

**COST-BENEFIT ANALYSIS FOR INVESTMENT DECISIONS,
CHAPTER 6:**

**DEALING WITH UNCERTAINTY AND RISK
IN INVESTMENT APPRAISAL**

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ABSTRACT

In the financial cash flow analysis, a set of values for the project variables are selected to carry out the analysis for the base case that are projected over the life of the investment project. The values of these variables used in the analysis and the resulting outcomes from a predictive model are single values. In reality, uncertainty, which refers to variability in the value, is always present surrounding each of the future values of a project's key variables throughout the project life. In some cases especially environmental and health projects, because of lack of scientific knowledge and presence of technological innovation, it would be even more difficult to make projections. The uncertainty is further compounded as the effects of the project would be spread over a long period of time in the future. This chapter shows how to move from the deterministic world developed in the base case to a dynamic and probabilistic world in which uncertainty and risk in outcomes prevail in order that the analysis can present more objective and realistic results for decision makers. It also discusses how uncertainty and risk can be addressed and mitigated while managing the project.

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CHAPTER 6

DEALING WITH UNCERTAINTY AND RISK IN INVESTMENT APPRAISAL

6.1 Introduction

In the financial cash flow analysis, project variables such as input and output prices and their quantities have been so far based on the deterministic values in which analysts make the best projection over the life of the investment project. The values of these variables used in the analysis and the resulting outcomes from a predictive model turn out to be single values with 100% certainty of occurring. In reality, uncertainty, which refers to variability in the value of some item such as a future commodity price, is always present surrounding each of the future values of a project's key variables throughout the project life. In some cases especially environmental and health projects, because of lack of scientific knowledge and presence of technological innovation, it would be even more difficult to make projections. The uncertainty is further compounded as the effects of the project would be spread over a long period of time in the future.

This chapter shows how to move from the deterministic world developed earlier to a dynamic and probabilistic world in which uncertainty and risk in outcomes prevail in order that the analysis can present more objective and realistic results for decision makers. It also discusses how uncertainty and risk can be addressed and mitigated while managing the project. Section 6.2 explains why the risk analysis of an investment project should be considered as an integral part of the appraisal exercise. Section 6.3 defines risk for the purposes of investment appraisal while Section 6.4 discusses how one can go about identifying a project's risk variables and how the risk analysis of the project is conducted. Section 6.5 provides a conceptual framework for the potential use of contractual arrangements for shifting and mitigating project risks. Contracts provide a vehicle to redistribute risk among project participants. While contracts can create incentives to alter the behavior of participants, they will also affect the overall return of a project. Section 6.6

describes a series of risks that are often encountered when arranging for project financing and outlines a few of the contractual arrangements for mitigating and shifting these risks. Conclusions are made in the last section.

6.2 Importance of Risk Analysis in Investment Appraisal

The traditional financial cash flow analysis, similar to those presented in Chapter 3, is based on single (deterministic) values for all of the project's variables. As a result, the outcome of the financial analysis is a point-estimate of a project's net present value, internal rate of return, loan life cover ratio, and some other financial performance measures. The outputs of the economic and distributional analyses are also point estimates of the economic return and the gains and losses to the project's different stakeholders. The decision whether to accept a project should not be made only on the basis of such information, because the values for most of the project's variables are likely to change. While historical values of a particular variable are known with certainty, predicting future values is an entirely different matter. There is no guarantee that the projected values, irrespective of how they were arrived at, will actually materialize. This indicates that uncertainty or variability of key project variables will generate a largely unpredictable single-value or "certainty equivalent" outcome of the project. As such, a project that may have appeared acceptable on the basis of the deterministic analysis may be much less desirable once the variability of the results is taken into account.

In the financial cash flow analysis, we are essentially dealing with the values of cost and revenue items projected over the distant future. These values are rarely known with any degree of certainty. Each of the project variables affecting the NPV of a project is subject to a high degree of uncertainty. For example, the costs of building plants, prices of machinery, oil and other intermediate inputs, and sales of the project outputs are all subject to changes in demand and supply in their respective markets that are difficult to project even for the next year or two, let alone for the next ten or more years. Similarly, the macroeconomic variables like the rate of inflation, market exchange rate and interest rate are subject to changes in the economic conditions and the government policies that go beyond the foreseeable future for

the project analyst. These variables, however, have an impact on both the financial profitability of the project and its economic viability.

Any judgment based only on the deterministic future values of project variables and the consequential NPV and debt service ratios can be dangerous because it is almost certain they will never occur in reality. For example, estimates of time and vehicle operating cost savings resulting from improving a road can be uncertain due to unpredictability of the passenger and cargo traffic in the future that are key factors affecting the investment decision. These phenomena in effect make the pin-point, single-value, outcome of the project unpredictable. It is therefore unrealistic to rely on the deterministic values of the variables influencing a project decision. It is rather better to build the analysis based on probabilistic values of the project's input variables which, in turn, will yield expected mean values as well as probabilities which in their totality will represent the certainty equivalent estimate for achieving the project's output variables such as NPV. Moreover, because such an analysis will reveal the pattern of possible outcomes (in the shape of a probability distribution), decisions can then be formed based on individual tolerance of risk as well.

Uncertainty and risk analysis is important for a number of reasons. First, we need to reduce the likelihood of undertaking a "bad" project while not failing to accept a "good" project. It may be easy to avoid "bad" projects simply by making very conservative assumptions about the values of the key variables and then accepting only those projects that still have a positive NPV. For example, we could lower the estimates of the net cash flows from operations by increasing the capital expenditures by 100 per cent. If a project still had a positive NPV, then we would be much more inclined to believe that it may still be viable.

Second, once uncertainty is analyzed and risk is understood, the project may enter into contractual arrangements to lower the riskiness of its returns and help save potentially good projects. For example, suppose the economic NPV of a project is positive based on the deterministic analysis but there is a large degree of variability in the returns that renders the project unacceptable. It may be possible to mitigate the overall risk of the project through

contractual arrangements among stakeholders, thereby saving a potentially good project from being rejected.

Third, one of the ways of reducing uncertainty is to gather more data and information, to the extent feasible, about the key project variables in order to narrow their likely range and to determine more precisely the appropriate input probability distribution. To do this, we first need to identify those variables that are key determinants of a project's NPV through sensitivity analysis. Otherwise, we risk wasting our scarce resources by researching many variables rather than focusing on the most critical ones. Moreover, attempting to estimate probability distributions for all or many input variables rather than just those that carry most of the risk will increase the level of complexity and exaggerate the problem of correlations between risk variables when applying Monte Carlo Simulation.

6.3 Definition and Measurement of Uncertainty and Risk

Risk analysis encompasses the identification of a project's risk variables and the uncertainty they represent, the analysis of the impacts of these risk variables on the project, and the interpretation of the results. A risk variable must be uncertain in terms of the difficulty in predicting its future values as well as being significant in terms of its impact on the project outcome.¹ A good example would be the price of a major product of the project. Quite often the price of a project's output is uncertain in the future and it has direct consequences in financial viability for the investors as well as the economic well-being for the nation as a whole.

Risk may result from the nature of uncertainty encompassing a particular variable and the availability of historical data on which to base an estimate for both the range of possible outcomes and their respective probabilities. For purposes of illustration, consider the case of a tradable commodity such as sugar. Historical world prices are available so one can venture a schedule of prices and associated probabilities. Despite having this information, there is

¹ See, e.g., Savvides, S.C., "Risk Analysis in Investment Appraisal", *Project Appraisal*, Vol. 9, No. 1, (March 1994).

still uncertainty as to what prices the project will face as there is no guarantee that the future will follow the same pattern as the past. A second level of uncertainty arises when we can reasonably estimate the range of expected possible prices but we cannot attach probabilities to each value with any degree of confidence. A third level of uncertainty arises when it is difficult to find any historical data or expert judgment on which to base a forecast for either the range of possible values or their respective probabilities. Based on the above definitions, we can see that project risk variables will involve different levels of uncertainty and variability.

It is important to realize that the uncertainty of a variable or group of variables does not necessarily result in a risky outcome. For example, a road project connecting two towns may be expected to generate a net economic NPV of \$20 million under low estimates of road use, value of time and operating cost savings. On the other extreme, under high estimates of road use, value of time and operating cost savings, the project may be expected to generate an economic NPV of \$100 million. In this case, the uncertainty in the input variables has resulted in variability in the outcome but not necessarily in any risk as the project is expected to yield positive economic benefits under all expected states of nature. It is, however, more common to end up with a situation that the project with certain probability may yield negative returns or values below an acceptable threshold.

