CHAPTER 8
PROJECT RISK MANAGEMENT

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8.1 THE IMPORTANCE OF PROJECT RISK MANAGEMENT

- Project risk management is the art and science of identifying, analysing, and responding to risk throughout the life of a project and in the best interests of meeting project objectives.
- A frequently overlooked aspect of project management, risk management can often result in significant improvements in the ultimate success of projects. Risk management can have a positive impact on selecting projects, determining their scope, and developing realistic schedules and cost estimates.
- It helps project stakeholders understand the nature of the project, involves team members in defining strengths and weaknesses, and helps to integrate the other project management knowledge areas.

- Good project risk management often goes unnoticed, unlike crisis management, which indicates an obvious danger to the success of a project.
- Resolving a crisis has much greater visibility, often accompanied by rewards from management, than successful risk management.
- All industries, especially the software development industry, tend to underestimate the importance of project risk management. William Ibbs and Young H. Kwak studied project management maturity in 38 organizations in different industries.
- The organisations were divided into four industry groups: engineering and construction, telecommunications, information systems/software development, and high-tech manufacturing. Survey participants answered 148 multiple-choice questions to assess how mature their organization was in the project management knowledge areas of scope, time, cost, quality, human resources, communications, risk, and procurement.

Table 8.1 Project management maturity by industry group and knowledge area

KEY: 1 = Lowest Maturity Rating , 5 = Highest Maturity Rating				
Knowledge Area	**Engineering/Construction**	**Telecommunications**	**Information Systems**	**High-Tech Manufacturing**
Scope	3.52	3.45	3.25	3.37
Time	3.55	3.41	3.03	3.50
Cost	3.74	3.22	3.20	3.97
Quality	2.91	3.22	2.88	3.26
Human resources	3.18	3.20	2.93	3.18
Communications	3.53	3.53	3.21	3.48
Risk	**2.93**	**2.87**	**2.75**	**2.76**
Procurement	3.33	3.01	2.91	3.33

Source: Ibbs and Kwak

* The rating scale ranged from 1 to 5, with 5 being the highest maturity rating.

KLCI Research Group surveyed 260 software organizations worldwide to study software risk management practices. The following points summarize some of their findings:

- Ninety-seven percent of the participants said they had procedures in place to identify and assess risk.
- Eighty percent identified anticipating and avoiding problems as the primary benefit of risk management.
- Seventy percent of the organizations had defined software development processes.
- Sixty-four percent had a Project Management Office.

