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Strengthening Risk Analysis in ADB Operations

Introduction

This Part of the Handbook provides some practical guidance on how to strengthen the analysis of risk in ADB operations, based on the technical material and discussion contained in Parts I to IV. Its format is primarily designed to be of use to practitioners of economic and financial analysis of all types of projects financed by ADB. (Much of the material in this Part of the Handbook is separately presented in ERD Technical Note No. 2 on *Integrating Risk into ADB's Economic Analysis of Projects* (2002).

The first section briefly summarizes the key features of the various possible techniques for risk analysis, both qualitative and quantitative.

The next sections show how strengthened analysis of risk through applying such techniques could potentially contribute to various ADB operational objectives. These are taken to be

- firstly, risk mitigation in the broadest sense (i.e., the strengthened design of individual projects such that the probability of their having an EIRR<EOCC or ENPV<0 is minimized)
- secondly, contributing to a more specific focus on ensuring the sustainability of project effects—through strengthened financial, environmental and institutional risk analyses, and
- thirdly, contributing towards the greater achievement of poverty reduction objectives through strengthened risk analysis.

This is followed by an outline of how risk analysis may contribute specifically (although in a fairly limited way) towards the formulation of policy/sector/program lending operations.

A consideration of some typical risk analysis situations sector-by-sector is then presented (again in tabular form), as within individual sectors and types of projects it is likely that similar technical/methodological, policy, and data issues will arise. The last section deals with various technical and resource implications of strengthened risk analysis being applied in practice, including some points on applying the '@RISK' package.

Summary of Risk Analysis Techniques: Applications and Limitations

In essence, what is fundamentally suggested in this Part of the Handbook is that 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 all projects.

Nevertheless, similar types of projects are likely to face similar analytical issues (e.g., of benefit estimation, of sustainability), and similar types of risk analysis techniques will therefore be appropriate to use across a number of project types. 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 likelihood of project failure (in the sense of EIRR<EOCC) will be reduced,
- the more that risk analysis can be used to investigate the specific financial, environmental and institutional aspects of project design, the greater will be the likelihood of the sustainability of project effects over time, and
- the more comprehensively the objective circumstances and subjective attitudes of poor project participants can be taken account of in project planning, the greater chance there is of projects achieving poverty-reduction objectives.

The following table (5a and 5b) summarizes the major approaches to risk analysis which have been covered in this Handbook. It outlines their main features, the type and form of results that come from such analyses, the circumstances in which application of each of them may be likely, and also some possible constraints to their application. The table classifies the techniques according to whether they are essentially qualitative or quantitative in nature. What is apparent from the table is that there are a number of techniques for dealing with risk in project design and analysis. They range from a spectrum of simple risk identification (and linking these risks with specific mitigating measures), to subjective quantification of likelihood of event occurrence and seriousness of impact in that event, description of the nature of exposure to risk on the part of project participants and some estimation of their attitudes towards risk in particular circumstances, and (finally) to 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).

These risk analysis techniques are of course likely to be applicable in different sorts of 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 are not mutually-exclusive. For example, the risk matrix technique can identify those risks that are thought to be the 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).

In essence, all the techniques attempt to identify and describe risk, and some of them try to quantify the extent of this risk. (Properly of course, it is only when some quantification has been achieved that the situation can be described as having modeled risk, rather than simply identified a source of uncertainty). Whether quantified or not, ultimately a decision about whether to accept a project in the face of the simple known existence of a risk (or of a particular level of that risk), is a subjective decision for planners and policy-makers. It remains practically impossible to derive

Table 5
Qualitative Risk Analysis Techniques

Type of Risk Analysis Technique	Main Features	
Logical framework 'risks and assumptions' elaboration	Expansion of consideration of risks within existing ADB Project Framework	
Risk Matrix Construction (and 'Risk Annex' preparation)	Construction of 3*3 (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	
Poverty and Risk Vulnerability Assessment	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.)	
Risk Aversion/'Focus of Loss' Estimation	Quantification of extent of target group's attitude to risk (especially any risk or risk reduction implied by the proposed project) and especially towards possible losses of incomes	

any decision rules about the acceptability or otherwise of any particular investments. However, because policy-makers and planners (within ADB and borrowing governments) are typically planning for particular groups within society, it is useful to know something about those groups' position with respect to exposure to risk and their attitudes towards any changes in that exposure which project interventions may imply in order to assess whether estimated levels of risk are acceptable to them or not.

