Object-Oriented Analysis and Design

with the Unified Process

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CALCULATING NET PRESENT VALUE, PAYBACK PERIOD, AND RETURN ON INVESTMENT

A capital investment is an expenditure by an organization in equipment, land, or other assets that are used to carry out the objectives of the organization. Since money—including money available for capital investment—is a scarce resource, one important responsibility of senior-level management of any organization is to decide which of the available alternative investments to choose. Organizations use several different methods to determine which investment is best. The three methods this appendix discusses are net present value (NPV), payback period, and return on investment (ROI). Definitions and brief explanations of these terms are given in Chapter 3. This appendix explains these measures in more detail and shows how to calculate them. More in-depth discussion of the principles behind these measurements, including important concepts about selecting alternatives, can be found in books on finance. You can calculate these measurements by hand using tables for rates and factors. In addition, financial calculators now have built-in function keys to calculate these measures. This appendix demonstrates the manual method to provide an understanding of the principles.

NET PRESENT VALUE CALCULATIONS

The two basic concepts of net present value are (1) that all benefits and costs are calculated in terms of today's dollars (that is, present value) and (2) that benefits and costs are combined to give a net value. Hence the name *net present value*.

discount rate

the annual percentage rate that an amount of money is discounted to bring it to a present value

The first step in calculating the NPV is to decide on the *discount rate* to use. Most organizations have a policy, determined by the chief financial officer, that states the standard discount rate used for investments. This rate may vary by type of investment—we will use the discount rate for software development. The discount rate equates future values to current values. For example, $100 received one year in the future is only worth $94.34 today with a discount rate of .06 (6 percent). The equation that represents this is

present value = amount received in future / (1 + discount interest rate) $^{\text{number of years}}$

discount factor

the accumulation of yearly discounts based on the discount rate

For dollar amounts received more than one year in the future—for example, in three years—the discount rate is applied three times to give a *discount factor.* Let's use *PV* for present value, *FV* for future value, *i* for discount interest rate, *F* for discount factor, and *n* for the number of years in the future. The equations that apply to find a present value for a future value across multiple years are

$$F^n = 1/(1 + i)^n \text{ and } PV = FV * F^n$$

For example, $100 received three years hence at a discount rate of 6 percent is

$$F^n = 1/[(1+ .06) * (1+ .06) * (1+ .06)] = .8396$$
$$PV = \$100.00 * .8396 = \$ 83.96$$

Finance books provide tables of discount factors by discount rate for multiple years, so you do not have to calculate them. Financial calculators have the preceding equations built-in, so you simply enter the future value, the discount rate, and the number of years to get the present value.

Figure C-1 shows the table containing the NPV calculations that were done for Rocky Mountain Outfitters (RMO) in Chapter 3. Notice that the NPV calculation is done over a period of five years. Most organizations have an investment policy that determines the time period allowed for NPV calculations. In this example, RMO policy states that an investment in a new information system must have a positive value within at most five years. Thus, the NPV calculations cover a five-year period. In the figure, year 0 is considered the present year.

	RMO COST BENEFIT ANALYSIS	YEAR 0	YEAR 1	YEAR 2	YEAR 3	YEAR 4	YEAR 5	TOTAL
1	Value of benefits	$ -	$ 889,000	$ 1,139,000	$ 1,514,000	$ 2,077,000	$ 2,927,000	$ 6,122,893
2	Discount factor (10%)	1	0.9091	0.8264	0.7513	0.6830	0.6209	
3	Present value of benefits	$ -	$ 808,190	$ 941,270	$ 1,137,468	$ 1,418,591	$ 1,817,374	$ (1,336,000)
4	Development costs	$ (1,336,000)						
5	Ongoing costs		$ (241,000)	$ (241,000)	$ (241,000)	$ (241,000)	$ (241,000)	
6	Discount factor (10%)	1 -	0.9091	0.8264	0.7513	0.6830	0.6209	
7	Present value of costs	$	$ (219,093)	$ (199,162)	$ (181,063)	$ (164,603)	$ (149,637)	$ (913,559)
8	PV of net of benefits and costs	$ (1,336,000)	$ 589,907	$ 742,107	$ 956,405	$ 1,253,988	$ 1,667,737	
9	Cumulative NPV	$ (1,336,000)	$ (746,903)	$ (4,796)	$ 951,604	$ 2,205,597	$ 3,873,334	
10	Payback period		2 years + 4796 / (4796 + 951,609) = 2 + .005 or 2 years and 2 days					
11	5-year return on investment		(6,122,893 − (1,336,000 + 913,559)) / (1,336,000 + 913,559) = 172.18%					

The anticipated benefits are also associated with the year in which they accrue. Line 1 in Figure C-1 shows the annual benefits of the new system. Notice that these benefits begin in year 1. RMO anticipates that these benefits will increase over time with increased usage and utility from the system. Year 0 is considered to be the period at the beginning of the useful life of the system—that is, the point in time of the initial investment. All of the development costs are assigned to year 0 even if the development project spans multiple years. Line 4 shows the development costs. Annual operating costs, as shown on line 5, are applied to the year in which they occur. Operating costs normally increase over time, since as the system gets older, it frequently requires more maintenance.