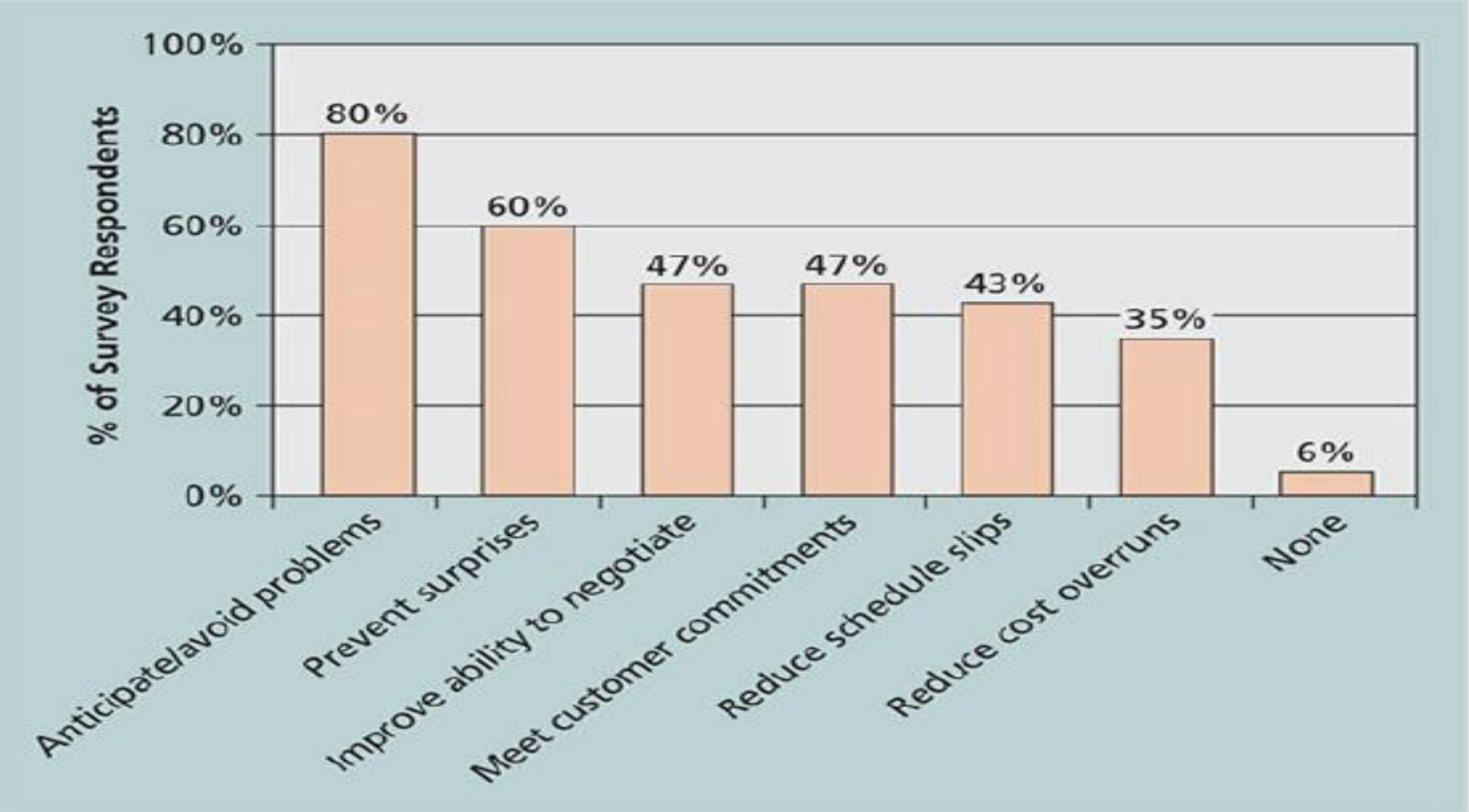


Figure 8.1 Benefits from software risk management practices

Six major processes are involved in risk management:

1. *Planning risk management* involves deciding how to approach and plan risk management activities for the project. The main output of this process is a risk management plan.

2. *Identifying risks* involves determining which risks are likely to affect a project and documenting the characteristics of each. The main outputs of this process are a risk register, risk report, and project documents updates.

3. *Performing qualitative risk analysis* involves prioritizing risks based on their probability of occurrence and impact. After identifying risks, project teams can use various tools and techniques to rank risks and update information in the risk register. The main outputs are project documents updates.

4. *Performing quantitative risk analysis* involves numerically estimating the effects of risks on project objectives. The main outputs of this process are project documents updates.

5. *Planning risk responses* involves taking steps to enhance opportunities and reduce threats to meeting project objectives. Using outputs from the preceding risk management processes, project teams can develop risk response strategies that often result in change requests, updates to the project management plan and project documents.

6. *Implementing risk responses*, just as it sounds, involves implementing the risk response plans. Outputs include change requests and project documents updates.

7. *Monitoring risk* involves monitoring identified and residual risks, identifying new risks, carrying out risk response plans, and evaluating the effectiveness of risk strategies throughout the life of the project. The main outputs of this process include work performance information, change requests, and updates to the project management plan, project documents, and organizational process assets.

8.2 PLANNING RISK MANAGEMENT

- Planning risk management is the process of deciding how to approach risk management activities and plan for them in a project; the main output of this process is a risk management plan.
- A **risk management plan** documents the procedures for managing risk throughout the project.
- The project team should review project documents as well as corporate risk management policies, risk categories, lessons-learned reports from past projects, and templates for creating a risk management plan. It is also important to review the risk tolerances of various stakeholders.

- The general topics that a risk management plan should address

Table 8.2 Topics addressed in a risk management plan

Topic	Questions to Answer
Methodology	How will risk management be performed on this project? What tools and data sources are available and applicable?
Roles and responsibilities	Which people are responsible for implementing specific tasks and providing deliverables related to risk management?
Budget and schedule	What are the estimated costs and schedules for performing risk-related activities?
Risk categories	What are the main categories of risks that should be addressed on this project? Is there a risk breakdown structure for the project? (See the information on risk breakdown structures later in this chapter.)
Risk probability and impact	How will the probabilities and impacts of risk items be assessed? What scoring and interpretation methods will be used for the qualitative and quantitative analysis of risks? How will the probability and impact matrix be developed?
Revised stakeholders' tolerances	Have stakeholders' tolerances for risk changed? How will those changes affect the project?
Tracking	How will the team track risk management activities? How will lessons learned be documented and shared? How will risk management processes be audited?
Risk documentation	What reporting formats and processes will be used for risk management activities?

- In addition to a risk management plan, many projects also include contingency plans, fall-back plans, contingency reserves, and management reserves.

  - **Contingency plans** are predefined actions that the project team will take if an identified risk event occurs. For example, if the project team knows that a new release of a software package may not be available in time to use for the project, the team might have a contingency plan to use the existing, older version of the software.

- Fallback plans are developed for risks that have a high impact on meeting project objectives and are put into effect if attempts to reduce the risk do not work. For exampl a new college graduate might have a main plan and several contingency plans for where to live after graduation, but if these plans do not work out, a fallback plan might be to liv at home for a while. Sometimes the terms *contingency plan* and *fallback plan* are used interchangeably.

- Contingency reserves or contingency allowances are funds included in the cost baseline that can be used to mitigate cost or schedule overruns if known risks occur. Fo example, if a project appears to be off course because the staff is not experienced with a new technology and the team had identified that as a risk, the contingency reserves cou be used to hire an outside consultant to train and advise the project staff in using the ne technology.

- Management reserves are funds held for unknown risks that are used for managemen control purposes. They are not part of the cost baseline, as discussed in Chapter 7, but they are part of the project budget and funding requirements. If the management reserves are used for unforeseen work, they are added to the cost baseline after the change is approved.

Many organisations develop their own risk questionnaires. Broad categories of risks described on these questionnaires might include the following:

- *Market risk*: If the IT project will create a new product or service, will it be useful to the organisation or marketable to others? Will users accept and use the product or service? Will someone else create a better product or service faster, making the project a waste of time and money?

- *Financial risk*: Can the organization afford to undertake the project? How confident are stakeholders in the financial projections? Will the project meet NPV, ROI, and payback estimates? If not, can the organization afford to continue the project? Is this project the best way to use the organization's financial resources?

- *Technology risk*: Is the project technically feasible? Will it use mature, leading-edge, or bleeding-edge technologies? When will decisions be made on which technology to use? Will hardware, software, and networks function properly? Will the technology be available in time to meet project objectives? Could the technology be obsolete before a useful product can be created? You can also break down the technology risk category into hardware, software, and network technology, if desired.