Type and Form of Results	Likely Applications	Possible Constraints / Limitations
Textual summary of how each risk may prevent achievement of objectives at different levels of the project's objective hierarchy. Each identified risk described in more detail than at present and linked to at least one specific mitigation measure	Any project for which Project Framework is completed.	No quantitative assessment of risks' likelihood or seriousness. Barest minimum of 'risk' analysis
Risk Matrix, with individual risks numbered and discussed (along with identified mitigating measures) in separate 'Risk Annex' to 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	Any project Particularly applicable to those involving physical constructions	Subjective assessment of risk exposure only. Minimum quantification of probability; limited classification of expected impacts
Part of Initial Social Assessment prior to PPTA, concentrated in 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.	Any project, but especially Poverty Intervention ones PBL	Qualitative assessment only Supported by existing household survey data and also primary data collection
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	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 may result	Relatively demanding in terms of consultant/staff and interviewee time

Table 5
Qualitative Risk Analysis Techniques *(continued)*

Type of Risk Analysis Technique	Main Features	
Simplified Probabilistic Analysis (e.g., Harberger, ADB power, WB Mexico irrigation examples)	Indicates likelihood of project EIRR/ENPV being acceptable, based on consideration of key variables as determinants of project performance	
Spreadsheet-Based Applications (e.g., Clarke and Low)	Use of standard spreadsheet functions (to generate random numbers and counts of observations of key variables) to produce distribution of project outcomes	
'Monte Carlo' Simulation with Continuous Distributions	Classic risk analysis technique based on continuous distributions for key variables	

Strengthening Project Design: Overall Economic Benefits Estimation

The primary utility of an analysis of risks faced by projects lies not in enabling choice among competing projects (as the orientation of much academic literature implies) but in the information this provides about the proposed project and its particular environment—such that consideration can be given as to how the project may be re-designed to reduce risks to an acceptable level. Ideally, the same level of expected benefits may be found to be achievable with less risk or, if risk reduction also reduces expected benefits, then the extent of that trade-off can be made clear to planners and/or beneficiaries.

Table 6 suggests some principles which 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.

Type and Form of Results	Likely Applications	Possible Constraints / Limitations
Estimate of expected EIRR/ENPV, plus CDF of project EIRR/ENPV, with measures of variance, minimum/maximum values	Any project where key variables can be identified and simplified, and probability distributions constructed.	Results will only be as good as the distributions are realistic; statistical complexities with co-variance; availability of software (@RISK, RiskEase, etc.)
Estimate of expected EIRR/ENPV, plus CDF of project EIRR/ENPV, with measures of variance, minimum/maximum values	No inherent advantages; likely to be used only in situations where risk analysis software is unavailable	Fairly extensive familiarity with EXCEL or LOTUS required; developing non-uniform distributions by writing formulae is complex
Estimate of expected EIRR/ENPV, plus CDF of project EIRR/ENPV, with measures of variance, minimum/maximum values	Where historical/cross-sectional data exist for key variables such that continuous distributions can be fitted	Demanding in data and staff time; experience may suggest that results add little to analysis over and above use of simplified distributions

In addition to modeling the technical variables which explain a project's performance, there may also be doubt about the values which have been 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 factors¾such 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.

