HLB

Forestry Research Partnership

Business Case Assessment for the Northeastern Ontario Enhanced Forest Productivity Study

Risk Analysis Process Guidebook

by

HLB Decision Economics Inc.
October 2, 2002

HLB DECISION ECONOMICS INC.

RISK ANALYSIS · INVESTMENT AND FINANCE · ECONOMICS AND POLICY

Forestry Research Partnership

Business Case Assessment for the Northeastern Ontario Enhanced Forest Productivity Study

Risk Analysis Process Guidebook

Prepared by:

HLB Decision Economics Inc.
Ottawa, Ontario

October 2, 2002

TABLE OF CONTENTS

1. RISK ANALYSIS PROCESS PRIMER

This short reference book provides an overview of the Risk Analysis Process (RAP) for the purpose of business case evaluation. HLB's approach to project evaluation involves incorporating Risk Analysis as a foundation by which planners and policy analysts can evaluate alternative options under a variety of scenarios. The result of a Risk Analysis is a forecast of future outcomes and the probability, or odds, of their occurrence. Not unlike modern weather forecasting, in which the likelihood of rain is projected with a statement of probability ("there is a 20 percent chance of rain tomorrow"), Risk Analysis is intended to provide organizations with a sense of perspective on the likelihood of future events. Risk Analysis is an easily understandable, but technically robust method that allows planners and decision-makers to select the level of risk within which they are willing to plan and make commitments.

1.1 Forecasting and the Analysis of Risk

The further into the future projections are made, the more uncertainty there is and the greater the risk is of producing forecasts that deviate from actual outcomes. Projections need to be made with a range of input values to allow for this uncertainty and for the probability that alternative economic, demographic, and technological conditions may prevail. The difficulty lies in choosing which combinations of input values to use in computing forecasts, and how to use those forecasts to produce a final estimate.

Forecasts traditionally take one of two forms: first, a single "expected outcome", or second, one in which the expected outcome is supplemented by alternative scenarios, often termed "high" and "low" cases. Both approaches fail to provide adequate perspective with regard to probable versus improbable outcomes.

The limitation of a forecast with a single expected outcome is clear -- while it may provide the single best guess, it offers no information about the range of probable outcomes. The problem becomes acute when uncertainty surrounding the underlying assumptions of the forecast is especially high.

The high-low case approach can actually exacerbate this problem because it gives no indication of how likely it is that the high and low cases will actually materialize. Indeed, the high case usually assumes that most underlying assumptions deviate in the same direction from their expected value; and likewise for the low case. In reality, the likelihood that all underlying factors shift to produce outcomes in the same direction simultaneously is just as remote as everything turning out as expected.

A common approach to providing added perspective on reality is through "sensitivity analysis", whereby key forecast assumptions are varied one at a time in order to assess their relative impact on the expected outcome. A problem here is that the assumptions are often varied by arbitrary amounts. But a more serious flaw in this approach is that in the real world, assumptions do not veer from actual outcomes one at a time; it is the impact of simultaneous differences between assumptions and actual outcomes (together with possible correlations) that would provide true perspective on a forecast. The result of a risk analysis is thus both a forecast and a quantification of the probability that the forecast will be achieved.

Risk Analysis provides a way around the problems outlined above. It helps avoid the lack of perspective in "high" and "low" cases by measuring the probability or "odds" that an outcome will actually materialize. This is accomplished by attaching ranges (*probability distributions*) to the forecasts of each input variable. The approach allows all inputs to be varied simultaneously within their distributions, thus avoiding the problems inherent in conventional sensitivity analysis. The approach also recognizes interrelationships and statistical dependencies (correlations) between variables and their associated probability distributions.