- *People risk*: Does the organization have people with appropriate skills to complete the project successfully? If not, can the organization find such people? Do people have the proper managerial and technical skills? Do they have enough experience? Does senior management support the project? Is there a project champion? Is the organization familiar with the sponsor or customer for the project? How good is the relationship with the sponsor or customer?

- *Structure/process risk*: What degree of change will the new project introduce into user areas and business procedures? How many distinct user groups does the project need to satisfy? With how many other systems does the new project or system need to interact? Does the organization have processes in place to complete the project successfully?

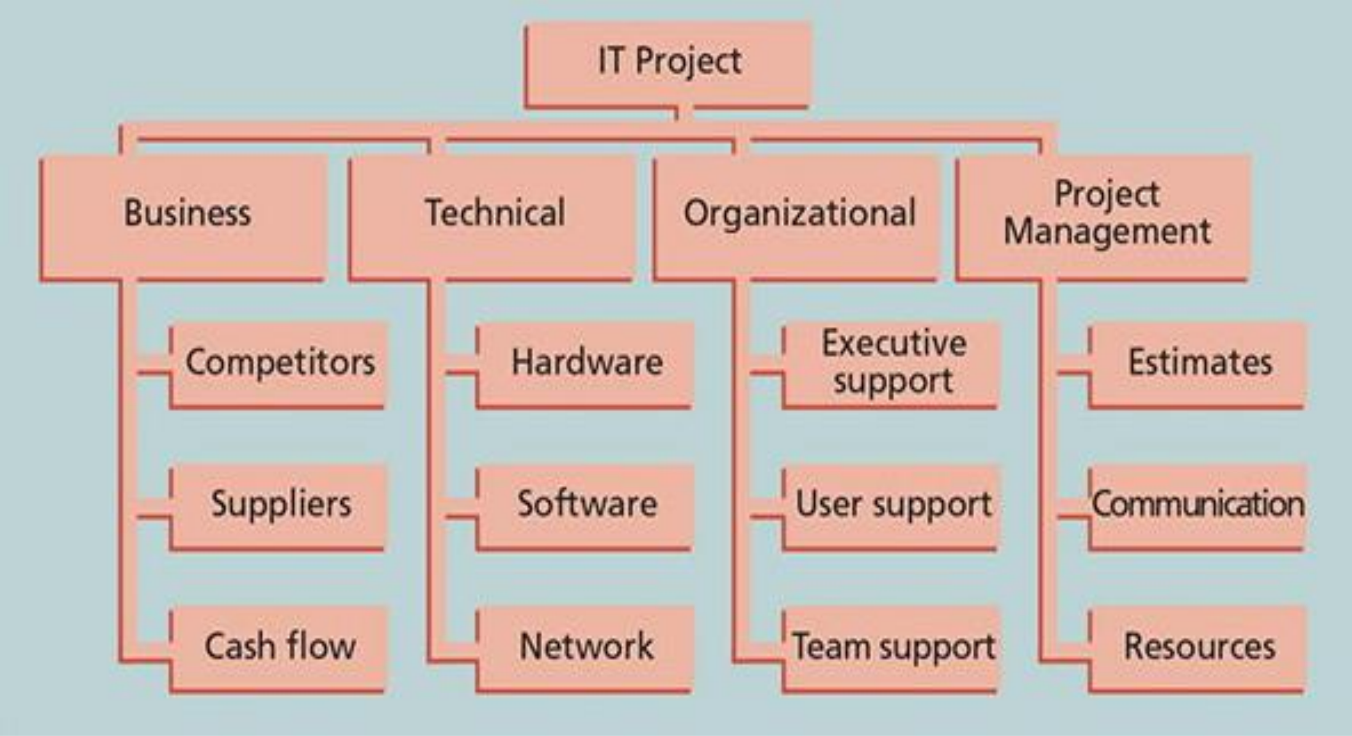


Figure 8.2 Sample risk breakdown structure

Table 8.3 Potential negative risk conditions associated with each knowledge area

Knowledge Area	Risk Conditions
Integration	Inadequate planning; poor resource allocation; poor integration management; lack of post-project review
Scope	Poor definition of scope or work packages; incomplete definition
Time	Errors in estimating time or resource availability; errors in determining the critical path; poor allocation and management of float; early release of competitive products
Cost	Estimating errors; inadequate productivity, cost, change, or contingency
Quality	Poor attitude toward quality; substandard design, materials, and workmanship; inadequate quality assurance program
Human resource	Poor conflict management; poor project organization and definition of responsibilities; absence of leadership
Communications	Carelessness in planning or communicating
Risk	Ignoring risk; unclear analysis of risk; poor insurance management
Procurement	Unenforceable conditions or contract clauses; adversarial relations
Stakeholders	Lack of consultation with key stakeholder; poor sponsor engagement

Source: R.M. Wideman

8.3 IDENTIFYING RISKS

- Identifying risks is the process of understanding what potential events might hurt or enhance a particular project.
- There are several tools and techniques for identifying risks. Project teams often begin this process by reviewing project documentation, recent and historical information related to the organisation, and assumptions that might affect the project.
- Project team members and outside experts often hold meetings to discuss this information and ask important questions about it as they relate to risk. After identifying potential risks at the initial meeting, the project team might then use different information-gathering techniques to further identify risks. Some common techniques include brainstorming, the Delphi technique, interviewing, root cause analysis, and SWOT analysis.

