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Decision-Making Tools and Expected Monetary Value (EMV)

Decision-Makers' Toolkit

"Decision-making is the cognitive process of selecting a course of action from among multiple alternatives. Every decision-making process produces a final choice." That's what Wikipedia says anyway. What it doesn't say is that some decisions must be made for outcomes that will occur in the future. However, there are a couple of tools that can be put to use in helping make complex decisions, namely, Expected Monetary Value and Decision Tree Analysis.

Expected Monetary Value (EMV)

EMV is a balance of probability and its impact over the range of possible scenarios. If you have to make a decision between two scenarios, which one will provide the greater potential payoff?

Scenario 1

Best case provides a 20% probability of making $180,000	BC = 20% X $180,000= $36,000
Worst case provides a 15% probability of losing [-$20,000]	WC = 15% X (-$20,000) = (-$3,000)
Most likely case provides a 65% probability of making $75,000	MLC = 65% X $75,000 = $48,750
Total Expected Monetary Value 100%	$81,750

Scenario 2

Best case provides a 15% probability of making $200,000	BC=15% X $200,000 =$30,000
Worst case provides a 25% probability of making $15,000	WC= 25% X $ 15,000 = $3,750
Most likely case provides a 60% probability of making $45,000	MLC=60% X $45,000 = $27,000
Total Expected Monetary Value 100%	$60,750

Which scenario do you choose? Scenario 1, because it has the highest EMV, or $81,750

Decision Tree Analysis

In decision tree analysis, a problem is depicted as a diagram which displays all possible actions, events, and payoffs (outcomes) needed to make choices at different points over a period of time.

Example of Decision Tree Analysis: A Manufacturing Proposal

Your corporation has been presented with a new product development proposal. The cost of the development project is $500,000. The probability of successful development is projected to be 70%. If the development is unsuccessful, the product will be terminated. If it is successful, the manufacturer must then decide whether to begin manufacturing the product on a new production line or a modified production line. If demand for the new product is high, the incremental revenue for a new production line is expected to be $1,200,000, and the incremental revenue for the modified production line is expected to be $850,000. If demand is low, the incremental revenue for the new production line is expected to be $700,000, and the incremental revenue for the modified production line is expected to be $150,000. All of these incremental revenue values are gross figures, i.e., before subtracting the $500,000 development cost, and $300,000 for the new production line or $100,000 for the modified production line. The probability of high demand is estimated as 40%, and of low demand as 60%.

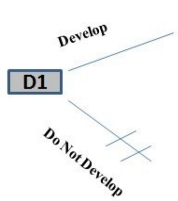
Step 1: Structure the Problem

The development of a decision tree is a multistep process. The first step is to structure the problem using a method called decomposition, similar to the method used in the development of a work breakdown structure. This step enables the decision-maker to break a complex problem down into a series of simpler, more individually manageable problems, graphically displayed in a type of flow diagram called a decision tree. These are the symbols commonly used:

Decision Node **Chance Node** **No Further Action**

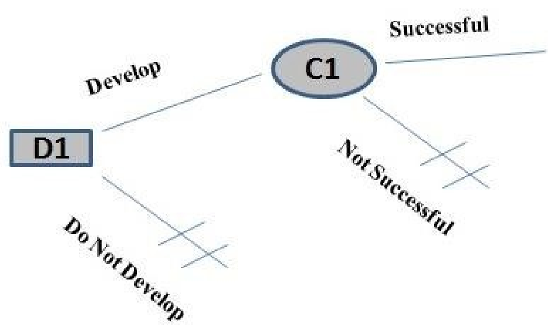
The first decision in this decomposition is whether or not to engage in the development.

Decision 1: Develop or Do Not Develop



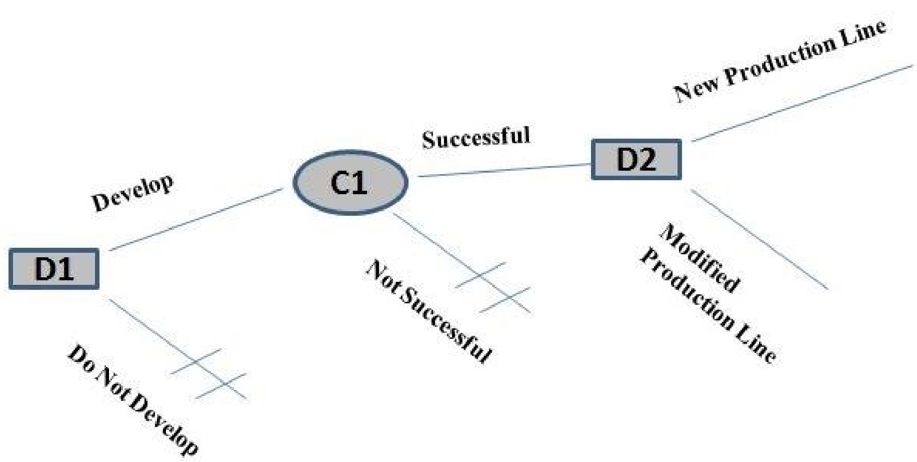
If development is done, the outcome could be Successful or Not Successful.

