the Asian Development Bank (ADB) and the World Bank (WB). Techniques for modeling risk on the basis of probability distributions are then described. This leads inevitably to questions of how to make choices among different risky investment possibilities (i.e., different projects or alternative designs of similar projects) that may have been identified through the application of such techniques. It will be noted that while there was quite a large academic literature on risk analysis in the 1970s (following the publication of the classic texts on project economic analysis in the 1960s and 1970s), there have been relatively few theoretical developments in recent years.

Part III reviews the practical experience of ADB and other major agencies with regard to the analysis of risk in project design. Some 50 ADB projects (across all sectors and from a number of countries over recent years), and a number of World Bank projects where risk analysis of different sorts has been applied (including some which are suggested to be representative of "good practice" in this regard) are reviewed. Consideration is also given to the practices of risk analysis by several other bilateral agencies, most notably the Department for International Development (DFID) of the United Kingdom (UK), and also to the UK Treasury in the application of the private finance initiative (PFI) in project design.

Part IV considers the implications for risk analysis of ADB's increasing emphasis on distribution and poverty impact analysis. As a guiding principle, it is suggested that increased lending to particular groups in society (notably the poor) now provides an imperative to extend the incorporation of risk analysis in project economic analysis. This is not only because targeting the poorest may be inherently more uncertain than reaching other groups, but also because the risks of project failure are more concentrated within society, and that the consequences of project failure can be more extreme to those at or below poverty lines. It is argued that practical applications of more rigorous risk analysis (i.e., by better incorporating planners' and project participants' awareness and perceptions of, and attitudes to, risk in project design) during investment preparation can strengthen projects as well as policy-based lending. This is expected to lead to better project selection in both cases—by both better identifying and quantifying sources of variability and by choosing project designs which meet poor peoples' aspirations and more closely fit their circumstances.

Finally, Part V provides practical guidance on how to apply different types of risk analysis in different situations, based on existing techniques and given the emerging nature of ADB's operations. Different sorts of lending are considered in relation to real-world situations with respect to data availability, time and resource implications, etc. Some practical guidance with applying software packages like the '@RISK' is provided.

Various supplementary materials are contained in the Appendixes, including brief case studies of computer-based risk analysis applied to recent ADB projects. The case studies are designed to highlight major features and key technical points—extending the original project materials in a demonstration context rather than necessarily a project-specific one.

Background

Johnson (1985) reviewed ADB's practice (and also that of the World Bank) with respect to the application of risk analysis. This paper provided a comprehensive and thorough review of literature and techniques available, but noted that risk analysis in any form had only been applied in one ADB project (a port project) and two World Bank projects (a port project and a fertilizer plant project) by that date. It may be relevant to note that this was despite the fact that major writers on the advocated techniques—e.g., Reutlinger, Pouliquen—were either World Bank staff, or were published by that institution).

The paper discussed the difficulties in obtaining reliable data in many circumstances (such that variables could be adequately described by different sorts of probability distributions), highlighted the statistical complexity of the techniques (particularly as regards dealing with covariance among variables), and noted the demands in staff and computer resources (mainframe, at that time) for undertaking risk analysis. There was also an inference that a spurious precision may appear to be attributed to results arising from risk analysis which was in reality based only on analysts' "best guesses" for variables' distributions rather than historical evidence. Also, an apparent methodological rigor in the appraisal process (as implied by a full-scale risk analysis) might actually obscure the search for radical project or policy alternatives.

Of the reviewed ADB and World Bank projects in the 1985 paper, it was also striking to note that the causes of differences between expectations (i.e., the modeling of the situation *ex ante*) and outcomes (i.e., the review of the situation *ex post*) had not been especially well-captured by the scope of the specific risk analyses which had been employed. The review also quite correctly pointed out that even where risk analysis was undertaken, in itself it did not provide a basis for choice among competing acceptable projects [i.e., among projects with net present value (NPV) > 0 at 12% discount rate] unless something was known about a society's social welfare function and extent of risk aversion—which in practice is still not likely to be available to analysts and planners today.