Brainstorming is a technique by which a group attempts to generate ideas or find a solution for a specific problem by amassing ideas spontaneously and without judgment. This approach can help the group create a comprehensive list of risks to address later during qualitative and quantitative risk analysis.

Delphi technique is a systematic, interactive forecasting procedure based on independent and *anonymous* input regarding future events. The Delphi technique uses repeated rounds of questioning and written responses, including feedback to responses in earlier rounds, to take advantage of group input while avoiding the possible biasing effects of oral panel deliberations.

- To use the Delphi technique, you must select a panel of experts for the particular area in question.

- For example, Cliff Branch from the opening case could use the Delphi technique to help him understand why his company is no longer winning many contracts. Cliff could assemble a panel of people with knowledge in his business area. Each expert would answer questions related to Cliff’s situation, and then Cliff or a facilitator would evaluate their responses, together with opinions and justifications, and provide that feedback to each expert in the next iteration. Cliff would continue this process until the group responses converge to a specific solution. If the responses diverge, the facilitator of the Delphi technique needs to determine if there is a problem with the process.

Interviewing is a fact-finding technique for collecting information in face-to-face, phone, email, or virtual discussions. Interviewing people with similar project experience is an important tool for identifying potential risks.

Another technique is a **SWOT analysis** of strengths, weaknesses, opportunities, and threats, which is often used in strategic planning. SWOT analysis can also be used during risk identification by having project teams focus on the broad perspectives of potential risks for particular projects.

- One important output of risk identification is a list of identified risks and other information needed to begin creating a risk register.
- A **risk register** is a document that contains results of various risk management processes; it is often displayed in a table or spreadsheet format.
- A risk register is a tool for documenting potential risk events and related information.
- **Risk events** refer to specific, uncertain events that may occur to the detriment or enhancement of the project.

Elements of a risk register include the following:

- *An identification number for each risk event*: The project team may want to sort by risk events or quickly search for specific risk events, so they need to identify each risk with a unique descriptor, such as an identification number.
- *A rank for each risk event*: The rank is usually a number, with 1 representing the highest risk.
- *The name of the risk event*: Example names include *defective server, late completion of testing, reduced consulting costs,* and *good publicity*.

- *A description of the risk event*: Because the name of a risk event is often abbreviated, it helps to provide a more detailed description. Consider using a risk statement format similar to the following: “Because of <one or more causes>, <risk event> might occur, which would lead to <one or more effects>.”
- For example, reduced consulting costs might be expanded to: “Because this particular consultant enjoys working for our company and is open to negotiating her rates, reduced consulting costs might occur, which could lead to saving money on the project.”

- *The category under which the risk event falls*: For example, *defective server* might fall under the broader category of technology or hardware technology.
- *The root cause of the risk*: The root cause of the defective server might be a defective power supply.
- *Triggers for each risk*: Triggers are indicators or symptoms of actual risk events. For example, cost overruns on early activities may be symptoms of poor cost estimates. Defective products may be symptoms of a low-quality supplier. Documenting potential risk symptoms for projects also helps the project team identify more potential risk events.
- *Potential responses to each risk*: A potential response to the defective server might be to include a clause in the supplier's contract to replace the server within a certain time period at a negotiated cost.

- *The* risk owner *or person who will take responsibility for the risk*: For example, a certain person might be in charge of any server-related risk events and managing response strategies.
- *The probability of the risk occurring*: There might be a high, medium, or low probability of a certain risk event. For example, the risk might be low that the server would actually be defective.
- *The impact to the project if the risk occurs*: There might be a high, medium, or low impact to project success if the risk event actually occurs. A defective server might have a high impact on successfully completing a project on time.
- *The status of the risk*: Did the risk event occur? Was the response strategy completed? Is the risk no longer relevant to the project? For example, a contract clause may have been completed to address the risk of a defective server.

8.4 PERFORMING QUALITATIVE RISK ANALYSIS

Qualitative risk analysis involves assessing the likelihood and impact of identified risks to determine their magnitude and priority. This section describes how to use a probability/ impact matrix to produce a prioritized list of risks.

Using Probability/Impact Matrixes to Calculate Risk Factors

- A project manager can chart the probability and impact of risks on **probability/ impact matrix or chart** , which lists the relative probability of a risk occurring and the relative impact of the risk occurring.

- For example, one project manager might list a severe market downturn as a negative risk that is low in probability but high in impact. Cliff may have listed the same risk as being medium in both probability and impact. The team could then plot all of the risks on a matrix or chart, combine common risks, and decide where those risks should be on the matrix or chart. The team should then focus on risks that fall in the high sections of the probability/impact matrix or chart. For example, Risks 1 and 4 are listed as high in both probability and impact. Risk 6 is high in probability but low in impact. Risk 9 is high in probability and medium in impact, and so on. The team should then discuss how it plans to respond to the risks if they occur, as you will learn later in this chapter in the section on risk response planning.