Chance 1: Development Successful or Not Successful



If development is successful, production could be done on a New Production Line or on a Modified Production Line.

Decision 2: New Production Line or Rebuild Existing Line



The Decision Tree shown above will serve as the foundation for this example.

Step 2: Assess Payoffs

The second step requires the payoff values to be developed for each end-position on the decision tree. These values will be in terms of the net gain or loss for each unique branch of the diagram. The net gain/loss is calculated as revenue less expenditure.

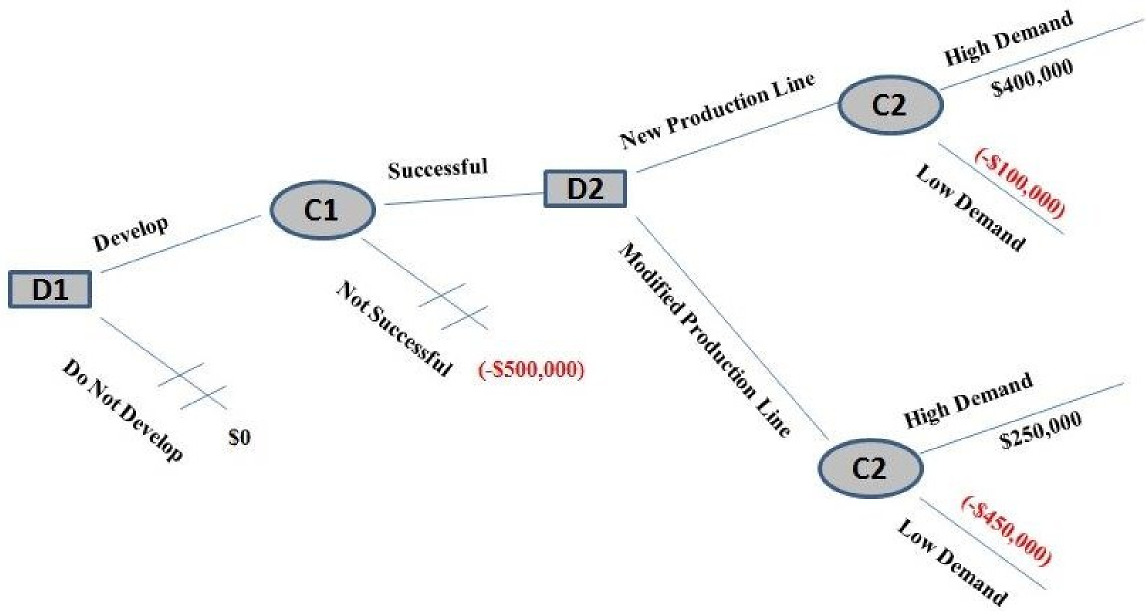
- If the decision to not develop is made, the cost is $0 and the payoff is $0.
- If the decision is to engage in product development but the outcome is unsuccessful, the cost is $500,000 but there is no revenue, so the payoff is -$500,000.
- If development is successful, the decision must be made either to build a new production line (NPL) or to modify an existing production line (MPL).
  - The payoff for the NPL high demand is ($1,200,000 revenue - $500,000 development cost - $300,000 build cost), or $400,000. For a low demand, the payoff is ($700,000 revenue - $500,000 development cost - $300,000 build cost), or -$100,000.
  - The payoff for the MPL high demand is ($850,000 revenue - $500,000 development cost - $100,000 build cost), or $250,000. For a low demand, the payoff is ($150,000 revenue - $500,000 development cost - $100,000 build cost), or -$450,000.

These data are all shown in the following table.