1.2 Application of the Risk Analysis Process to Project Evaluation

The Risk Analysis Process as applied to Project Evaluation involves four steps:

Step 1. Adaptation of the project evaluation steps and procedures into the Risk Analysis framework;

Step 2. Assignment of estimates and ranges (probability distributions) to each variable and assumption in the forecasting process;

Step 3. Expert and stakeholder evaluation and involvement, including revision of estimates and ranges developed in Step 2; and

Step 4. Risk Analysis.

Step 1. Integration of Data and Model Logic into RAP

The process begins with the development of "Structure-and-Logic Models". A Structure-and-Logic (S&L) Model depicts the methodology non-mathematically, indicating how all variables and assumptions combine to yield a forecast. The models provide detailed documentation of how the methodologies are characterized for Risk Analysis. They also provide a clear and accessible means of the evaluation steps and procedures to outside experts, stakeholders and others in an expert panel session. The use of Structure-and-Logic Diagrams allows all stakeholders, regardless of their familiarity with mathematical and analytical modeling techniques, to understand and critique the models.

Once the structure-and-logic of the model is properly represented, it is programmed into the Risk Analysis software.

Step 2. Central Estimates and Probability Distributions

A set of risk analysis model variables is selected and assigned central estimates and a range (a probability distribution) to represent the degree of uncertainty.

Special data sheets are used (see Table 1) to record these estimates. In this case, the first column provides space for an initial median (50%) estimate, and the second and third columns define a range which represents in effect "an 80 percent confidence interval" -- the range within which we can be 80 percent confident of finding the actual outcome. Thus the greater the uncertainty associated with a forecast variable, the wider the range will be (and vice versa). This process ensures that all risks are properly reflected in the forecasting process and that all stakeholders' views are reflected in the probability ranges. For some models, variables are stratified under a suitable grouping mechanism.

Table 1: Data Sheet for Road Construction Costs

Variable	Median	10% Lower Limit	0% Higher Limit
Road Construction Cost			
Primary	$32,000/km	$30,000/km	$35,000/km
Secondary	$22,000/km	$20,000/km	$25,000/km
Tertiary	$7,500/km	$5,000/km	$10,000/km

Probability ranges for the variables in-question are established on the basis of both statistical analysis and subjective probability. Ranges need not be normal or symmetrical -- that is, there is no need to assume the standard bell shaped normal probability curve. The bell curve assumes an equal likelihood of being too low and being too high in forecasting a particular value. It might well be, for example, that if projected inflation rates for instance deviate from expectations, they are more likely to be higher rather than lower. The RAP process places no restrictions on the degree of "skewness" in the specified ranges and thus maximizes the extent to which the Risk Analysis reflects reality.

Although the computer program will transform all ranges into formal "probability density functions", they do not have to be determined or presented in either mathematical or graphical form. All that is required is the entry of upper and lower limits of an 80 percent confidence interval in the Data Sheets. The RAP software will then use numerical analysis to translate these entries into a uniquely defined probability distribution automatically. This liberates the non-statistician from the need to appreciate the abstract statistical depiction of probability and thus enables administrators, stakeholders and decision-makers to understand and participate in the process whether or not they possess statistical training.

When making assessments of probability distributions of model variables, stakeholders need to consider various external factors that may lead to the possible range of outcomes. Some of these are shown at Figure 1 below. This process allows and expert panel to incorporate their knowledge and experience about key variables even if actual outcomes are unknown.

FINANCIAL OUTCOMES

- CAPITAL EXPENSE
- MAINTENANCE EXPENSE
- OPERATING EXPENSE
- OBSOLESCENCE
- FISCAL PRIORITIES
- FUNCTIONALITY
- SOCIAL POLICY
- PARTNERING
- SKILL MIX AND TIMING
- STAFF TURNOVER
- MEASUREMENT RISK

ECONOMIC OUTCOMES

- DESIGN/ROLL-OUT
- SHAKE-OUT

HUMAN FACTORS

- LABOUR RELATIONS
- OBSOLESCENCE
- FISCAL PRIORITIES
- FUNCTIONALITY
- SOCIAL POLICY
- PARTNERING
- SKILL MIX AND TIMING
- STAFF TURNOVER
- MEASUREMENT RISK

Figure 1: Typical risk factors in project assessment.