There are several measures for assessing a project's risk. We rely on two measures: the project's probability of having a negative return or not meeting a certain threshold value for a particular outcome, and the expected loss from the project. While these two measures are typically used irrespective of the point of view of the stakeholder, the actual outcome assessed may vary from one stakeholder to another. For example, the main concern of a project's owner is the increase in net wealth as reflected by the financial NPV, while a banker's concern would be the project's ability to pay its debt services, thereby focusing on probabilities of meeting targeted DSCRs. The government is primarily concerned about the probability of an overall economic benefit, or a return to certain groups in society.

6.4 Steps to Conduct Risk Analysis

Risk variables are not only uncertain in nature but also significant in terms of their impact on the project outcome. The latter can be identified from sensitivity analysis. The analysis and management of the risk impacts can be carried out using the Monte Carlo simulation technique. The steps in conducting risk analysis are described below.

6.4.1 Sensitivity Analysis

The first step in conducting risk analysis of a project is to identify the risk variables. Sensitivity analysis is typically utilized in the identification of these variables. This analysis is a means of testing how sensitive a project's outcomes (e.g., financial NPV, economic NPV, DSCRs, gains and loss to different stakeholders) are to changes in the value of one parameter at a time. It is often referred to as “what if” analysis, because it allows a financial analyst to answer questions, such as “*What would happen to the NPV if variable x were to change by a certain amount or percentage?*”² It should be noted that some of the input variables that have a significant impact on the financial outcome of a project may have a much smaller impact on the economic appraisal and vice versa.

The following steps are used for conducting the sensitivity analysis on the financial results of a project:

- a) Develop the deterministic financial cash flow model of a project and estimate its NPV and DSCRs as explained in Chapters 3 and 4. This is called the *base case* analysis.
- b) Conduct sensitivity analysis by altering either the values of the project input variables or the assumptions that underpin the values that were estimated. The variables can be specific to the project (such as prices, costs and quantities sold) or

² Most spreadsheet software programs allow for changes in either one or two input variables at a time. It is essential to have sensitivity analysis before conducting Monte Carlo simulation. One of the uses of sensitivity analysis is also to check whether the financial cash flow model has been correctly developed since it provides a

macroeconomic variables like the performance of the economy (e.g., the growth rate of real GDP).

- c) While holding the values of other variables constant, let the base-case value of an input variable (price for example) change by, say, 10%, and calculate the percentage change in the financial NPV and DSCRs for certain years. The resulting numbers measure the degree of sensitivity of each of the project outcomes (e.g., financial NPV and DSCRs) to change in an input variable, while holding other variables constant.

This process is repeated for each of the input variables that are expected to have some impact on the financial outcomes of the project. For those variables that cause the greatest change in the financial outcomes, one can calculate what happens to the financial NPV as values for one variable are changed over their likely range. If the NPV turns negative after only a small change in a variable, it may signal that the project is financially risky to the investors and would need to be either rejected by them or restructured in a way that can mitigate the risks before the project is initiated.

The risk variables must satisfy two criteria. First, they account for a large share of cash receipts (benefits) or cash disbursements (costs). Second, their impact on the projected results remains significant within the range of probable values. Where it is possible to narrow down the margins of uncertainty through gathering additional information or by entering into an appropriate contractual arrangement, a highly sensitive variable will not qualify to be a risk variable. For example, if appropriate remedies in the form of undertakings and guarantees are provided by a contractor to build the project, then escalations in “capital investment costs” may cease to be an active risk variable. Moreover, in some cases where a variable could have a wide range of values, but its variation may not impact much on the NPV unless it represents a considerable share of the revenues or costs. Suppose an input accounts for 1% of the project cost, having a large fluctuation will not likely to create much uncertainty in the financial results of the project. Similarly, a variable

good means to audit the model and correct mistakes.

could constitute a large proportion of revenues or costs, but it will not be a major source of risk unless it is expected to vary considerably. For example, if the tariff for the electricity received by a power producer is fixed, the price of electricity is not going to be a source of risk even though the price is a major determinant of the project's revenues.

That being said, sensitivity analysis has a number of limitations. First, although it accounts for the likely range of values for a variable, there are no probabilities attached to the values in a range. As a result, sensitivity analysis does not recognize that certain values are more likely to occur than others. Second, input variables are altered one at a time without taking into account any relationship between variables. When the selling price of a product varies, for example, it is likely to affect the quantities sold but so will revenue projections. This shortcoming can be rectified by conducting the scenario analysis on revenues rather than selling prices, or by specifying a formula link or some correlation between variables in the deterministic base case model. Third, how the results of a sensitivity analysis are viewed may depend on the risk preferences of investors or other stakeholders. That is to say, what one individual may consider unduly risky, another one who is less risk averse may consider acceptable.³ For these reasons, it is difficult to derive a general decision rule about whether to accept or reject a project based on sensitivity analysis alone.

6.4.2 Scenario Analysis

A scenario analysis simultaneously changes two or more variables to determine the joint, or combined, effect. It recognizes these interrelationships to be altered in a consistent manner at the same time. Scenarios can be based on macroeconomic factors like the performance of the economy (e.g., expansion, normal, recession), industry-specific factors like the behavior of competing firms, or project-specific factors like the possibility of a technological breakthrough.

³ It should be noted that investor risk preference affects all aspects of capital investment decisions and as such it has an impact not only in sensitivity analysis but also in scenario analysis and Monte Carlo simulation risk analysis.

General steps for conducting a scenario analysis of a project are outlined as follows:

- a) Identify the key sets of circumstances, usually based on the major sources of uncertainty, that are likely to determine the success or failure of a project. For example, scenarios are sometimes defined as worst (pessimistic) case, expected (best-guess) case, and best (optimistic) case.
- b) The values of each of the variables in the financial or economic analysis are adjusted to be consistent with each scenario.
- c) Calculate the values of different project outcomes required (such as financial NPV and economic NPV) for each scenario.

In some cases the interpretation of the results is easy. For example, if the NPV is positive even in the worst case, one can accept the project; if the NPV is negative even in the best case, then the project should be rejected. However, if the NPV is positive in the best case and negative in the worst case, then the results are more difficult to interpret, but a decision can still be made with the knowledge of the “downside” and “upside” risk potential. If the downside risk is too great, further measures may be necessary to mitigate the risk if the project is to be undertaken.

The main shortcoming of scenario analysis is its failure to take into account the probabilities associated with each scenario even though it allows for interrelationships between variables. Second, the scenarios themselves are likely to be discrete rather than continuous. This presents no problem in some cases where an event either happens or does not happen, but in others the scenarios that are defined may not fully reflect all of the possible situations that could arise. Third, it is rather difficult to determine the various scenarios that are relevant for decision making before one has first determined what the range of possible outcomes for the project is.

6.4.3 Monte Carlo Analysis

Monte Carlo analysis is a natural extension of sensitivity and scenario analysis. It uses a random sampling process to approximate the expected values and the variability inherent in the assumptions which are expressed as probability distributions for the most sensitive and uncertain parameters (risk variables). It is a computer-aided methodology through which many possible project scenarios are generated through a random selection of input values from the specified probability distributions. Monte Carlo is a scientific technique (originally devised and used in the physical sciences) through which it is possible to simulate how the project may develop in the future. It creates multiple versions of the future based on what is considered possible to happen by studying and defining the expected variability of the input parameters used in the projected financial and economic model. This is made possible by expressing the uncertainty of input variables as probability distributions and then through customized software the computer is allowed to select randomly, but in accordance to their specified probabilities, values which are inserted into the parameter table of the financial cash flow model to generate a series of possible project outcomes. This process is repeated numerous times (1,000 to 10,000) so that a number of probability distributions (and statistics) of project results are produced that also includes the variability of the project and represents the wider picture of the expected risk and return to the investors, the financiers and other stakeholders in the project. As such, the technique can also be employed to assess the potential benefit or costs of financial contracts used to mitigate some of the project's risk. Risk analysis using Monte Carlo methodology is therefore a useful tool in developing contracts to mitigate and manage project risk.