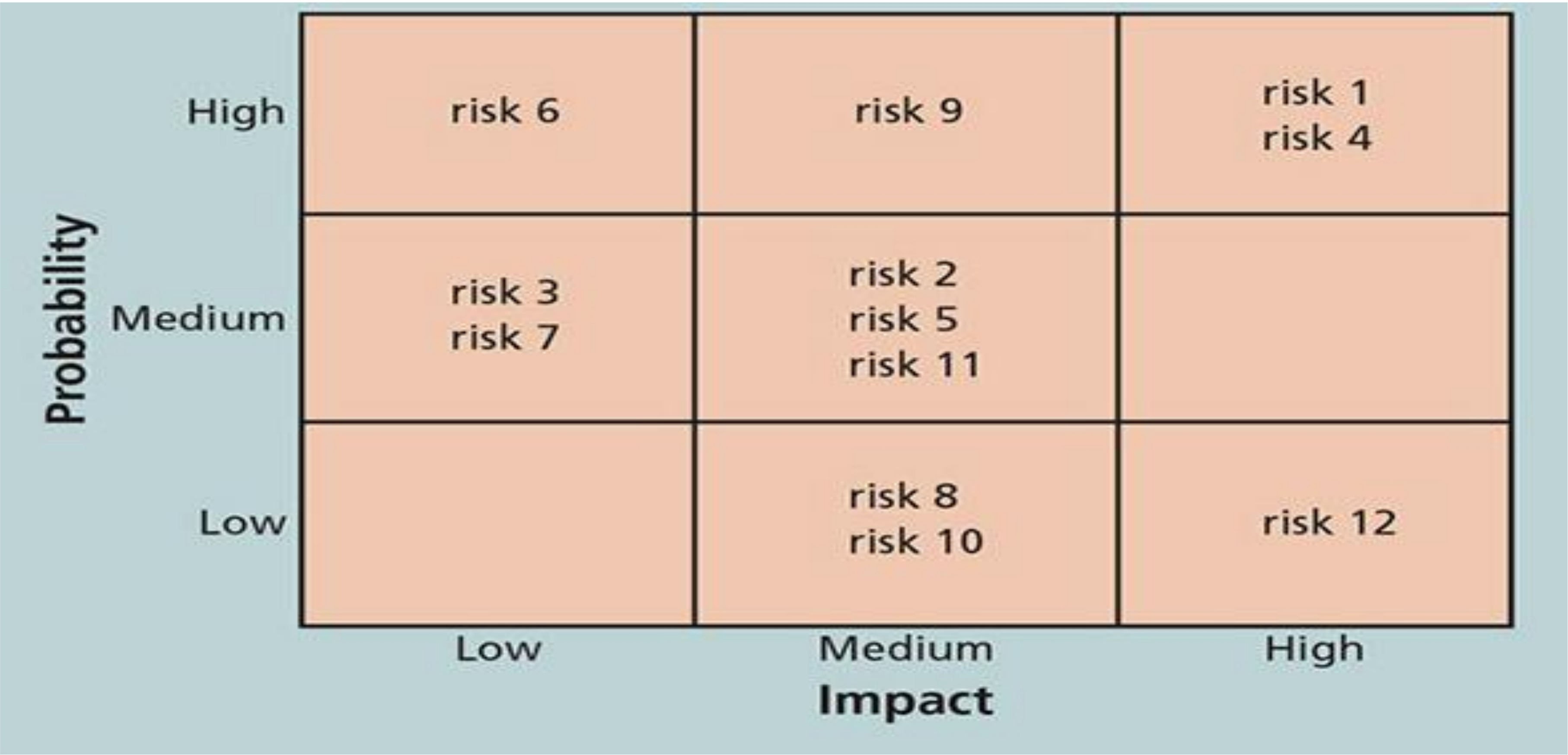


Figure 8.3 Sample probability/impact matrix

Figure 8.4 provide an example of how risk factors were used to graph the probability of failure and consequence of failure in a research study on proposed technologies for designing more reliable aircraft.