Promoting the Sustainability of Project Effects

The delivery of project effects over time depends upon sustainability being built into project design. It is suggested here that risk analysis can specifically help with ensuring that ADB projects are made more sustainable in various ways. Following

Table 6
Principles in Applying Risk Analysis in Project Design

	Principles to Apply
1	Identify any risks facing the proposed project as soon as possible (i.e., pre-PPTA); include description of expected risks in first draft of Project Framework
2	Construct 'Risk Matrix' for proposed project, ranking risks according to their relative likelihood of occurrence and their expected scale of impact
3	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
4	Decide which of these variables may be subject to quantitative description
5	Identify data sources for each variable (i.e., 'objective' historical or forecasts, 'subjective' 'best guesses', expert-Delphi, etc.)
6	Construct probability distributions of key variables
7	Perform simplified probabilistic analysis (e.g., using @RISK, RiskEase, etc.) to generate CDF of expected EIRR/ENPV, minimum/maximum expected values, etc.
8	Consider whether the derivation of distributions from primary/empirical sources is justified; if so, perform probability-based analysis using such distributions
9	On the basis of results from 7 and 8, decide whether risk of EIRR<EOCC or ENPV<0 is 'acceptable'
10	*If extent of risk is regarded as 'acceptable'* – redesign 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 which causes average values to be substantially higher than the most likely values)
11	*If extent of risk is regarded as 'not acceptable'* – possible redesign (in particular, check to see what can be done about any low values in distributions; in particular, investigate any negative skewness, and attempt re-design to truncate distribution)

the *Guidelines*, the notion of sustainability has at least separate dimensions—financial, environmental, and institutional—and these can be approached in different ways through risk analysis. In all aspects, however, the emphasis remains on considering and modeling sources of risk and designing mitigating actions to reduce that risk if its level is considered unacceptable.

Financial sustainability risk analysis

The financial sustainability of institutions is important in most project situations. In some projects, the institutions under consideration will be financial institutions proper (e.g., state-owned or commercial agriculture banks, industrial development banks, credit unions, nongovernment organization-run operations, housing banks). In other situations they will be project executing agencies managing or providing technical or consumer services (e.g., a municipality, a commercial bus company, a state-owned plantation, a water supply and drainage authority). In all cases, lack of financial sustainability will compromise the delivery of project effects to beneficiaries, either by causing liquidity to dry up or for service provision to be suspended and/or curtailed. Risk analysis can be used to assist in designing projects so that there is less chance of this occurring.

For financial institutions such as banks, a major concern of their appraisal and consideration for participation in an ADB project is their situation with respect to risk. Following standard international banking practice, and as summarized in the *Financial Guidelines*, a number of standard measures for credit risk (borrower default), value at risk (VaR), foreign exchange risk, maturity risk, contagion risk, etc. can be derived. They generally involve some subjective estimate being made by financial analysts/PPTA teams about the probabilities of specific outcomes, typically based on a mixture of expert judgment and some forecast data. It is suggested that in many cases it would be possible to extend this analysis for at least some measures of risk to be based on probability distributions. This is especially true for the VaR, which is theoretically based on forecast values (which could be presented in probabilistic terms), and is supposed to measure

> "over a 10-day period, what is dollar amount of V such that there is only a 1% probability that a portfolio will lose more than V?" (Financial Guidelines, section 6.4.4.2)

The calculation of VaR is essential where loans are from ADB to a nongovernment-guaranteed FI, and is still useful even if the loan is treated as risk-free.

ACCION International (an American nongovernment organization) has extended the CAMEL framework ('Capital Adequacy, Assets Quality, Management Quality, Earnings and Liquidity' - see *Financial Guidelines*, 6.4.3.1) to analysis of microfinance institutions—particularly relevant in the context of increased lending to the poorest. It is the case that many of the essentially 'static' measures under CAMEL for assessing financial performance of whatever type of lending institution, are presently calculated as individual 'point' or 'average' estimates, and could usefully be turned into financial forecasts if based on distributions of variables.

In addition to these strictly financial performance risk measures, other techniques are available to assess the performance of such institutions according to a whole range of technical and management criteria. The French Development Agency (ADF) has experience in applying such techniques to developing country financial institutions, and, although they are primarily point value or logical (i.e., 'Yes' or 'No') indicator-based at present, some of the variables (e.g., for likelihood of meeting certain targets by particular dates) could be subject to probability techniques.