Monte Carlo analysis addresses the main concerns regarding sensitivity and scenario analyses. By identifying probability distributions for the uncertain variables, we obtain a defined distribution for each of the specified variables according to historical data or subjective judgments by professional experts in the field. The distribution tells us the expected value of the outcome as well as the probabilities of higher and lower values for the outcome. The analysis allows for the modeling of a large number of scenarios that generate a

random, and therefore methodologically objective, probability distribution of the outcome resulting from the combined effect of all the specified input probability distributions.⁴

The following steps are required to undertake a Monte Carlo risk analysis of a project:⁵

- a) Identify risk variables that not only constitute a large share of revenues or costs of the project but also uncertain in nature.
- b) Link each risk variable in the financial cash flow model of the deterministic case.
- c) Assess how likely the risk is to occur and determine whether any truncation limits are needed. Truncation allows an analyst to put a ceiling on the value of a variable.
- d) Select the probability distribution (uniform, triangular, normal, step, or discrete) and the range of values for each risk variable.⁶ The appropriate probability distribution is selected based on a historical series of values or the opinions of experts in the field.⁷
- e) Identify and manage the relationship between correlated variables to avoid inconsistent simulation results.
- f) Select the model results that the computer program is supposed to monitor and report during the simulation.
- g) Specify the desired number of simulation runs (usually 1,000 to 10,000) and then run the simulations.⁸ Each run represents a scenario where a particular value for each identified risk variable is selected according to the specified probability distribution, correlations between variables, etc.

⁴ A crucial part of any Monte Carlo exercise is the setting and handling of correlated risk variables during the simulation phase. For more on the treatment of correlated variables in Monte Carlo Simulation, please refer to Pouliquen, L.Y., "Risk Analysis in Project Appraisal", World Bank Staff Occasional Papers no.11, the John Hopkins University Press, (1970), and Savvides, S.C., "Risk Analysis in Investment Appraisal", *Project Appraisal*, Vol. 9, No. 1, (March 1994)

⁵ At least three software programs are available for this purpose: *RiskEase*, *Crystal Ball* and *@risk*.

⁶ For the symmetrical distributions (uniform, triangular, and normal), the range is completed by indicating the minimum and maximum values. For the normal distribution, the range can also be set by specifying the mean and standard deviation. For the step and discrete distributions, it is necessary to define a series of intervals or discrete values along with their probability weights. These probabilities must add up to one.

⁷ For example, when dealing with the projected traffic on a new road, the projected number of visitors to a clinic, or the projected number of students in a classroom, the opinions of experts should be utilized in identifying the probability distributions and ranges.

⁸ It should be noted that the larger the number of input risk variables, the harder it is to determine the minimum number of runs to obtain plausible results, but given the speed of computers, this does not represent an obstacle as we can afford to be conservative and run a large number of simulations.

- h) Present a series of statistical measures such as the expected financial NPV, economic NPV, and variability of the outcomes.

Statistical measures of the project outcomes generated from Monte Carlo simulations are important. They are briefly described below.

- a) *Expected Value*: The expected value is a probability-weighted average of the outcomes of the simulation runs. Since the probability of each run is equal to the inverse of the number of simulation runs, the expected value is the same as the arithmetic mean of the results (e.g., the mean NPV).
- b) *Variability and Risk*: The variability of the outcomes can be measured by their range (maximum value minus minimum value), their variance, or the coefficient of variation which is the standard deviation divided by the mean.

The riskiness of a project can also be measured by the probability of getting a negative outcome, which is displayed as the expected loss from the project. The *expected loss* and *expected gain* provide a measure of the cost associated with making the wrong decision when approving or rejecting a project. The expected loss is a probability weighted average of all the negative outcomes. It is the expected value of the loss that might be incurred following a decision to accept a project. It is important because it gives an indication of what is really at stake (or at risk) from taking a decision to invest in the project. On the other hand, the expected gain is a probability-weighted average of all the positive outcomes. It is the expected value of the gains forgone following a decision to reject the project.

The expected loss ratio (*el*) defines risk to be dependent on both the shape and position of the cumulative probability distribution of returns (e.g., NPVs) relative to the zero “cut-off” mark. The ratio is calculated as the ratio of the absolute value of the expected loss divided by the sum of the expected gain and the absolute value of

the expected loss as follows:⁹

$$el = \frac{|\text{Expected Loss}|}{\text{Expected Gain} + |\text{Expected Loss}|}$$

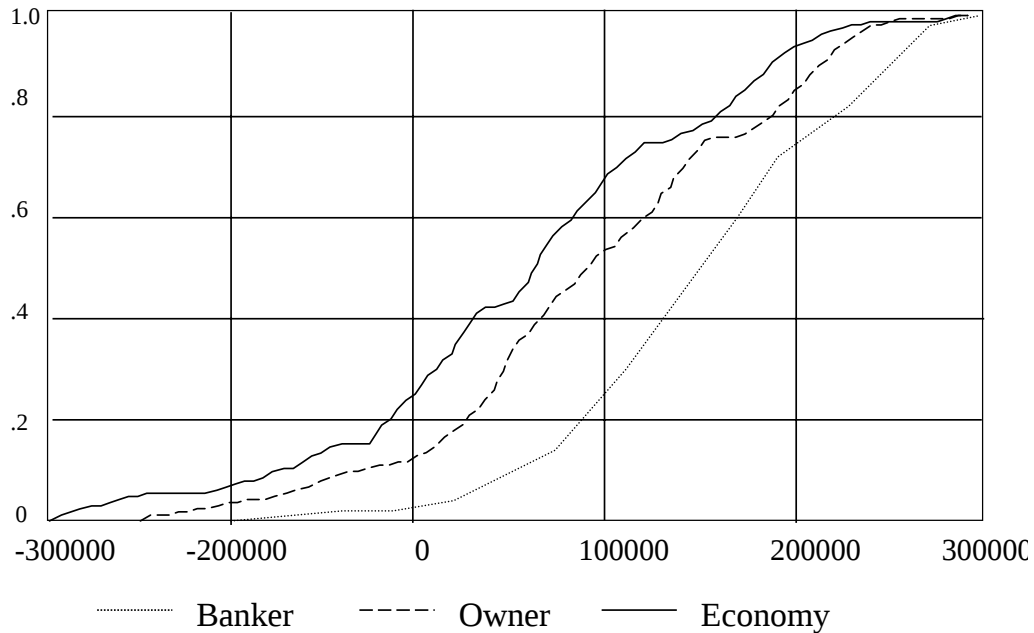
The expected loss ratio can vary from 0 when there is no expected loss, to 1 when there is no expected gain.

Instead of a single point-estimate of a project's NPV, Monte Carlo simulation generates a probability distribution of the NPVs based on the underlying uncertainty surrounding each of the key risk variables. The main question is how this additional information alters our decision criteria for accepting or rejecting projects.

The distribution of NPVs can be presented as either a frequency distribution or as a cumulative probability distribution. Figure 6.1 illustrates the latter for NPVs from three points of view: the owner, the bankers and the economy. Any point on the cumulative probability distribution indicates the probability that the NPV will be equal to or less than the corresponding value on the horizontal axis. By the same token, one minus any point on the cumulative probability distribution indicates the probability that the NPV will be greater than the corresponding value on the horizontal axis. The farther to the right is the distribution, the more attractive is a project. Several decision rules can be drawn below.

⁹ These measures of risk and the decision rules relating to Monte Carlo simulation presented below have been taken from Savvides, S.C., "Risk Analysis in Investment Appraisal", *Project Appraisal*, Vol. 9, No. 1,

Figure 6.1
Net Present Value Distribution: Cumulative Probability



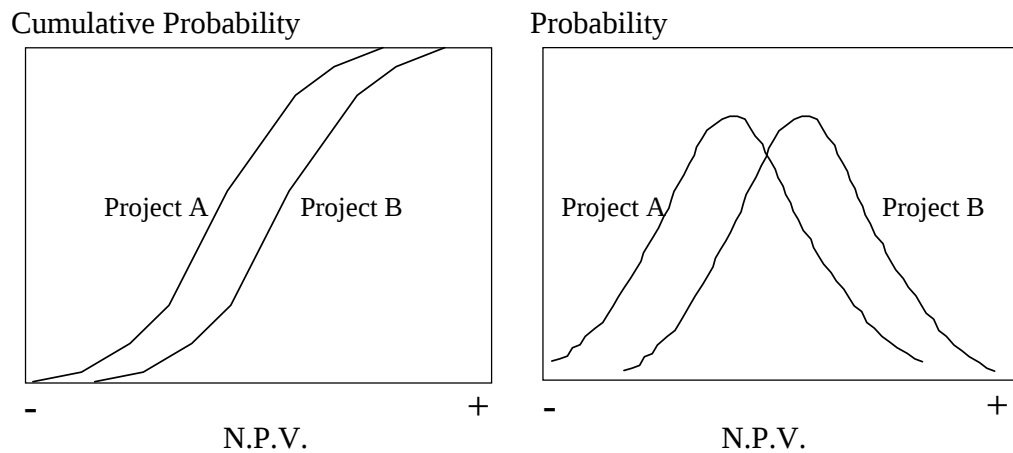
Decision Rule 1: If all of the cumulative probability distribution lies to the right of the zero “cut-off” mark, then the NPV has zero probability of being negative. One should therefore accept the project.