Decision D1	**Result C1**	**Calculation**	**Payoff**
Do not develop	No action taken	Cost = $0; Revenue = $0	$0
Develop	Unsuccessful: no revenue	Payoff = $0 revenue -$500,000 development cost	**-$500,000**
	Successful	Go to Decision D2 (next table)	

Decision D2	**Result C2**	**Calculation**	**Payoff**
Build New Production Line (NPL)	High Demand	Payoff = $1,200,000 revenue - $500,000 development cost - $300,000 build cost	**$400,000**
	Low Demand	Payoff = $700,000 revenue - $500,000 development cost - $300,000 build cost	**-$100,000**
Modify Production Line (MPL)	High Demand	Payoff = $850,000 revenue - $500,000 development cost - $100,000 build cost	**$250,000**
	Low Demand	Payoff = $150,000 revenue - $500,000 development cost - $100,000 build cost	**-$450,000**

Payoffs are now added to the Decision Tree as shown here.

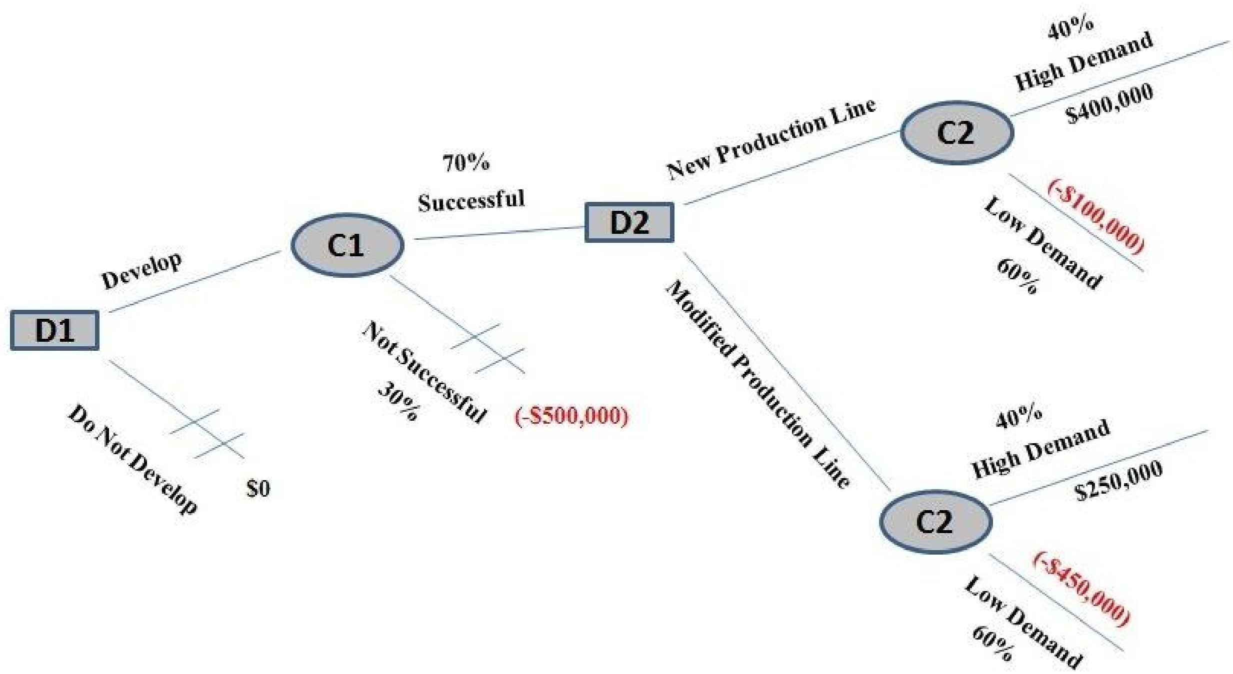


Step 3: Assess Probabilities

The third step is to assess the probability of occurrence for each outcome. This is shown in the chart below. Probabilities of all outcomes of any event must always equal 100%. As an example, the probability of successful development is 70%, making the probability of an unsuccessful development 30%. Probabilities of NPL and MPL high and low demand are also shown in this chart.

Development Successful	70%	NPL High Demand	40%	MPL High Demand	40%
Development Unsuccessful	30%	NPL Low Demand	60%	MPL Low Demand	60%
Total Probability*	100%		100%		100%

These probabilities are now added to the Decision Tree as shown here.