For project operating entities and executing agencies, the primary concern however is typically with earnings performance, cash flow, and overall FIRR and FNPV estimates. Typically, financial statements for such entities are prepared, and then standard sensitivity testing (i.e., 'costs up 10%, 20%'; 'revenues down 10%, 20%'; 'revenues delayed by 1 or 2 years', etc.) is conducted in exactly the same way as for project EIRR/ENPV estimates. What is quite apparent in this respect is of course that the modeling of risk to financial projections of project institutions is just as applicable as it is to estimates of economic benefits for the project as a whole. Instead of individual point estimates plus sensitivity testing, it is quite possible to model probabilistically (for example) such financial estimates as

- current and constant terms price projections for inputs and outputs (i.e., probabilities of current price streams and also probabilities of particular inflation rates applying)
- foreign exchange rate projections (relative appreciation and depreciation during the life of the project)
- interest rates (e.g., on loans to sub-borrowers), and
- repayment rates (e.g., from sub-borrowers).

These kinds of variables are just as amenable (and probably even more so) to probabilistic-based forecasting as any more 'technical' variables affecting a project's performance. In this respect, it may be recalled that the 'Harberger' critique of project analysis practice of major multilateral agencies included the view that not only were estimates of project costs typically understated and estimates of project benefits typically overstated, but also that price estimates (e.g., for commodities, services, wages) and exchange rate forecasts frequently turned out to be wildly inaccurate. The greater use of quantitative risk analysis techniques, for at least some of these essentially financial variables, would be of use in ensuring project financial sustainability.

Environmental sustainability risk analysis

Another major area in which the sustainability of project effects needs to be ensured is that of impacts on the environment. Environmental sustainability of projects is ensured to the extent that environmental costs and benefits are included within the project's economic analysis. Typically, investigating and estimating the economic value of environmental costs and benefits is difficult; this is because

- biophysical relationships tend to be complicated (and thus hard to entirely capture through sampling and statistical techniques) and data are usually external to that collected during normal project preparation processes,
- market prices for many factors and project outputs do not exist, and
- different techniques for economic valuation may well lead to different results.

In addition, various biases (often stemming from professional perceptions and backgrounds) may arise in determining which impacts are important or will be large.

In general, the situation with respect to valuing environmental impacts is traditionally thought to be characterized more by uncertainty than risk, i.e., it is impossible to attach probability distributions to particular outcomes. Typical ADB practice has been that where environmental benefits have been valued at all, 'lower bounds' from estimates of 'expected values' (e.g., from carbon sequestration, from soil conservation) are quoted as the basis for benefit calculation—i.e., conservative or pessimistic forecasts are used for description of the base case. Sometimes, sensitivity testing is performed on such estimates where they are included in the base case EIRR calculation—i.e., in a manner identical to the standard treatment of other economic benefits. Occasionally a table summarizing 'Omissions, Biases and Uncertainties' in such estimates is provided—along the lines of practice recommended in ADB (1997b)—which simply indicates possible biases in the estimates for particular environmental impacts and shows what the impact on the project EIRR might be if these were corrected.

In many situations, however, it may be possible to extend this sort of analysis such that instead of simple 'uncertainty' being reflected, it would be possible to model the expected benefits in terms of their risk. The scope for the application of such techniques will vary from situation to situation, depending upon factors such as

- how familiar the analyst(s) is with the biophysical circumstances under consideration,
- the quality of primary data collected from such techniques such as hedonic pricing, contingent valuation, travel cost methods, etc., and
- the relevance and applicability of costs/benefits transferred from secondary sources (i.e., the benefits transfer method).

The utility of attempting to apply quantitative risk techniques to such situations will vary according to the relative importance of environmental impacts within overall benefits (and costs) streams—for natural resource management projects (with often large but essentially unvalued benefits) the implications of such techniques may well be significant. It may also be true that as experience with primary data collection techniques for benefit valuation within Asia expands, and as more examples of benefits transfer are applied, greater knowledge about such estimates' variability will be built-up—enabling moves towards the fuller modeling of risk rather than the simplistic description of uncertainty.