Step 3. Expert Evaluation and Consensus Building

Facilitated by the HLB team, a RAP Session is conducted as a structured workshop that incorporates the views of all stakeholders. Participants receive a briefing book in advance and during the session they review the model (via the Structure-and-Logic Diagrams) and review each Data Sheet. This approach facilitates consensus building in the underlying assumptions and associated probabilities.

Where necessary, changes are made, often consisting of adding variables to the models in order to ensure that they reflect all or at least the dominant factors affecting the outcome. The purpose is to ensure that prior to the transformation of the Structure and Logic models into RAP forecasting software, the models truly reflect the reality and that the collective vision of the relevant stakeholders is reflected in the modeling and risk analysis results.

Step 4. Risk Analysis

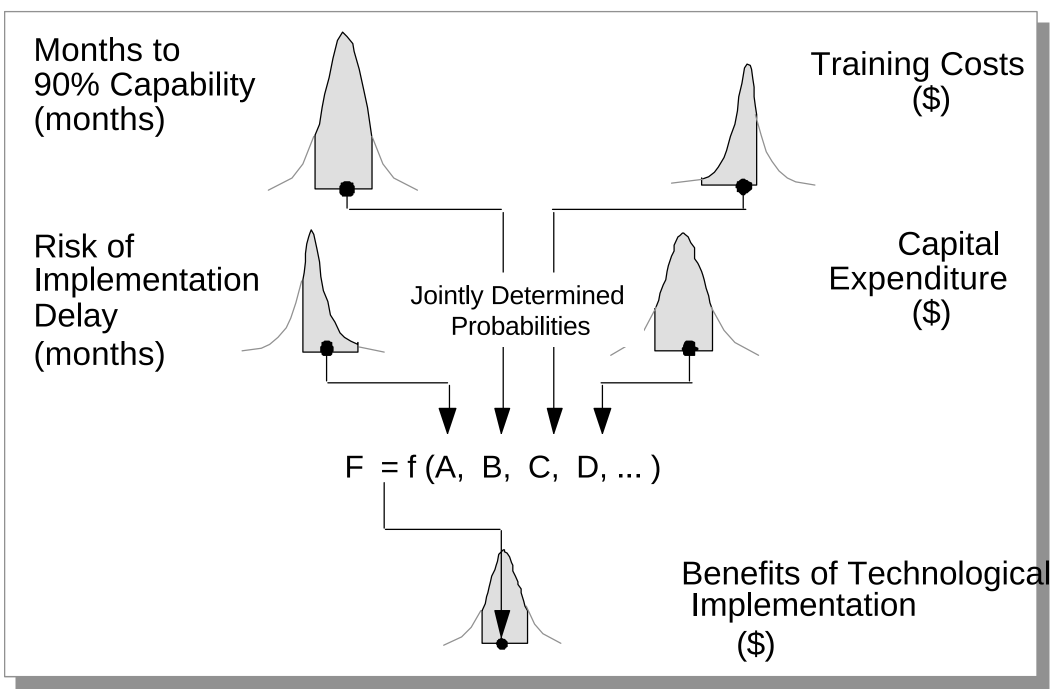
Once the Data Sheets are finalized, the RAP model transforms ranges given in the Data Sheets into statistical probability distributions.

These distributions are combined using simulation techniques that allow all variables to vary simultaneously from their expected values. The result is *the expected total benefits* together with estimates of the probability of obtaining these values given uncertainty in the underlying assumptions.