Decision Rule 2: If all of the cumulative probability distribution lies to the left of the zero “cut-off” mark, then the NPV has no chance of being positive. One should therefore reject the project.

Decision Rule 3: If the cumulative probability distribution crosses the zero “cut-off” mark, then there is a risk of having a negative NPV that must be weighed against the probability of getting a positive return. The investment decision is indeterminate through purely objective criteria. It really rests on the risk profile of the investor. The cost of making a mistake about whether to approve a project, as measured by the expected gain and the expected loss, and the magnitude of the probability of a negative NPV are factors that should be taken into account in making this decision.

Decision Rule 4: If the cumulative probability distributions of the returns of two mutually exclusive projects do not intersect at any point, then one should always choose the project whose probability distribution curve is farther to the right (Figure 6.2). This is because given the same probability, the return of project B is always higher than the return of project A.

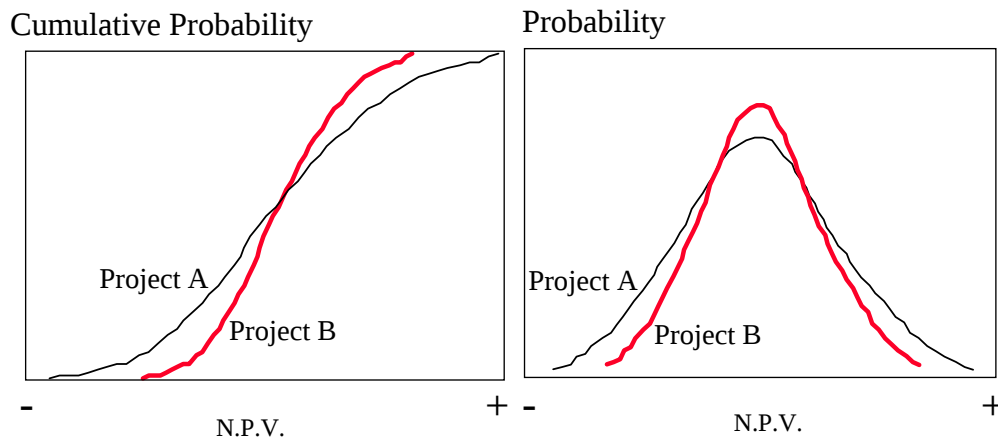
Figure 6.2
Mutually Exclusive Projects: One with a Higher Return



Decision Rule 5: If the cumulative probability distributions of the returns of two mutually exclusive projects intersect at any point, then the decision rests on investors' risk predisposition. In Figure 6.3, project B is less risky than project A. However, the expected value of project A's NPV could be higher than that of project B. Whether the added return of project A is worth the added risk depends in part on the degree of investors' risk aversion. The rules, given the risk predisposition of the investor, are shown below:

- (i) If risk neutral, then it is uncertain which project is best.
- (ii) If risk averse, then project B may be preferred to project A.
- (iii) If risk lover, then project A may be preferred to project B.

Figure 6.3
Mutually Exclusive Projects: High Return versus Low Loss



6.5 Risk Management with Contracts

Any step that can be taken to reduce the variability of the returns of a project will generally help to reduce its risk. One way to reduce a project's risk exposure is to enter into contractual arrangements. In the case of certain commodities, forward and futures contracts can be bought or sold to hedge risks. Gold or platinum producers, for example, can sell futures contracts to lock in a price today for delivery at some time in the future. While these futures markets are very useful for an operating company, the duration of the contracts is usually short and they can be costly to obtain. Consequently, they often do not provide the kind of sufficiently long-term contracts that would allow a new mining company to be established. That is why companies seek to secure long-term contracts that will permit them to arrange their financing, to invest in the necessary physical capital, to hire workers, and to begin operations in a stable environment. The key to a stable environment is managing risks in such a way that the parties to a contract have incentives to abide by the terms of a contract and to avoid actions that would undermine it.

6.5.1 Risk Reallocation

In order to manage risk a way must be found to redesign or reorganize a project in order to reallocate risk efficiently. The aim is not just to reduce risk to one party by shifting it to others -- a zero-sum game -- but rather aim for an efficiency perspective, where with the right contract one party can gain substantially without corresponding cost to the other parties. The objective is to reallocate risk to those who can best bear it. This section explores how contracts (i.e., contracts with purchasers, suppliers, and workers that govern the operation of a project) can be used and implemented to share risk efficiently.

Contract efficiency has a number of attributes. One of these is the degree of risk aversion. Customers or suppliers who are perhaps more optimistic or who are simply less averse to taking chances are more willing to accept risk; they will assign a lower cost of risk to an uncertain situation than others less willing to “go out on a limb”. Another attribute of efficiency is the comparative advantage of different project participants to diversify risks. For example, large international mineral contractors are able to diversify geologic risks by undertaking exploration activity in many sites around the world.¹⁰ They are better able to reduce that risk than the government, or an organization that owns one potential reserve.

(a) *Risk-Sharing Contracts that Limit the Range of Values*

If a project’s risk is deemed to be unacceptably high, then one should first identify and isolate the key sources of risk. For example, suppose that a project to build a water pipeline has been proposed. The water is going to be used for mining activities. A pipeline requires a major capital expenditure, and at the very least it is likely that lenders will require assurances

¹⁰ Blitzer, C.R., Lessard, D.R. and Paddock, J.L., “Risk-Bearing and the Choice of Contract Forms for Oil Exploration and Development”, *The Energy Journal*, Vol.5, No.1, ((1984) provide a comparison of alternate contracts for off-shore oil exploration in Ecuador.

that the debt service for the pipeline will be met. To be economic, the pipeline must be used at a high rate of capacity utilization to justify its costs.

- i) A common type of contract for this type of projects is a take-or-pay contract that would bind potential water users (the mineral companies) to take a certain volume of water when the product is available or to make at least minimal payments sufficient to cover debt service on the pipeline. The mineral companies that will use the water are offering assurances to water suppliers and indirectly guaranteeing the debt service for lenders. The mineral companies might be willing to enter into such a contract in order to have the pipeline project proceed.¹¹
- ii) Suppose, instead of a water pipeline, the project is a pipeline to transport natural gas to be used for industrial purposes. One possible contractual arrangement to ensure the uninterrupted sales revenue of natural gas at the required level could be a specific price-escalator clause that would index the price of natural gas to the prices of close substitutes, e.g., coal or oil. This provision would cause gas suppliers and customers to share any oil price risk, and it would help protect the pipeline from a drastic decrease in throughput.
- iii) Another approach that could be used to attract and retain customers would be to offer customers a limited product-price range. In this scenario, gas suppliers would offer their customers a ceiling on gas prices. Suppliers would thereby assume the risk of natural gas prices above the ceiling. Typically such a contract will have to be approved by the lenders to ensure that there is no due strain on the project's ability to repay its debt.

Another source of risk might be the availability of natural gas for the pipeline. Suppliers may have to be induced to give this pipeline project through such measures as *minimum quantity guarantees*. If a *minimum gas price* for natural gas is used to induce supply, purchasers would be signaling their willingness to assume more of the price risk. *Bonuses* could be

¹¹ In some situations, the much stricter "all-events-full-cost-of-service-tariff" arrangement can be used. Under such a contractual arrangement, customers are obligated to pay under all circumstances, i.e., whether the product is available or not. This type of contract is sometimes referred to as a hell-or-high-water contract because purchasers must pay "come hell or high water."

offered for maintaining consistency of supply, and *penalties* could be imposed for supply interruptions. Where the quality of the goods supplied is an issue, supply contracts would also have to include terms that would clearly state the minimum acceptable quality.¹²

These types of arrangements can be analyzed by incorporating the contract terms into a spreadsheet model. For example, *take-or-pay contracts* can be modeled using the “If” function in Excel. *Price-escalator clauses* can be introduced as equations linking gas prices to oil or coal prices; the oil and/or coal prices may themselves be risk variables for simulation purposes. Contract limitations that establish floor, ceiling prices or delivering minimum quantities can be captured while modeling the risk analysis.