Institutional sustainability risk analysis

The last dimension of sustainability traditionally considered in project economic analysis is that of institutional sustainability. This is conceptually the dimension of sustainability which is most difficult to capture quantitatively, and few examples of quantitative benefit estimation or risk analysis from institutional performance exist. However, some recent literature suggests that institutional performance and its risk may reasonably be quantitatively estimated.

Institutional sustainability is usually considered in terms of both external factors (i.e., the project institution(s) as located within a political/policy/sector context) and internal factors (i.e., does the institution have sufficient resources to complete its tasks? is there enough technical assistance provided? etc.). One major concern which affects many projects (as well as most policy-based loans) is to what extent project institutions will be able to implement policy changes which are critical to project success, or at the very least survive in less than benign environments. A recent study of the risks associated with institutional reform in Pakistan's water sector (Dinal et al. 1997) applied a multi-stage methodology to analyze quantitatively the probability of reforms (involving the shift of policy and decision-making responsibilities away from federal and state-administered agencies and towards decentralized autonomous public utilities and end-users/water groups—as such they could expect to be contentious) succeeding or not. The key stages included evaluation of who would win and lose from the reforms, definition of reform performance levels, identification of the various ways agents would seek to influence reform implementation (and the costs of such ways), and (lastly) application of a Delphic approach to estimate probabilities of level of achievement of each reform. The Delphic approach involves asking a group of experts (in this case managers from water agencies) to assign probabilities to particular outcomes (in this case particular reform levels). Its advantage is that it provides direct assessment of risks from a collection of subjective but knowledgeable individuals and does not depend upon use of proxy measures—it could also be repeatedly performed throughout project implementation to monitor change.

What, ideally, should emerge from a Delphic-based analysis of institutional performance is therefore the best-possible guess from knowledgeable locals about the institutional environment and the probabilities of particular outcomes expressed in a quantitative form.

Supporting Poverty Reduction Objectives

In addition to more fully considering the likely distribution of overall economic benefits and also ensuring that various aspects of sustainability are built into project design, it was suggested that risk analysis could be useful in ensuring that poverty reduction objectives were better targeted. These involve not only considering the distribution of financial and economic outcomes at individual, household, farm, etc., level—in a way which is identical to describing project economic benefits and enterprise/financial institution profitability, but also considering what target groups' attitudes towards risk are, given the context of their vulnerability. The following table therefore summarizes how these various techniques can be employed to support poverty reduction; it can be seen that they attempt to marry 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 sort 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 re-design can take place to more closely pursue ADB's poverty reduction objectives.

Risk Analysis and Policy-Based Lending

Policy-based lending is probably the area of ADB operations least disposed to techniques of risk analysis.

In contrast to project economic analysis, PBL tends to be characterized by the existence of a clear economic rationale for the intervention (i.e., the 'why' of the intervention is clear—and usually some kind of reform is envisaged within a particular

Table 7
Application of Risk Techniques for Poverty Analysis

	Risk Analysis Technique
1	**Describe textually nature and extent of vulnerability**:
	This can be approached in terms of consequences of loss (catastrophic or not), reversibility, ability for households to have any control, possibilities for insurance, etc., as part of Initial Social Assessments, Poverty Impact Assessment Matrix (in PBL).
2	**Estimate risk aversion/focus of loss for participants**:
	Estimate quantitatively to the extent possible participants' attitude to risks at different income levels, and 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 the one hand compared to higher but risky outcomes on the other.
3	**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 the focus on the likelihood that returns may be negative or unacceptable. (This analysis should include possibilities that 'benefits leakage' will occur).
4	**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.
5	**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% 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.

sector) although the actual mechanisms and processes by which impacts on particular groups are delivered (i.e., the 'what' of the intervention) are typically less clear. It is therefore arguable that policy-based lending is inherently 'uncertain'. Quantitative relationships between individual variables and policy-based lending outcomes are not usually examined in PBL, and for this sort of reason the application of quantitative risk techniques is limited.