Table 2: **Risk Analysis of Project Implementation**

EXPECTED TOTAL NET BENEFITS OF PROJECT ALTERNATIVE	robability of Not Exceeding the Value at Left (In Percent)
$3.7 M	95%
$3.2M	90%
$2.2 M	80%
$1.9 M	70%
$1.5 M	60%
$0.9 M	50%
$0.7 M	40%
$0.5 M	30%
$0.2 M	20%
-$0.01 M	10%
-$0.99	5%

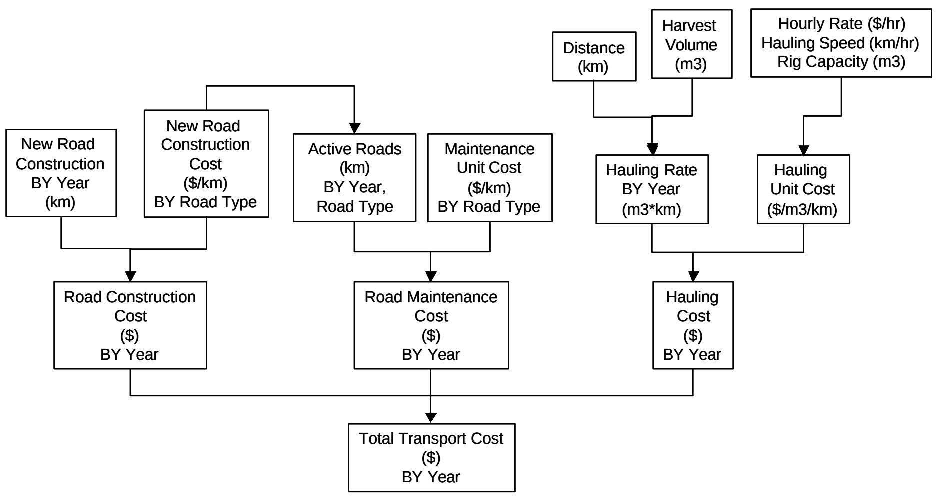
Figure 2: **Combining Probability Distributions using Monte Carlo Simulation**



1.3 Structure and Logic Models

The structure and logic model illustrates the way in which the input variables combine to obtain the dollar estimate of benefits, costs or other business case element. At figure 3, for example, the estimate of road construction cost (by road type) is multiplied by the level of road construction. The diagram shows that hauling costs are a function of both the hauling rate and hauling unit costs. The volume of product to be transported may be the result of another component of the risk model. Some S&L diagrams can in fact span multiple pages depending on the complexity of relationships.

Figure 3: Example of a Structure and Logic Model – Transportation Costs



1.4 Estimate and Probability Ranges

Each variable in the Structure-and-Logic diagrams is given an estimate (a median forecast) and a range (a **probability** interval that represents the range within which there is a 80 percent certainty of obtaining the value). An associated RAP workbook is generally used to document initial estimates for some key variables as a basis for panel scrutiny and revision. Additional information is provided during the workshop.

During a panel session, each variable is discussed in-turn. Panelists are asked to record their views on the median forecast -- either quantitatively, qualitatively or both -- in the Risk Analysis Workbook. Space is reserved for describing factors and experience considered in the forecast by individual panel members. This provides useful information for a thorough consideration of past evidence and expert knowledge.

1.5 Base Case and Alternatives for Evaluation

Once suitable data has been obtained, the process moves to options analysis. The business case analysis requires the identification of an appropriate base case against which all project benefits and costs can be compared. The status quo is not always a good choice, as it may not reflect what could be or would have to be done if the project was not considered.

The appropriate base case takes into account the measures that could be implemented within the current budgetary mandates that would ensure that plans reflect the optimal use of resources.

In the case of enhanced forest productivity, the base case for analyzing benefits and costs streams could be equated the current approved Forest Management Plan (FMP) provided it allocates resources in the most effective way with respect to intended business outcomes, while satisfying regulatory requirements.

In addition to the base case, business case alternatives are defined, usually according to various investment levels. This allows for the examination and quantification of risk reward relationships under suitable business arrangements.