The effect of these contract provisions is to change the expected value and/or the variance of the distribution of project outcomes. An increase in the expected value or a decrease in the variability of project outcomes would make a project more attractive to investors. For example, the introduction of a ceiling price on natural gas could be modeled by truncating the distribution of gas prices at that ceiling. The truncation has the effect of taking the probabilities of a price above the ceiling and assigning them to that value.¹³ The results are twofold: the expected price of natural gas would be lower, and the variance of the gas revenue would be lower because the range of possible values is reduced. This contract provision would make the project more attractive to customers and less attractive to gas suppliers. Provided that gas suppliers would continue to fulfill their contracts, investors might find the pipeline project to be more attractive because gas customers have a greater incentive not to switch fuels. While the project may have given up some of its returns through this contract, it also reduces the variability and riskiness of these returns.

¹² It should be noted that when re-allocating risk through risk-sharing agreements it is important to maintain viability across the chain of intermediaries that are crucial in taking the product through to the final consumer. A risk sharing contract which puts a vital intermediary in a precariously non-viable position will risk the success and the viability for all the stakeholders in the project.

¹³ If in the simulation process the price of natural gas were above the ceiling, then the model would insert the ceiling price; if the price of natural gas were below the ceiling price, then the model would use the market price. Glenday, G., “Monte Carlo Simulation Techniques in the Valuation of Truncated Distributions in the Context of Project Appraisal”, paper presented at 64th Annual Conference of the Western Economic Association, (June 1989); and Glenday, G., “Risk Sharing Contracts in Project Appraisal”, *Canadian Journal of Program Evaluation*, (1997).

(b) *Risk-Sharing Contracts that Establish a Correlation between Revenues and Costs*

A reduction in risk can arise from establishing a correlation between sales revenues and costs. This result is based on the same principle as portfolio diversification in which the variance of the sum of two random variables that are combined in certain proportions is equal to the weighted sum of their individual variances plus a covariance term:

$$V(ax + by) = a^2V(x) + b^2V(y) + 2abCov(x, y) \quad (6.1)$$

where x and y are two random variables, and a and b are two constants that could be scale factors or proportions.

In the context of risky net cash flows, let x be sales revenues (R), y be costs (C), $a = 1$ and $b = -1$. Equation (6.1) then becomes:

$$V(R - C) = V(R) + V(C) - 2Cov(R, C) \quad (6.2)$$

The variance in the net cash flows, $R - C$, is equal to the variance in cash receipts plus the variance in costs *minus* two times the covariance between receipts and costs. If a contract can be drawn up that will create a positive correlation, and hence a positive covariance between cash receipts and some of the cost items, and if in the process the variance of the costs does not increase by more than twice the covariance, then the variance of the net cash flows will be less than the sum of the variances of receipts and costs. Simply put, when the revenues and costs move in tandem, there will be less variability in the project's returns.¹⁴

Examples of such contracts include indexed bonds¹⁵ and profit-sharing agreements with

¹⁴ The reduced variability also puts a ceiling on the "risk-upside" which is the possibility of excessive returns.

¹⁵ A number of years ago, Pemex, Mexico's state-owned oil company, issued bonds whose interest rate was

workers. In a profit sharing agreement, let g stand for a proportion of the total costs (C) that is still paid to workers as a wage and h be the labor's share of profit after wages have been paid. Thus, the total cost will become: $C = gC + h(R - gC)$ where R stands for gross revenue. The net profit will be equal to: $R - C = R - gC - h(R - gC)$. The variance of net profit will be:

$$v(\text{net profit}) = (1-h)^2v(R) + g^2(1-h)^2v(C) - 2g(1-h)^2\text{cov}(R,C) \quad (6.3)$$

If $0 < g < 1$ and $0 < h < 1$, then the variance of net profit will be lower than it was without the agreement. Thus, any contract that creates a positive correlation between revenues and supply costs would likely have a similar effect.

(c) *Other Risk-Reallocation Techniques*

Contingent claims analysis can be used to value options that are available to either project managers or investors to manage risks. It is clearly advantageous if a firm is able to switch product lines, production techniques, or input suppliers, to expand capacity if sales are growing rapidly (where failure to expand could mean the loss of sales to larger firms), or to suspend production if revenues do not cover variable costs. The problem of quantitatively assessing overall project flexibility is beyond the scope of this manual, but the underlying principles should be kept in mind.

6.5.2 Contracting Risk

Contracting risk refers to potential unilateral departures from the contract terms by one party that may jeopardize the other party's position.¹⁶ If a contract is one-sided, or if circumstances arise that would cause one party to take actions under the terms of a contract,

indexed to the price of oil. When the price of oil rose, then interest rates would be higher, but then Pemex would be better able to afford the higher rates; when the price of oil fell and the company was squeezed for cash, then interest rates would be lower which would help to keep the net cash flow to equity positive.

¹⁶ Blitzer, C.R., Lessard, D.R. and Paddock, J.L., "Risk-Bearing and the Choice of Contract Forms for Oil Exploration and Development", *the Energy Journal*, Vol.5, No.1, ((1984).

then that party is likely either to take defensive or evasive actions or to simply walk away from the project.

For example, if a supplier has agreed to a price ceiling on materials that are used as inputs to a project, but due to shortages the market price for the materials has risen substantially above the ceiling, then the supplier has an incentive to take actions that would weaken the impact of the price ceiling. These actions might include the substitution of lower quality materials, or delayed deliveries. The effect of such actions would be to reduce overall product quality or to disrupt regular production runs to such an extent that project managers would be willing to re-negotiate the price-ceiling clause in the materials contract. These negotiations may take time and could disrupt a project's normal operations. This is why an efficient contract does not load too much risk, given the compensation, on one party. An efficient contract is a stable contract that is able to withstand unanticipated shocks without costly gaming behavior or frequent re-negotiation.

6.5.3 Incentive Effects

Efficient contracts can sometimes not only offer an improved allocation of risk, but also an incentive structure that will encourage project participants to change their behavior in such a way as to improve project outcomes. Whereas risk sharing takes the distributions of the risk variables as given and tries to re-allocate risk to those who can best bear it, risk management provides incentives for participants to alter their behavior so as to change the probabilities of the outcomes. The challenge is to design a contract whose incentives are compatible with the project's objectives.

Many of the incentive problems that arise with a project are due to imperfect and/or asymmetric information. This gives rise to the so-called principal-agent problem where the principal (owner) of the assets would like the agent (manager, employee) to manage the assets in the best interests of the owner. The problem is that the agent may understand the operations of the project better than the owner, and the agent probably has better data and information about how the project is progressing. It is very difficult for the owner to monitor

thoroughly the manager's activities and performance, and hence, the manager has some leeway to pursue his/her own objectives rather than those of the owner. The result is a less than fully efficient operation.

For example, workers who enter into a profit-sharing agreement and who possibly have membership on the company's board of directors, will have more information about the company's financial situation and will experience a different set of incentives than salaried workers. Profit-sharing workers, on the one hand, will not only share in the risks, but will also be more willing to engage in activities that will help to boost profits. Salaried, or hourly paid employees, on the other hand, would be more inclined to pursue their own interests (e.g., longer lunch hours, more vacation time, etc.), which are unlikely to be the same as those of the owner.

Managerial incentives can also be affected by contracting risks, mentioned in the previous section. If managers are suspicious of the owner's (government's) intentions, then they will take actions to benefit themselves at the expense of the owners. This could mean running the equipment for more than the optimal number of hours, failing to observe maintenance schedules, or failing to maintain good customer relations.

6.6 Risks and Mitigating Measures in Project Financing

6.6.1 Introduction

Governments' use of project finance as a source of capital for medium and large-scale development projects has increased considerably in the past two decades. Project finance has also evolved, and continues to do so, over time into different structural forms with respect to ownership, operating and financing. A common feature in project finance is that the project is structured as an independent legal entity. The ownership of the project can take one of many forms. For example, the project can be owned by a private-sector company, a government enterprise, a multinational corporation, a joint venture between private companies, or a partnership between the private sector and the government. Some of the

increasingly popular private-public partnerships that use project finance are ‘build, operate and transfer’ (BOT), and ‘build, operate, and own’ (BOO).