In conclusion, the paper recommended an extremely pragmatic approach to the use of risk analysis, suggesting that only certain sorts of situations were likely to be suitable for application of probability-based techniques. Practical applications of risk analysis in ADB project work did not appear to change significantly after the preparation of the review.

ADB's *Guidelines for the Economic Analysis of Projects* (1997)—hereafter the *Guidelines*—built upon the contents of the earlier review, and recommended the application of quantitative risk analysis techniques for situations where

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

Quantitative risk analysis involves 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 economic 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% 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." (*Guidelines*, Appendix 21, page 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 which may 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.

The *Guidelines for the Financial Governance and Management of Investment Projects Financed by the Asian Development Bank* (hereafter, *Financial Guidelines*) also take a very similar approach to analysis of unknown financial outcomes. The analysis is seen largely in terms of sensitivity testing, and the advocated techniques are such that standard changes (e.g., +/- 10% or 20% for values of critical financial cost and benefit items, delays in implementation of one or two years, etc.) are measured in terms of their effects on estimates of financial internal rate of return (FIRR), financial net present value (FNPV), etc., and sensitivity indicators (SI) and switching values (SV) calculated for each variable tested. In almost identical format to the *Guidelines* (i.e., for economic analysis), the *Financial Guidelines* mention the possibility of quantitative risk analysis and describe circumstances in which it may be appropriate (i.e., for large, marginal or very uncertain projects), but provide no description of particular techniques.

Where the *Financial Guidelines* do differ from the *Guidelines* in their analysis of risk, however, is in their analysis of financial institutions (FIs) which may participate in ADB investment projects. When assessing FI performance, a range of standard accounting and financial measures is used, which includes indicators designed to assess risk. The *Financial Guidelines* therefore describes and advocates the use of risk measures such as credit at risk, value at risk (VaR), foreign exchange risk, maturity risk, and contagion risk. These are conceptually probability-based, although the actual data upon which they are calculated may come from entirely objective sources (e.g., historical data series) or can result from largely subjective assessments [e.g., of project preparatory technical assistance (PPTA) consultants, ADB staff] depending upon individual country and project circumstances. In addition to these financial measures, some development agencies (e.g., the French Development Agency - AFD) use systems of indicators (covering management practices, monitoring and evaluation systems, compliance with regulations, etc.) to assess exposure to risk of FIs as a result of endogenous rather than exogenous factors. Although these measures are available to project designers, actual practice suggests that use is not made of them as much as might be expected (they are typically considered in larger, 'financial sector' operations, rather than for smaller projects – e.g., for agriculture banks, microcredit/credit unions, etc.). It will be suggested later that their selective extension and wider application to other typical sorts of project institutions (e.g., executing agencies in transport, power, water and sanitation projects, etc.) may assist with ensuring greater sustainability of project effects (as the ultimate realization of economic benefits often depends upon the operating performance of such institutions).

One reason for the relative paucity of material on risk analysis in the *Guidelines* (and *Financial Guidelines*) is that economic theory suggests 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. The original conceptual basis for this argument was established in a classic article by Arrow and Lind (1970). 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, certain sectors, etc.) the burden of risks becomes more concentrated within society and these general assumptions begin to break down.

As will be described in Part III of the Handbook, actual applications of risk analysis in ADB operations have remained relatively limited since 1985, and have been concentrated in certain sectors, notably power. One reason for this situation has undoubtedly been difficulties for staff and consultants with obtaining reliable data about key variables, and also having easily available computer software capable of fitting probability distributions (e.g., normal, uniform, log-normal, binomial, beta, exponential, etc.) to data sets and generating expected values (e.g., for project ENPVs, EIRRs, etc., and also for absolute values in the context of cost-effectiveness analysis) with associated measures of variance.