However, some of the techniques already described for institutional and 'subjective' poverty analysis can be applied with PBL analysis. Specifically, it is suggested that

- as the modified Poverty Impact Assessment matrix lays greater emphasis on the use of inference, interview-data, and statistical data for examining risks to which participants are exposed, in many situations of PBL, case studies of individuals, households, farms, etc., can be used to explain typical risk exposure and consequences, and likely attitudes towards risk by target groups
- techniques for quantifying the probabilities of particular levels of institutional performance be considered (as in Dinal et al. 1997) in circumstances where major reform interventions are proposed.

It is also recommended that the approaches suggested previously to link any identified risk to specific mitigation measures be followed in PBL.

Sectors and Projects: Some Typical Risk Analysis Situations

Each project design will encompass different sets of variables, many of whose actual outcomes will be unknown, and therefore the analysis of risk in that project can be as unique as each individual proposed project itself. Any proposed project may be able to show, for example, how its expected EIRR/ENPV has a particular probability of being acceptable (i.e., EIRR>EOCC, 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 many 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, agriculture, etc., projects. What may be left to consider, therefore, are fairly typical 'technical' issues as they occur across different sectors and as are frequently faced by analysts.

Table 8
Project Types and Some Possible Risk Analysis Considerations

Sector/Project Type	Examples of Likely Analytical Concerns	
Agriculture: Plantation/Estate	Realized tree crop yields and production; factory/mill throughput; future prices as determinants of farmers' and/or estates' incomes	
Agriculture: Irrigation	Scheme maintenance; realized new and existing crop yields; crop prices; adoption/uptake rates; household and farm incomes	
Forestry	Volume of harvestable wood in 7-20 years time, and price of output (e.g., pulp/wood) at that point	
Fisheries	Impact of new culture technologies from aquaculture; future stocks and landings from capture; fish prices; determinants of fishermen's incomes	
Environment and Natural Resources: Various	Extent of identification, quantification and valuation of indirect, non-use and option impacts of total economic value (TEV)	
Transport: Rural Roads	Construction costs in difficult or unknown environment; traffic composition mixtures; extent of generated traffic and VOC savings	
Transport: Highway/Toll Roads	Construction costs, price elasticity of demand for new road use; currency depreciation for loan repayment; sustainability of road authority	
Transport: Railways and Ports/Shipping	Future passenger and/or freight volumes; extent of maintenance, operating costs	
Energy: Rural Electrification	Operating costs, consumer price elasticity of demand	
Energy: Power Generation/Transmission	Costs of inputs; poor maintenance of equipment; consumer demands for power	

Potential Key Variables To Investigate	Possible Variable and Data Characteristics
Price projections; tree crop yield estimates; machinery operating capacity/efficiency	Use of World Bank 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
Operating/water supply costs; yields and prices (as above); WTP estimates for water demand; adoption/uptake of new varieties	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
Wood and by-product yields, losses to theft, harvest efficiency, etc. as determinants of production in future periods	Considerable doubt about point estimates of volumes and prices when wood is harvested a long time into the future; current real prices plus considerable variation should be considered
Harvest yields and fish stocks; commodity price projections and local variety	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
Quantities of particular biophysical impacts; alternative methodologies for benefit estimation	Knowledge of the extents 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
Construction cost estimates; traffic volumes by types of vehicles; VOCs	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
Contractor's / analysts' estimates allow for several states of costs; price elasticity of demand for road use; foreign exchange projections	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 (see material on 'financial sustainability')
Costs estimates, passenger and freight forecasts	Costs based on simplified distribution estimate; forecasts of traffic demands can be modeled continuously if necessary
Capital and operating costs; consumers' demand schedules	Costs based on simplified distribution estimate; distribution of WTP estimates can be derived at same time as averages
Costs of equipment; input prices; operating efficiency; consumer demands	All subject to simplified probability distribution analysis (e.g., ADB/WB power)