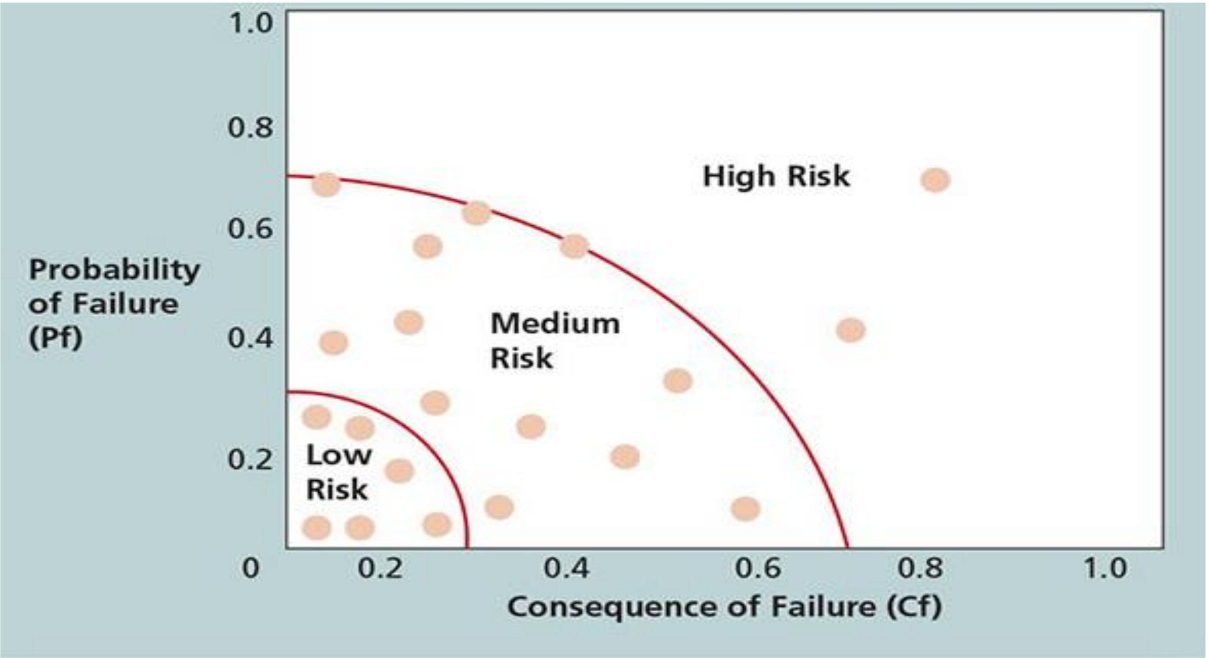


Figure 8.4 Chart showing high-, medium-, and low-risk technologies

Table 8. 5. Example of top ten risk item tracking

MONTHLY RANKING

Risk Event	Rank This Month	Rank Last Month	Number of Months in Top Ten	Risk Resolution Progress
Inadequate planning	1	2	4	Working on revising the entire project management plan
Poor definition	2	3	3	Holding meetings with project customer and sponsor to clarify scope
Absence of leadership	3	1	2	Assigned a new project manager to lead the project after the previous one quit
Poor cost estimates	4	4	3	Revising cost estimates
Poor time estimates	5	5	3	Revising schedule estimates

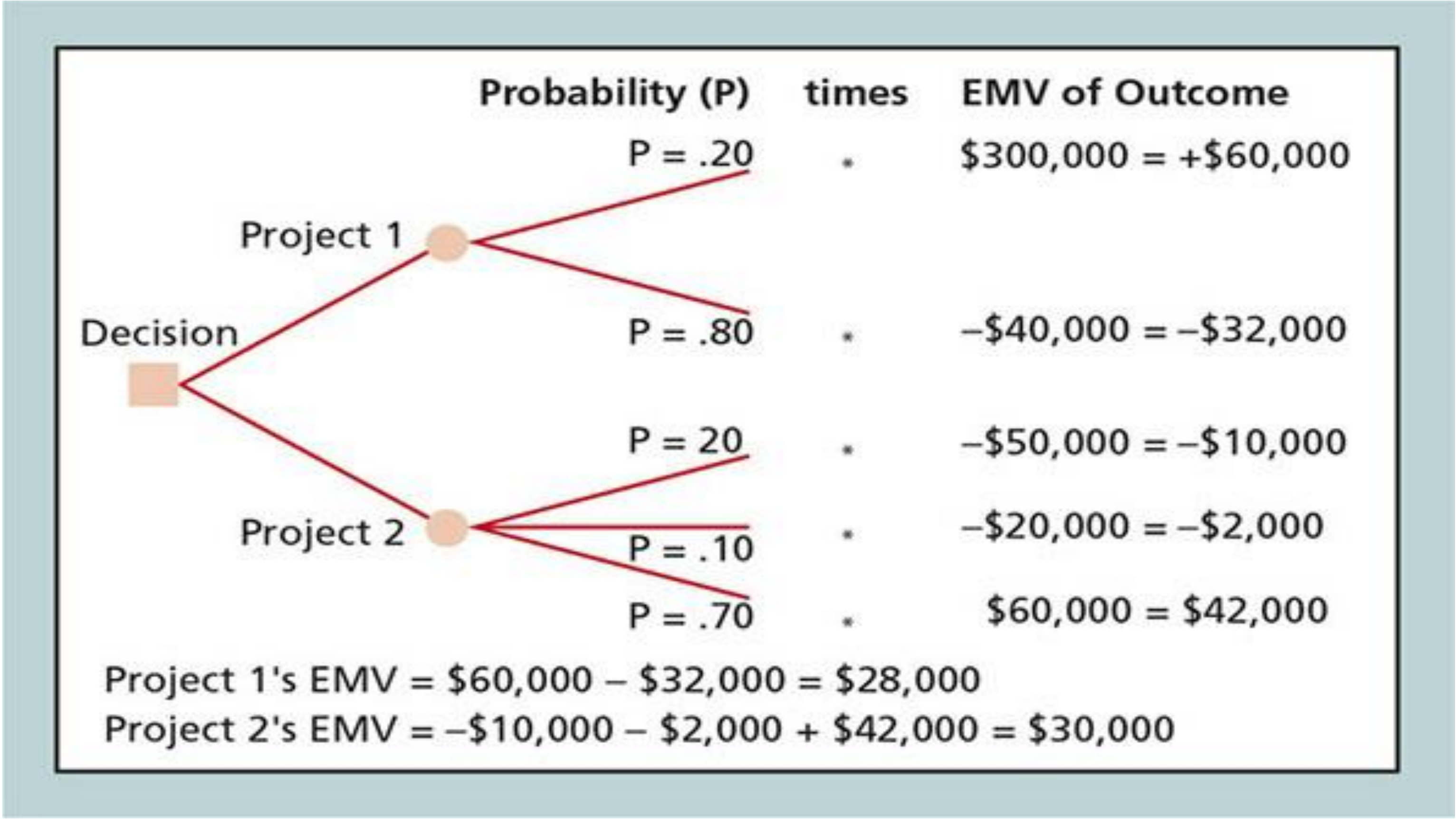
8.5 PERFORMING QUANTITATIVE RISK ANALYSIS

- Quantitative risk analysis often follows qualitative risk analysis, yet both processes can be done together or separately.
- On some projects, the team may only perform qualitative risk analysis. The nature of the project and availability of time and money affect which risk analysis techniques are used.
- Large, complex projects involving leading-edge technologies often require extensive quantitative risk analysis.
- There are three quantitative risk analysis and modelling techniques: **decision tree analysis, simulation, and sensitivity analysis**.