Step 4: Roll-Back

The fourth step is referred to as the Roll-Back. It involves calculating the expected monetary values (EMV) of the payoff for each alternative course of action. The calculation is:

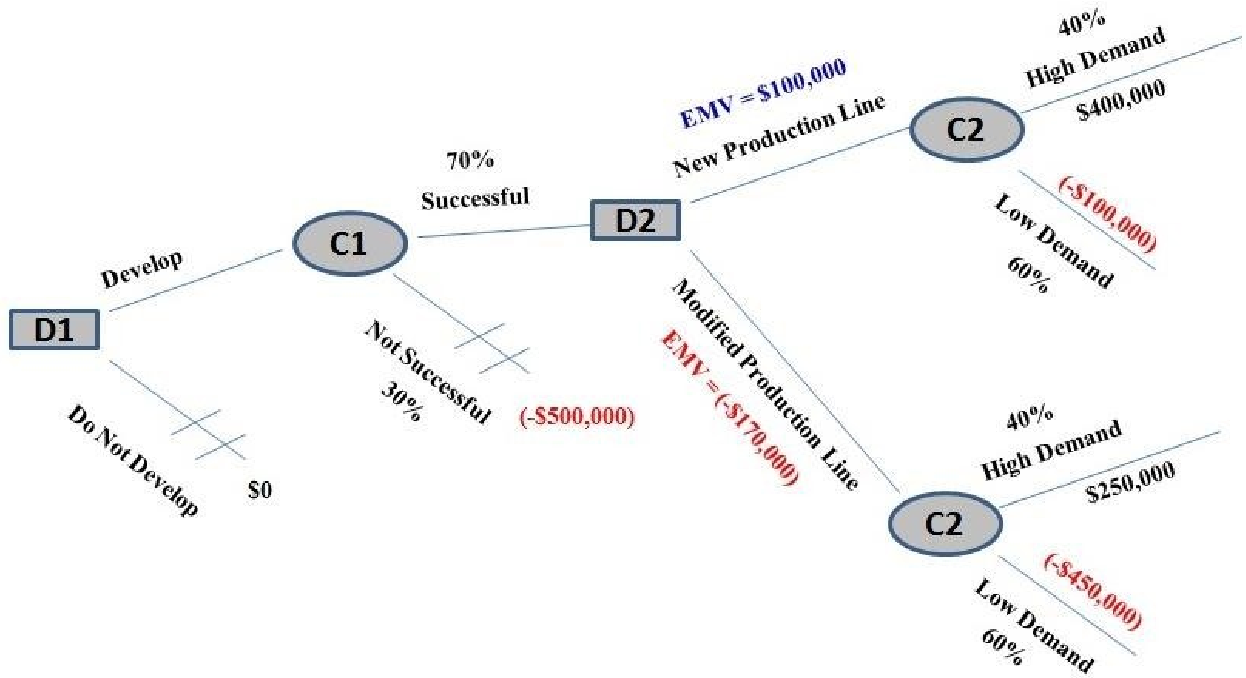
EMV = (probability x payoff)

This is accomplished by working from the end points (right hand side) of the decision tree and folding it back towards the start (left hand side) choosing at each decision point the course of action with the highest EMV. In this example, two decisions must be made: use a new or modified production line, and then whether or not to engage in development.

Decision D2: New Production Line vs. Modified Production Line

New Production Line	vs.	Modified Production Line
EMV = High Demand + Low Demand		EMV = High Demand + Low Demand
= (40% x $400,000) + (60% x -$100,000)		= (40% x $250,000) + (60% x -$450,000)
= $160,000 + (-$60,000)		= $100,000 + (-$270,000)
= **$100,000**		= **(-$170,000)**

EMV values for Decision D2 are now added to the Decision Tree as shown here.