Project financing typically refers to *Limited Recourse Financing* where the project’s lenders have recourse to the owners in certain situations only. In other words, some of the project’s risks are borne by the lenders while others are borne by the sponsors or other credit-worthy third parties. For example, lenders could have full recourse to the owners until the project is complete after which their only recourse is to the project’s assets and cash flows. Limited recourse financing falls between two extremes: full recourse financing which is similar to corporate (collateral-based) lending and non-recourse financing where the lenders’ only recourse is to the project’s assets and cash flows.¹⁷

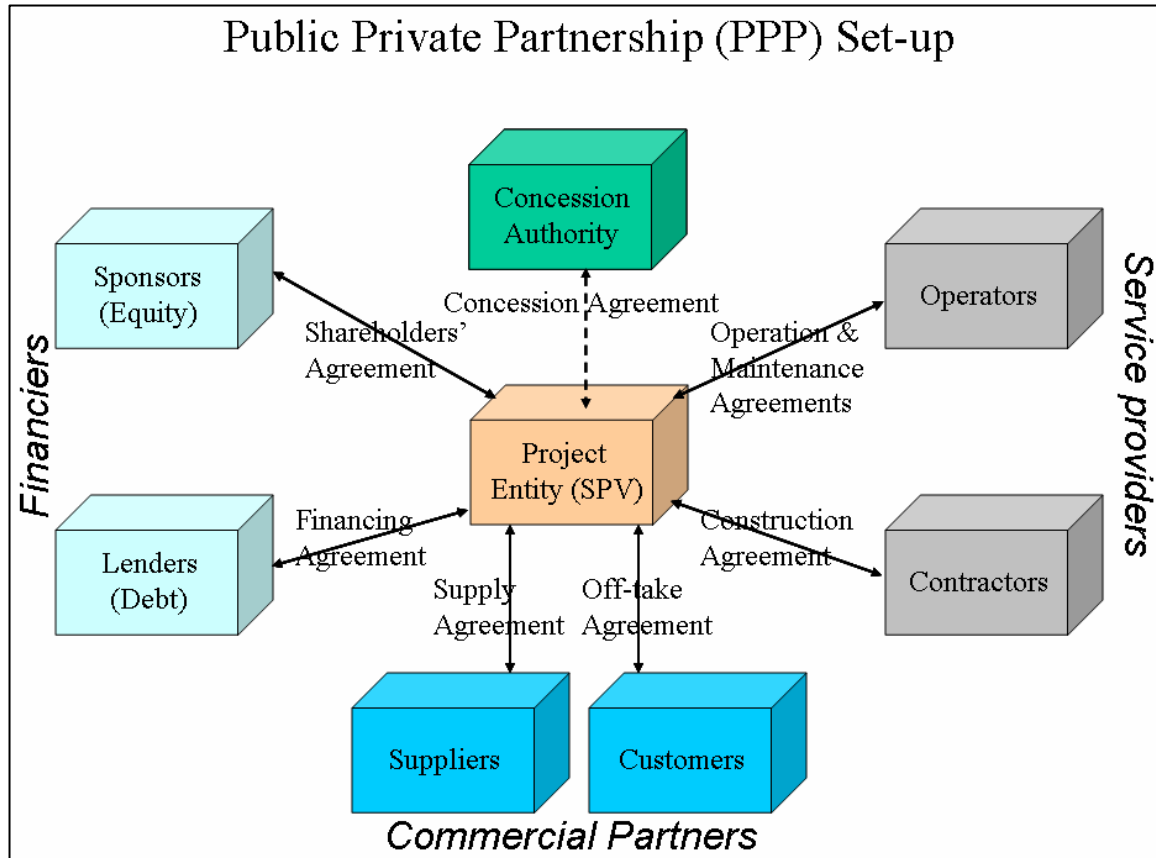
Project finance started in the oil and gas industry where sponsors wanted to reduce their risk exposure and preserve their borrowing capacity and the lenders were protected by the large profit margins of that industry. Since then, the scope and use of project finance has expanded and continues to do so. At present, it finds wide applicability in the financing of infrastructure as international and regional banks encourage the undertaking of these investments by private sector companies or through public-private partnerships. Project finance is no longer limited to large-scale capital projects, as medium-scale projects with capital costs as low as US\$5 million have begun to use project finance to raise capital. Many industrial projects are financed in this manner.

A typical project finance set up is displayed in Figure 6.4 below. The project entity -- the special purpose vehicles (SPV) -- makes appropriate contractual agreements with Service providers, Commercial partners and Financiers. The latter make sure that the agreements are in place so that the project represents a bankable risk. A project finance structure becomes a “Public Private Partnership” when a public authority is directly involved and makes available to the project public sector assets and other resources through a concession

¹⁷ See Beale, C.S., “Trends in Limited and Non-Recourse Financing”, a speech delivered to a project financing conference, (1984); and Niehuss, J.M., “An Introduction to International Project Financing”, edited by Hellawell and Wallace, D. Jr., *Negotiating Foreign Investments: A Manual for the Third World*, International Law Institute, (1982).

agreement for the purpose of undertaking and executing an economic development project (such as an airport, a motorway or a port and marina development).

Figure 6.4



Governments in developing countries are increasing their utilization of project finance as a major source for raising capital for large projects. The use of project finance through BOT arrangements in particular has become quite popular for large infrastructure projects in the power, water and transportation sectors. The use of BOT enables the governments to tap sources of capital that were not otherwise available, attracts the required expertise, or perhaps enhance the technology transfer process.

Project finance is not without its disadvantages and can be a more expensive means of finance than corporate (collateral-based) borrowing. The higher cost of project finance loans

is attributed to higher interest rates and other charges and fees that are only applied to project lending. The higher interest rates are in part attributable to the additional risk that the lenders are being exposed to, and in part is compensation for some of the expenses incurred in carrying out the different studies and in putting the deal together. These expenses and fees also include commitment fees, management fees paid to the lead underwriter, participation fees paid to other banks if the loan is syndicated, selling fees, legal fees, etc. In addition, closing project finance agreements is a lengthy and time-consuming process that often takes a few years and projects' sponsors end with incurring some additional costs in putting the deal together.¹⁸ Nevertheless, the main risks associated with project finance are better understood both by the project's lenders and owners and as a result contracts and other mechanisms are appropriately used to mitigate, spread out and manage the risks.

6.6.2 Contractual Arrangements and Other Mechanisms for Mitigating Project Risks

Project risks and mitigating mechanisms are commonly approached from the point of view of the lenders. While the risks belong to the project, the mitigation mechanisms and contracts considered typically seek to eliminate or reduce the risk to a project's lenders. It is imperative that project sponsors analyze the risks and propose contracts to ensure that risks are being shifted in the most efficient way so that are being undertaken by those project participants best equipped to bear them.

One of the misconceptions associated with risk in project finance is that lenders take a lot more risk when involved in project finance than they do in conventional corporate lending. This is not necessarily true. Banks have enhanced their capabilities of analyzing projects by hiring the necessary expertise. Consequently, their understanding of the nature of a project's risks and their magnitudes has improved significantly. This enables lenders to accept some low risks that they might not have accepted in the past had they not carried out detailed

¹⁸ For example, the undertaking of independent studies for the evaluation of reserves and certain risks, the negotiation and preparation of the different contracts, the setting up of certain funds, etc. all contribute to raising the cost of project financing to a project's sponsors.

project studies. Since these detailed analyses are not commonly undertaken for projects using corporate lending, it may appear that lenders are bearing substantially more risk with project finance.

The critical period for most projects is the completion of the project and its preparation for operation. Lenders generally divide risks into two broad categories, pre-completion risks and post-completion risks. These risks and ways to manage them are briefly discussed below.¹⁹

(a) Pre-Completion Risks

Pre-completion risks include completion risk and participant risk. Completion risk is the risk that a project may not be completed. Completion is defined in physical, mechanical and financial terms. Physical completion risk is the risk that the construction will not be completed within the specified time and budget, or will not be completed at all. Time delays generally translate into cost overruns as well due to, among other things, accrued interest during construction and increases in the general price level. Mechanical or technical risk is the risk that the project cannot sustain production at a specified capacity for a specified period of time. Financial completion risk is the risk that the project cannot produce under a certain unit cost or that it cannot meet certain financial ratios for a specified period of time.

Lenders rarely accept completion risks and seek some sort of completion guarantee from the sponsors. These guarantees may take one of several forms. If the project is not completed on time or if there are cost overruns, project owners may be required to pay back the debt. Alternatively, project owners may be asked to absorb the project debt as a liability of the parent company and pay it according to a specified schedule out of the company's cash flows. A third alternative is for the project sponsors to guarantee completion by financing any overruns using new equity. It is clear that any of the above guarantees imply that prior to completion, project debt is treated as full-recourse debt or basically as the sponsors' debt. In

¹⁹ More extensive discussions of the various risks can be found in various references such as Nevitt, P.K. and Fabozzi, F., *Project Financing*, Rochester: Euromoney Publications, (1995), Chapters 10 and 11; Finnerty, J.D., *Project Financing – Asset-Based Financial Engineering*, New York: John Wiley and Sons, (1996),

the case of large development projects that are beyond the financial ability of the sponsors, the government may be called upon to provide a completion guarantee.