You can apply the next two steps in either order: You can either combine the benefits and costs (net them together) and then apply the discount factor, or you can apply the discount factor to the benefits and costs individually and then combine the two discounted amounts. This example uses the second approach and discounts the benefits and costs separately before combining them. (You will see the reason later when we discuss ROI.)

In the example, we have used a discount rate of 10 percent. Notice that in year 0, which is the present, the discount factor is 1.00. Each year thereafter, the factor reduces since it is a continual multiplication of the previous year's factor by $1/(1 + \text{discount rate})$. The discount factors are given in line 2 and repeated on line 6. On line 3 is the present value of each of the future annual benefits, and line 7 has the present value of the future operating costs. Finally, line 8 combines lines 3 and 7 for each year of the benefits and costs.

To obtain the net present value across all the years, you combine the amounts in each column of row 8. Figure C-1 shows a running accumulation, year by year, in row 9. As the figure shows, at the end of five years, the total NPV for this investment is $3,873,334.

PAYBACK PERIOD CALCULATIONS

Payback is a method to determine the point in time at which the initial investment is paid off. Various methods are used to calculate payback. You can calculate the payback period using either present value amounts or cash flow amounts. Cash flow amounts do not take the time value of money into consideration and only calculate based on nondiscounted dollar amounts. Another approach is to consider only the initial investment and not include annual operating costs in the calculations. In our example, we use the time value of money (that is, the discount rate), and also use net benefits (that is, benefits minus operating costs). The year when this value goes positive is the year in which payback occurs. In the RMO example, this happens within the third year.

You can obtain a more precise answer by determining the fraction of a year when payback actually occurs. In this example, the third year began with a deficit of $4,796 and ended the year with a positive value of $951,609. The equation for the fraction of a year is

$$(|\textit{beginning-year amount}| \ / \ (\textit{year-end amount} + |\textit{beginning-year amount}|\ ))$$

where the vertical bars indicate absolute value. For RMO, the fraction of a year before payback is

$$(4796 \ / \ (951,609 + 4796)\ )\ ) = .005$$

Payback thus occurs in 2.005 years. Therefore, the payback period is two years and two days (.005 * 365).

RETURN ON INVESTMENT

The objective of the NPV is to determine a specific value based on a predetermined discount rate. The objective of the return on investment is to calculate a percentage return (like an interest rate) so that the costs and the benefits are exactly equal over the specified time period. Figure C-1 illustrates a return on investment calculation for RMO. The time period can be the expected life of the investment (that is, the productive life of the system), or it can be an arbitrary time period. This example simply calculates the ROI for the five-year period. In another situation, RMO might want to consider a 10-year ROI, assuming the system will be functional for at least 10 years.

Line 11 of Figure C-1 contains the calculations for a five-year return on investment. The process is to use the amounts for the discounted benefits and the discounted costs. These numbers are given on the last column in the table. The equation to calculate ROI is

ROI = (Estimated time period Benefits – Estimated time period Costs) / Estimated time period Costs

For RMO, assuming a five-year benefit period, the ROI is

ROI = (6,122,893 – (1,336,000 + 913,559)) / (1,336,000 + 913,559) = 172.18%

In other words, the investment in the development costs returned over 172 percent on the investment for a period of five years. Obviously, since the system is generating benefits at that point in time, if we assume the lifetime was longer, we would get a much higher ROI.

KEY TERMS

discount rate, p. C-2   discount factor, p.C-2

REVIEW QUESTIONS

1. What is the difference between the following two procedures?
   a. Discount benefits and discount costs first, then net these values together to get a net present value.
   b. Net benefits and costs together first, then discount the combined figure to get a net present value.

2. Explain the difference between the discount rate and the discount factor.
3. How do you determine the time period for NPV? For ROI?
4. What is meant by payback period?

THINKING CRITICALLY

1. Calculate the net present value, the payback period, and the return on investment using a discount rate of 8 percent for the following systems development project. The development costs for the system were $225,000.

YEAR	ANTICIPATED ANNUAL BENEFITS	EXPECTED ANNUAL OPERATING COSTS	DISCOUNT FACTORS AT 8 PERCENT
1	$55,000	$5,000	.9259
2	$60,000	$5,000	.8573
3	$70,000	$5,500	.7938
4	$75,000	$5,500	.7349
5	$80,000	$7,000	.6805
6	$80,000	$7,000	.6301
7	$80,000	$7,000	.5833
8	$80,000	$8,000	.5401