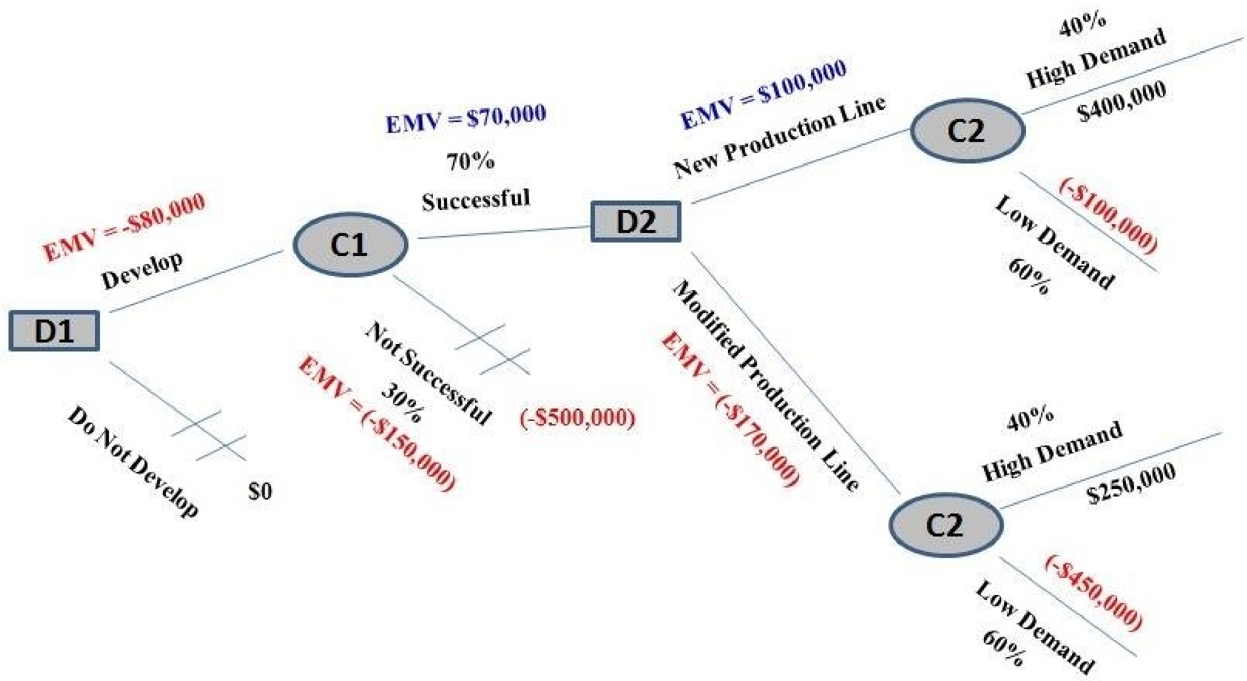
Our Decision Point 2 (D2) decision is to **Use the New Production Line** because it has a greater EMV value of $100,000. Use of the Modified Production Line would result in a financial loss of -$170,000.

Now it is time to make the Develop vs. Do Not Develop decision. We do this by calculating a total EMV using Successful and Not Successful outcomes, as shown here.

Decision D1: Develop or Do Not Develop

Total EMV =	EMV of Successful Development	+	EMV of Unsuccessful Development
	(70% x $100,000)		(30% x -$500,000)
	$70,000	+	(-$150,000)
=	**-$80,000**		

EMV values for Decision D1 are now added to the Decision Tree as shown here.



On the basis of this analysis, our Decision Point 1 (D1) decision is **DO NOT DEVELOP the Product** because the expected financial result is a negative number (-$80,000).

When doing a Decision Tree analysis, any amount greater than zero signifies a positive result. However, the decision to engage in an investment usually will depend on additional considerations such as minimum acceptable Return on Investment. This tool is also very useful when there are multiple cases that need to be compared. When this is done, the case with the highest payoff should be picked.

How to Learn More about This Topic

Courses

Decision-making tools are an important part of any good course on project management. Eogogics offers a large project management curriculum based on the Project Management Institute (PMI®) methodologies.

Those who want a quick but intensive overview of the entire range of project management issues should consider our three-day Effective Project Management Workshop.

Those who need to prepare themselves for the PMI Professional (PMP®) certification should take our four-day Project and Team Management Workshop which has been specifically designed to satisfy the preparation and training requirements of the PMP Professional examination. We also offer a five-day PMP® / CAPM® Exam Preparation workshop.

Books

- Risk and Decision Analysis in Projects by John Schuyler. Project Management Institute, 2001.
- Project Risk Management by Bruce T. Barkley. McGraw-Hill, 2004.
- Identifying and Managing Project Risk: Essential Tools for Failure-Proofing Your Project by Tom Kendrick. AMACOM, 2003.
- Proactive Risk Management: Controlling Uncertainty in Product Development by Guy M. Merritt and Preston G. Smith. Productivity Press, 2002.

Web Resources

- http://en.wikipedia.org/wiki/Decision_tree: A good article on decision trees that also lists some of the software tools used in decision tree analysis.
- www.managementhelp.org Free Management Library is one of the world's largest collections of resources on management topics.
- www.pmi.org PMI develops project management standards as well as certifies project management professionals worldwide. Its Guide to the Project Management Body of Knowledge (PMBOK® Guide), an ANSI (American National Standards Institute) standard, is used worldwide as a reference on how to manage projects.