8.5.1 DECISION TREES AND EXPECTED MONETARY VALUE

- A **decision tree** is a diagramming analysis technique used to help select the best course of action when future outcomes are uncertain. A common application of decision tree analysis involves calculating expected monetary value.
- **Expected monetary value (EMV)** is the product of a risk event probability and the risk event's monetary value.
- **Example** : Suppose Cliff Branch's firm was trying to decide if it should submit a proposal for Project 1, Project 2, both projects, or neither project. The team could draw a decision tree with two branches, one for Project 1 and one for Project 2. The firm could then calculate the expected monetary value to help make this decision.

Figure 8.6 Expected monetary value (EMV) example



- To create a decision tree, and to calculate expected monetary value specifically, you must estimate the probabilities or chances of certain events occurring.
- For example, **Figure 8.6** shows a 20 percent probability that Cliff's firm will win the contract for Project 1, which is estimated to be worth $300,000 in profits—the outcome of the top branch in the figure. There is an 80 percent probability that the firm will not win the contract for Project 1, and the outcome is estimated to be −$40,000, meaning that the firm will have invested $40,000 into Project 1 with no reimbursement if it does not win the contract. The sum of the probabilities for outcomes for each project must equal one (for Project 1, .20 plus .80). Probabilities are normally determined based on expert judgment. Cliff or other people in his firm should have a sense of the likelihood of winning certain projects.

- **Figure 8.5** also shows probabilities and outcomes for Project 2. Suppose there is a 20 percent probability that Cliff's firm will lose $50,000 on Project 2, a 10 percent probability that it will lose $20,000, and a 70 percent probability that it will earn $60,000. Again, experts would need to estimate these dollar amounts and probabilities.
- To calculate the EMV for each project, multiply the probability by the outcome value for each potential outcome for each project and sum the results. To calculate the EMV for Project 1, going from left to right, multiply the probability by the outcome for each branch and sum the results. In this example, the EMV for Project 1 is $28,000.

$$.2(\$300{,}000) + .8(\$40{,}000) = \$60{,}000 - \$32{,}000 = \$28{,}000$$

The EMV for Project 2 is $30,000.

$$.2(-\$50{,}000) + .1(-\$20{,}000) + .7(\$60{,}000) = -\$10{,}000 - \$2{,}000 + \$42{,}000 = \$30{,}000$$

Because the EMV provides an estimate for the total dollar value of a decision, you want to have a positive number; the higher the EMV, the better. Because the EMV is positive for both Projects 1 and 2, Cliff's firm would expect a positive outcome from each and could bid on both projects. If it had to choose between the two projects, perhaps because of limited resources, Cliff's firm should bid on Project 2 because it has a higher EMV.

- Notice in **Figure 8.5** that if you just look at the potential outcome of the two projects, Project 1 looks more appealing. You could earn $300,000 in profits from Project 1, but you could only earn $60,000 for Project 2. If Cliff were a risk seeker, he would naturally want to bid on Project 1. However, there is only a 20 percent chance of earning the $300,000 on Project 1, as opposed to a 70 percent chance of earning $60,000 on Project 2. Using EMV helps account for all possible outcomes and their probabilities of occurrence, thereby reducing the tendency to pursue overly aggressive or conservative risk strategies.

8.5.2 SIMULATION

- A more sophisticated technique for quantitative risk analysis is simulation, which uses a representation or model of a system to analyse its expected behaviour or performance. Most simulations are based on some form of Monte Carlo analysis. Monte Carlo analysis simulates a model's outcome many times to provide a statistical distribution of the calculated results.

For example, Monte Carlo analysis can determine that a project will finish by a certain date only 10 percent of the time, and determine another date for which the project will finish 50 percent of the time. In other words, Monte Carlo analysis can predict the probability of finishing by a certain date or the probability that the cost will be equal to or less than a certain value.

You can use several different types of distribution functions when performing a Monte Carlo analysis. The following example is a simplified approach. The basic steps of a Monte Carlo analysis are as follows:

1. Collect the most likely, optimistic, and pessimistic estimates for the variables in the model. For example, if you are trying to determine the likelihood of meeting project schedule goals, the project network diagram would be your model. You would collect the most likely, optimistic, and pessimistic time estimates for each task. Notice that this step is similar to collecting data for performing PERT estimates. However, instead of applying the same PERT weighted average formula, you perform the following steps in a Monte Carlo simulation.

2. Determine the probability distribution of each variable. What is the likelihood of a variable falling between the optimistic and most likely estimates? For example, if an expert assigned to a particular task provides a most likely estimate of 10 weeks, an optimistic estimate of 8 weeks, and a pessimistic estimate of 15 weeks, you then ask about the probability of completing that task between 8 and 10 weeks. The expert might respond that there is a 20 percent probability.

3. For each variable, such as the time estimate for a task, select a random value based on the probability distribution for the occurrence of the variable. For example, using the preceding scenario, you would randomly pick a value between 8 weeks and 10 weeks 20 percent of the time and a value between 10 weeks and 15 weeks 80 percent of the time.

4. Run a deterministic analysis or one pass through the model using the combination of values selected for each of the variables. For example, one task described in the preceding scenario might have a value of 12 on the first run. All of the other tasks would also have one random value assigned to them on the first run, based on their estimates and probability distributions.