While the fundamental issues concerning data (and the extent to which situations can be described as "risky" as opposed to simply "uncertain") remain and are germane to individual project situations, considerable advances in computer software in recent years mean that (where data are available) risk analysis can now be undertaken extremely easily as an "add-in" to existing, predominantly spreadsheet-based, financial and economic analysis at any stage of project preparation. Some forms of risk analysis can also be undertaken within existing spreadsheet software (e.g., Lotus, Excel)—not even requiring any add-ins.

A survey of commercially available risk modeling software (Mariano 2001) concluded that [among several competing packages, including 'Crystal Ball, 'RiskEase' (updated version of 'RiskMaster'), @RISK] the @RISK package (Professional Edition, and an add-in to Microsoft Excel) was highly suitable for

- undertaking "Monte Carlo" based simulations to derive probability distributions of outcomes (including of project EIRRs/ENPVs)
- fitting distributions to data sets (using advanced algorithms), and
- viewing graphically the distributions of variables and outcomes.

The implication is therefore that the tools for at least some types of risk analysis are now potentially widely available (and indeed one software package for dealing with risk in this way, i.e., "Risk Master" has already been applied within ADB). The question remains as to how and in what circumstances such tools may be advocated as appropriate to be applied much more widely.

Why Undertake Risk Analysis?

Before considering in some detail the various techniques available for risk analysis, it may be worth reviewing exactly what the purpose of applying any such techniques really is.

Much of the discussion in project economic analysis texts and in academic literature concentrates on the outputs of quantitative risk analysis (i.e., 'expected' EIRRs/ENPVs plus associated measures of variance) as being useful for making choices between different investment projects (i.e., projects with higher expected returns but more variability of returns may be compared to less attractive but more stable opportunities). Following on from this, it is demonstrated that understanding a decision-maker's (i.e., planners, policy-makers, society) subjective attitude towards risk—how higher expected returns are traded off against increased variability—enables consistent choices to be made across a portfolio of public sector investments.

In practice, however, ADB is typically not concerned with making choices among a number of mutually-exclusive, competing projects but is more usually engaged in reviewing projects one-by-one. For this reason the analysis of risk through the techniques described below is practically of most use in

- identifying those factors (e.g., quantities, prices, rates of adoption and usage) which are the key determinants of project outcomes
- determining the likelihood of an individual project's returns being unacceptable (i.e., EIRR<EOCC, ENPV<0) because of the effects of the identified key risk factors, and
- designing measures within that project environment and its sector context to mitigate the identified risks arising from the identified key factors.

The emphasis and presentation of any form of risk analysis in project economic analysis observed in practice is thus usually on demonstrating that risks to individual project success have already been identified and mitigated as far as possible within the proposed project design, and that the extent of any remaining risk is both quantified (i.e., known) and its existence is regarded as 'acceptable' (i.e., to ADB, borrowing government, project beneficiaries, etc.) given the nature of the particular intervention proposed. The risk analysis techniques are thus essentially used to complement sensitivity testing in demonstrating project robustness.

It is also the case that comprehensive analysis of project risks helps in designing projects so that different parties (e.g., borrowing government, operating entity, private operators) can share and manage risks appropriately. In general, the principle to be followed is that the parties who can best manage different sorts of risks to projects (e.g., construction costs, operating costs, defaults, delays, etc.) should be allowed to reap the rewards or bear the costs of risk management. Where project environments include a private sector participant (e.g., in running a toll road, building a hospital), appropriate consideration of all risk types enables them to be shared among the participants; this type of analysis has been particularly well-developed within the UK Treasury PFI methodology.

Therefore, although risk analysis (of whatever particular form) may typically appear at the end of an economic analysis in a typical Report and Recommendation of the President (RRP), it should be noted that, from ADB's perspective, risk analysis is fundamentally a project design tool. It is not simply an afterthought to economic analysis.