Any of the above guarantees largely reduces the risk that the project will not be completed. In other words, by virtue of any of these guarantees, bankers have shifted the entire completion risk to the project sponsors or a creditworthy third party. The project's owners on the other hand should not be indifferent between guarantees.²⁰

The project's sponsors should also attempt to shield themselves from the completion risk or part of it, if possible, by passing it on or sharing it with other stakeholders. One way to accomplish this is through a turnkey arrangement or a fixed-price contract with the contractor undertaking the construction of the project.²¹ The project's analysts should assess whether the additional cost incurred in commissioning a turnkey project is necessary or not. In other words, has the contractor completed similar projects in the past on time and within budget? Have there been delays? Do they warrant a fixed-cost contract? Will the lenders be willing to accept the turnkey contract as their completion guarantee?

In certain situations, the project's lenders may agree to share construction cost overruns up to a limit with the project's sponsors. Owners can pre-arrange other sources of cost-overrun funding such as standby lines of credit. This will depend on the strength of the project's cash flows and whether they can cover additional debt repayments or not.

Lenders may be willing to share financial completion risks if they appear to be relatively low. Various conditions must be satisfied before lenders are willing to fully or partially accept completion risks. For instance, the project must be using a proven technology.

Chapter 3.

²⁰ For example, assuming the project debt as parent company debt may implicitly entail the first guarantee, which is to pay off the debt, hence providing more flexibility. When guaranteeing to complete the project from equity funds, will the sponsor commit unlimited funds or does a cap exist? Perhaps a guarantee that has some elements from each of the three guarantees mentioned above will work best for the sponsors without compromising the lenders. Another question that should be addressed is how force majeure is handled during the completion phase.

²¹ The most common of such contracts are known as an EPC contract. EPC is referring to a contract covering engineering, procurement and construction obligations.

Lenders will seldom take the completion risk in the case of a new technology. Lenders will also require that the contractor have sufficient experience in undertaking similar projects and in completing them on time; the expected cash flows are strong enough to withstand substantial cost overruns; the project management and staff are competent; procurement has been secured early, and the political climate is stable. In a few cases and when all these conditions hold, some projects have succeeded in obtaining non-recourse financing from the lenders. Such non-recourse financing is more common for oil and gas production projects than for projects from other sectors.

One or more of the project sponsors may be financially weak. In such case, a financially weak sponsor may not be able to meet his financial obligations. Under certain legal structures for ownership, each individual sponsor is responsible for his share of the project's financial obligations and debt. If lenders are concerned that there are weak participants among the sponsors, they may require cross default clauses on non-defaulting borrowers for the default of another borrower. An alternative that lenders may resort to is to seek third-party credit support for the weak sponsor(s). The most common form of this support is a letter of credit. If the lenders are concerned about the commitment of one of the sponsors, they may require pre-committed and/or additional equity which will reduce their overall exposure to the project by lowering the debt/equity ratio.

From the sponsors' perspective, the cross default may add to the financial burden of the non-defaulting borrowers and so may not be desirable to all sponsors. It may be possible, however, in certain cases that the non-defaulting sponsors assume the debt of the defaulting sponsor and buy his share in the project. If cross-default is not acceptable to the sponsors, third-party credit support or pre-committed equity may be preferable solutions.²²

(b) *Post-Completion Risks*

Post-completion risks include raw material risk, resource risk, operating risk, market risk,

²² The legal structure of the project entity and issues of default need to be considered carefully to avoid any unexpected disruption to the project and distress to any of its sponsors before completion.

political risk, force majeure risk, abandonment risk and so on.

(1) *Raw Material Risk*

Raw material risk is the risk that the project will not be able to secure the sufficient supply of any of its raw materials to ensure the timely production of the project's output. This disruption may in-turn jeopardize the sponsor's ability to service the project's debt. Raw material risk includes the risk of unavailability and the cost risk. If the project's sponsors do not own the sources of the project's main raw materials, lenders often require that the project have firm contracts with the suppliers of the project's main raw materials.

Such contracts are not only beneficial to the lenders but also to the project's sponsors. First, obtaining this contract helps secure the financing for the project. Just as important, it provides a great incentive to the supplier to adhere to the specified delivery schedule. These contracts can take the form of *supply or pay*. Under this contract, a creditworthy supplier is committed to deliver the required amount of raw material to the project or to pay the project so that it can service its debt. How the suppliers can recoup such payments, if at all, is something that can be specified in the contract.

These contracts need not be zero-sum contracts where one stakeholder has to lose for the other to gain. Long-term contracts with the project's suppliers can be beneficial to both the project's owners and the suppliers of the raw materials. For example, the supply price specified in the contract can be based on the long-run price of the raw material and can be indexed to reflect changes in the general price level or linked to the price of a close substitute. Alternatively, the input price can be linked to the price of the output itself.

Project owners will gain by securing the supply of the raw material at a price to be determined according to an already specified formula. The supplier of the raw material can also gain by securing a stable income stream. Both the owners and suppliers are likely to gain due to a lower variability over time in their cash flows as a result of the contract. In some instances, it may be beneficial to the project's owners to pay a premium to secure a

long-term supply-or-pay contract with its raw material suppliers. The availability of a spot market for the raw material can generally reduce the need for a contract to secure the long-run supply.

(2) Resource Risk

The resource risk is limited to mining projects. It is the risk that the mine will not have sufficient recoverable reserves. To deal with this risk, lenders often carry out their geological surveys and analyses, or require the sponsors to carry out independent studies, to ascertain the quantity and quality of mineable reserves. Typically, lenders will consider providing project finance to a mining project if the amount of reserves to be mined is at least twice or more than the planned production. In other words, the loan repayment period should not exceed half the mine's life. Whether the lenders have the technical staff to conduct their own analysis or the project's owners will commission an independent investigation, this imposes an additional cost on the project's sponsors. This additional cost manifests itself either in higher interest rates charged by the lenders, or increased expenditures to pay for the study. For projects that prove to have satisfactory reserves, lenders may be willing to assume the completion risk or at least share it with the sponsors of the project.

(3) Operating Risk

This is the risk that the project may run into some operating difficulty, which impedes its ability to generate sufficient cash flows to service the project's debt. In the case of proven technology and experienced operators and managers, lenders are usually willing to assume the operating risk. If the technology is relatively new, lenders will require performance guarantees from the equipment suppliers. With unproven technology, it is safe to say that project financing, if made available, will approach full-recourse financing, as the lenders will require at least completion guarantees and operating guarantees from the equipment supplier or the technology provider. The guarantees will only be accepted if the supplier or technology provider is creditworthy.

(4) Market Risk

The market risk is the risk that the project will not be able to generate enough revenues and cash flows to service its debt due to either low market prices of the output or an inability to sell the expected volume or a combination of both. The risk of a low market price is known as price risk and the risk of not selling sufficient volumes is known as volume risk. However, it should be noted that this standard way of describing market risk is an oversimplification of what is usually the main cause of failure of major projects.²³ Market risk is in fact both the most critical and the most difficult part to assess and evaluate in cost-benefit analysis. This is because it revolves around the wider and deeper subject of what constitutes project competitiveness.²⁴

Lenders will be looking for guarantees that the output of the project will be sold. This requires long-term sales contracts for the project's output. Several types of sales contracts exist. Under a *take-and-pay* contract, the project's customers commit to buying a certain amount of the project's output if it is made available by the project. In other words, the project's customer will have to take and pay the amount agreed upon even if the customer does not need it. This is perhaps the most often used of the long-term sales contracts, although not the preferred one by lenders. Such contracts should in principle be avoided as being too one-sided but may be necessary in some situations in order to make the project financeable. For example, an independent power producer will require such a contract from the utility to ensure continuous and sufficient sales.

The *take-or-pay* contract is a variation of the take-and-pay contract. Under the provisions of this contract, the project's customers will pay for a fixed amount of the product whether available or not. A more radical form of the take and pay is the "hell or high water" contract

²³ Flyvbjerg, B., Bruzelius, N. and Rothengatter, W., *Mega Projects and Risk*, Cambridge University Press, (2003).

²⁴ For an introduction on the subject of market analysis and the assessment of competitiveness of a project's market risk, see Savvides, S.C., "Market Analysis and Competitiveness in Project Appraisal", Harvard Institute for International Development, Development Discussion Paper No. 755, (February 2000).

under which customers pay even if the plant breaks down or if stoppage is related to force majeure.