Table 8
Project Types and Some Possible Risk Analysis Considerations *(continued)*

Sector / Project Type	Examples of Likely Analytical Concerns	
Urban: Water Supply and Sanitation/ Wastewater /Solid Waste, etc.	Construction costs; value to consumers; willingness of authorities to pursue policy reforms (e.g., charges for service provision)	
Health: Primary Care	Service uptake rates; extent of cost recovery from rural poor; benefit estimation methodology (if applied in EIRR calculation)	
Education: Secondary and Post-secondary	Nature of beneficiaries' ultimate employment and the income differentials arising from such employment	
Education: Teacher Training	Numbers ultimately failing to find or accept work as teachers after training	

The following table 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 to consideration of some key variables for such projects. The table is not exhaustive in its content; it is meant to be indicative and general only.

Technical and Resource Considerations (including applying '@RISK')

The last issue to consider concerns possible implications in technical resource terms for extending the analysis of risk in ADB operations.

Again, because the application of risk analysis is likely to vary greatly in nature and extent across projects, it is difficult to develop firm conclusions about what may be needed to support any desired expansion of current practice. However, it is possible to draw out the following points related to technical and resource issues from the foregoing analysis:

- 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 not to be generated. This means that some kind of essentially technical/statistical support needs to be made available within ADB

Potential Key Variables To Investigate	Possible Variable and Data Characteristics
WTP estimates; probability of success of implementing institutional reforms	Distribution of WTP estimates can be derived at same time as averages/point estimates; quantitative institutional reform analysis may be considered
Use of services and consumer demand/ ability to pay; estimated WTP	Economic values, for example, DALY (disability-adjusted life year), may be contentious
Employment rates; income differentials	Can be extensively modeled with continuous distributions if necessary (see WB Mauritius example)
Policies such as school construction/funding programs; on-going institutional changes; employment rates	Institutional aspects can potentially be investigated quantitatively; modeling of employment through discrete or continuous distributions

- in such a context, it may be useful to develop some 'typical' project-based or sector-based models of anticipated statistical issues (e.g., 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 costs estimates for projects across a range of sectors may be log-normally distributed, for example)
- for the construction and application of either simplified, discrete probability distributions or fuller continuous distributions to generate estimates of expected EIRR/ENPV and their associated variance, the use of some kind of dedicated risk modeling software will be appropriate. While standard spreadsheets can theoretically be used for such purposes, practitioners must be prepared to either use only uniform distributions and/or develop their own distributions through complex formulae application. There is no reason for analysts to try to develop their own analytical tools when 'off-the-shelf' solutions are now widely available
- dedicated risk analysis packages such as @RISK have far greater functionality and ease of use than spreadsheets
- the use of @RISK is extremely simple. It can be applied to any existing spreadsheets, 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) having distributions generated for

them, which can then be represented and analyzed both numerically and graphically

- the usual considerations of designing spreadsheets with as many individual variables specified separately therefore apply, and make the application of @RISK quite possible even for any or all variables affecting project outcomes
- there are a wide range of distribution types to choose from, and users can specify central tendency, dispersion and cut-off characteristics where appropriate; all specified distributions can be represented graphically
- 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
- users can specify estimated covariance between variables in the form of an easy to use 'correlation matrix'
- typically, several thousand simulations can be processed in minutes using @RISK on a fairly standard personal computer (PC)
- alternative sampling methods for these simulations can be used, including standard Monte Carlo random sampling and the stratified Latin Hypercube sampling
- the typical time taken to apply @RISK in this way 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
- 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
- @RISK will most typically be applied to demonstrate the probability that 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, PIR), if such calculations are in cells (which @RISK will designate as 'outputs') which depend 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

- for projects which are 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
- 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 about which more data describing such variables' distributions may be collected
- the undertaking of some form of risk-based analysis in the early stages of project design and the presentation of risk analysis results in a PPTA report would probably take only a few days work for an economist and/ or other staff.