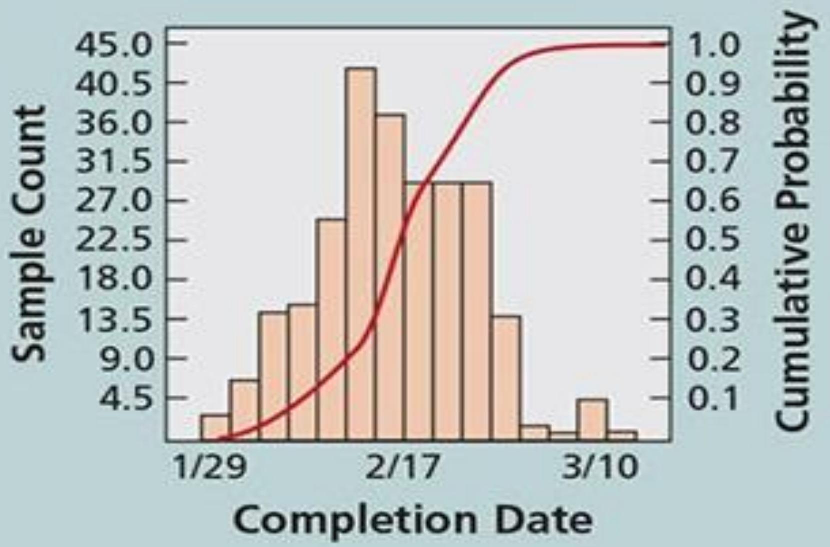
5. Repeat Steps 3 and 4 many times to obtain the probability distribution of the model's results. The number of iterations depends on the number of variables and the degree of confidence required in the results, but it typically lies between 100 and 1,000. Using the project schedule as an example, the final simulation results will show you the probability of completing the entire project within a certain time period.

- **Figure 8.6** illustrates the results from a Monte Carlo–based simulation of a project schedule. The simulation was done using Microsoft Project and Risk+ software. On the left side of Figure 8.6 is a chart displaying columns and an S-shaped curve. The height of each column indicates how many times the project was completed in a given time interval during the simulation run, which is the sample count.

- In this example, the time interval was two working days, and the simulation was run 250 times.
- The first column shows that the project was completed by January 29 only two times during the simulation.
- The S-shaped curve shows the cumulative probability of completing the project on or before a given date. The right side of Figure 8.6 shows the information in tabular form.
- For example, there is a 10 percent probability that the project will be completed by 2/8 (February 8), a 50 percent chance of completion by 2/17 (February 17), and a 90 percent chance of completion by 2/25 (February 25).

Date: 1/14 11:13:56 AM
Number of Samples: 250
Unique ID: 1
Name: Widget

Completion Std Deviation: 5.2 days
95% Confidence Interval: 0.6 day
Each bar represents 2 days.



Completion Probability Table

Prob	Date	Prob	Date
0.05	2/4	0.55	2/17
0.10	2/8	0.60	2/18
0.15	2/9	0.65	2/19
0.20	2/10	0.70	2/22
0.25	2/11	0.75	2/22
0.30	2/12	0.80	2/23
0.35	2/15	0.85	2/24
0.40	2/15	0.90	2/25
0.45	2/16	0.95	2/26
0.50	2/17	1.00	3/10

Figure 8.7 Sample Monte Carlo–based simulation results for project schedule Several

8.5.3 SENSITIVITY ANALYSIS

Many people are familiar with using sensitivity analysis to see the effects of changing one or more variables on an outcome. For example, many people perform a sensitivity analysis to determine their monthly payments for a loan given different interest rates or periods of the loan. What will your monthly mortgage payment be if you borrow $100,000 for 30 years at a 6 percent rate? What will the payment be if the interest rate is 7 percent? What will the payment be if you decide to pay off the loan in 15 years at 5 percent?

- Many professionals use sensitivity analysis to help make several common business decisions, such as determining break-even points based on different assumptions. People often use spreadsheet software like Microsoft Excel to perform sensitivity analysis. **Figure 8.7** shows an example Excel file created to quickly show the break-even point for a product based on various inputs: the sales price per unit, the manufacturing cost per unit, and fixed monthly expenses. The current inputs result in a break-even point of 6,250 units sold. Users of this spreadsheet can change inputs and see the effects on the break-even point in chart format. Project teams often create similar models to determine the sensitivity of various project variables.
- For example, Cliff’s team could develop sensitivity analysis models to estimate their profits on jobs by varying the number of hours required to do the jobs or by varying costs per hour.

Units Sold	Revenue	Expense
0	$0	$25,000
500	6,000	29,000
1,000	12,000	33,000
1,500	18,000	37,000
2,000	24,000	41,000
2,500	30,000	45,000
3,000	36,000	49,000
3,500	42,000	53,000
4,000	48,000	57,000
4,500	54,000	61,000
5,000	60,000	65,000
5,500	66,000	69,000
6,000	72,000	73,000
6,500	78,000	77,000
7,000	84,000	81,000
7,500	90,000	85,000
8,000	96,000	89,000
8,500	102,000	93,000
9,000	108,000	97,000
9,500	114,000	101,000
10,000	120,000	105,000
10,500	126,000	109,000
11,000	132,000	113,000
11,500	138,000	117,000
12,000	144,000	121,000
12,500	150,000	125,000
13,000	156,000	129,000
13,500	162,000	133,000
14,000	168,000	137,000
14,500	174,000	141,000

Figure 8.7 Sample sensitivity analysis for determining break-even point

The main outputs of quantitative risk analysis are updates to project documents, such as the risk report and risk register. The quantitative analysis also provides high-level information about the probabilities of achieving certain project objectives. This information might cause the project manager to suggest changes in contingency reserves. In some cases, projects may be redirected or canceled based on the quantitative analysis, or the quantitative analysis might be used to help initiate new projects to help the current one succeed.