Throughput and cash deficiency agreements are generally associated with pipeline projects. A throughput agreement stipulates that a specified amount of gas or oil will have to be shipped through the pipeline in a certain period of time. The specified amount is enough to generate sufficient revenues so that the project can pay all expenses and service the debt. A cash deficiency agreement complements the throughput agreement by requiring the shipping companies to make cash payments to the project if for any reason the project does not have enough cash to service the debt. This payment by the shipper can be treated as an advance to the project and settled in the future in a manner that does not hinder the project's viability or its capability to service its debt.

All of the contracts mentioned above primarily secure specified sales (volume) levels but can be also used to set prices as well. For example, the project's sponsors can agree with its customers on an initial selling price and a formula for indexing this price over time. The formula can include changes in general price levels, input prices, costs of substitutes, etc. Although including a large number of variables may sound conceptually appealing, it is likely to complicate the price estimation. In some cases, minimum prices can be specified in the contract.

When designing and analyzing these contracts, all contracting parties should be creditworthy, and contracts should be reasonable and fair from all perspectives. Otherwise, contracts can, and will, be breached. Building some flexibility in the contracts is also advisable to avoid unintended hair-trigger breaches that are the outcome of rigid clauses in the contracts.

The design of contracts can get more involved and complicated when it deals with multiple issues. Suppose, for example, that we have two projects, an oil-production project and an oil refinery. The refinery may wish to pursue throughput and cash deficiency agreements with the oil production project to ensure a continuous supply. At the same time, the oil production

project may wish to pursue a take-and-pay contract with the refinery to ensure the sale of its output. While the first set of agreements protects the lenders to the refinery against some risks, the second contract would increase the refinery's risk and hence have a negative impact on the refinery's ability to service its debt.

Another consideration when designing contracts is whether the entire output of the project should be under contract or not. The objective is that the cash flows guaranteed by contract cover the debt servicing. If this is accomplished by having only a proportion of the project's output under contract, the lenders may be readily agreeable to accepting long-term sales contracts that only cover a portion of the project's output.

(5) Force Majeure Risk

Force majeure risk is the risk that something outside the control of the lenders and sponsors would hinder the operations of the project. This includes natural disasters such as earthquakes and floods, and situations other than natural disasters such as strikes. Lenders may require the sponsors to seek insurance against force majeure risks, or alternatively, establish a debt service reserve fund that would be used to service the debt in such an eventuality. The financing provisions can also be structured in a way that allows for some restructuring in the case of a force majeure.

(6) Political Risk

Political risk covers a range of issues ranging from nationalization, expropriation, currency inconvertibility and other controls on capital, changes in tax laws and so on. Some of these risks may be motivated by environmental concerns, the importance of which continues to increase worldwide and in developing countries in particular. Political risk is a concern for joint ventures and multinationals undertaking projects in developing countries.

There are several ways to protect the project's lenders against these risks. Governments can provide guarantees that the project will not be subjected to any of these political risks.

Alternatively, governments can provide a guarantee that they will assume the project debt if the project is adversely impacted by any of these political actions. Project sponsors can also insure the project against political risks. Insurance can be sought from official sources such as the Multilateral Investment Guaranty Agency (MIGA) from the World Bank group and the Overseas Private Investment Corporation (OPIC) in the USA. Project sponsors can also seek private insurance from insurance organizations, such as Lloyds, that undertake such risks.

Political risk can be also mitigated if large international and regional financial agencies (such as the World Bank, the African Development Bank, the Asian Development Bank, and the International Finance Corporation) that have various other dealings with the country are involved. In fact, it may be to the benefit of the project in the host country to involve one or more of these financial agencies to signal the country's seriousness and commitment to the project.

Certain political risks can be avoided by establishing offshore escrow accounts to be held in sound financial institutions. In such cases is a trust fund typically created outside the project's country. The purchaser of the project's output will agree to deposit the proceeds of the sales directly into the fund. The trustees of the fund are obliged to service the debt, maintain some reserves, and then release the remainder to the project's sponsors. This mechanism is more readily applicable if the project's output is exported and the receipts are generated overseas. This scheme may be difficult to implement if the project's output is non-tradable and not generating foreign exchange. In other words, it may be difficult to use an offshore escrow account for infrastructure projects such as power, water and wastewater and road projects.

(7) Abandonment Risk

The abandonment risk is the risk that the project owners will abandon the project before all project debt has been serviced. Project lenders are concerned that the project's sponsors may abandon the project during its operation stage if it is no longer profitable to them but still

capable of generating the funds (at least partially) to service the debt. To protect themselves against abandonment, lenders formulate an ‘abandonment test’ based on historical and projected costs and receipts. If the test is met, sponsors may be allowed to abandon the project, otherwise they have to continue to operate it to service the debt. If abandonment is only under severe conditions, the sponsors may have no recourse but to pay off the debt. For example, if the test provides that the project should be operated at the sponsors’ cost while the revenues are used to service the debt, the owners may have no recourse but to pay off the debt. In other words, stringent abandonment tests can end up converting the loan from what appears to be limited-recourse financing to full-recourse financing.

(8) Interest Rate Risk

Floating interest rates can be risky. An increase in the interest rates can impair the project’s ability to service debt. This risk can be reduced by entering into interest rate swaps according to which a project borrowing at a floating interest rate can enter into an agreement under which it agrees to pay a fixed rate of interest and receive a floating rate of interest. Alternatively, the project owners can select an interest rate cap which is a contract that protects the borrower (the project) against increases in interest rate by obligating another party, for a fee, to pay the difference between the market interest rate and the cap rate whenever the market interest rate is higher than the cap rate. To reduce the costs of the derivative the borrower may choose a “collar” agreement which provides for a ceiling as well as a floor condition. In such an arrangement the cost of limiting the risk of high interest rates is offset against the possibility of gain in the event that the base rate falls below a certain point.

(9) Foreign Exchange Risk

There may be a currency risk if the project’s receipts are in one currency and its costs are in another currency. Changes in the exchange rate can have detrimental impacts on the project’s ability to service its debt. These risks can be reduced or partially hedged by taking

out a loan in the currency in which the project will receive its receipts. Alternatively, the sponsors can use the forward or future markers, or arrange currency swaps.

(10) Rigid Debt Service and Hair Trigger Defaults

The terms of the loan repayment period should take into account the economic life of the project and not put unnecessary pressure on the cash flows of the project in the early years. Rigid debt service may result in a project defaulting during a downturn even though it is still viable. To avoid these unnecessary defaults, debt servicing should be structured in a flexible manner and avoid hair trigger defaults. For example debt servicing can be positively tied to a pre-agreed index (such the sales price) or the sales revenues; whereby the servicing increases when the sales revenues are above an agreed budget and vice versa. In such cases, it is also common for the financing bank to also demand to have some leverage over the management's decision to sell within a certain price range.

(11) Syndication Risk

It is quite common for the sponsors of large-scale projects to arrange their financing through a lead underwriter from a group of banks. This group is known as the syndicate. There is always the risk that the lead underwriter will not be able to secure the financing after negotiating the basic terms and conditions with the project's sponsors. This can delay the projects for long periods of time. To avoid such delays, the sponsors can try to secure a firm underwritten commitment from the lead underwriter(s). If this approach does not succeed, the sponsor can approach a group of underwriters to finance the project without really creating a syndicate (each bank will co-finance the project based on separately negotiated loan agreements). This is commonly known as club financing or project co-financing agreements where the common factor is usually the fact that the co-financing banks make a separate agreement between them to share the available project collaterals and security available.

6.7 Conclusion

A project usually lasts for many years and faces a great deal of uncertainty including each of the future values of project inputs and project outputs, the project financing arrangements as well as the macroeconomic and political environment. The project analysis would be far from over if it ends at the stage of the deterministic evaluation. This chapter has shown how one can and must move from the analysis of a deterministic world to a probabilistic world.

We have explained that project analysts have to first identify the key risk variables of the project in question using traditional sensitivity and scenario analyses; and then estimate correlation among risk variables with historical data to the extent available or with the help from experts in the area. It takes into account the different ranges of possible values and different probability distributions for the risk variables employed in a Monte Carlo simulation of the project. The analysis presented in this chapter is indeed part of our integral project analysis approach as it integrates key risk variables into the financial, economic, and stakeholder analysis of the project. Key project evaluation criteria for the financial and economic appraisal can all be summarized and presented based on the frequency or cumulative distributions for the items of interest such as the financial NPV, the economic NPV, debt service coverage and the expected loss ratio.

With the understanding of this technique, we have presented a conceptual framework using numerous contracts to manage project risks in the most efficient manner. As project financing is also a key element for a successful project implementation, we have identified the possible pre-completion risks and post-completion risks and presented some of the mitigation mechanisms and contracts to eliminate or reduce the risks to the project's lenders, sponsors and other participants in the project.

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