

CHAPTER 7

Making Decisions with Marginal Analysis

How much time should you spend studying for your Microeconomics Exam?

Assume you have ten hours per week to spend on two courses, ECON 102 and CH 203.

The opportunity cost of one hour of studying for economics is that you must give up one hour of study for CH.

But we want to measure this in value, not time, so we consider the grade you would earn. (For now, let's pretend that is all that matters to you.)

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Suppose this is the grade production function for the typical student...

Time Studying Econ	Econ Grade	Time Studying CH	CH Grade
0	-1.0	10	4.0
1	0.0	9	3.9
2	0.5	8	3.7
3	1.2	7	3.4
4	1.9	6	3.0
5	2.5	5	2.5
6	3.0	4	1.9
7	3.4	3	1.2
8	3.7	2	0.5
9	3.9	1	0.0
10	4.0	0	0.0

We are assuming that the relationship between time studying and the grade is more or less identical for the two courses.

The production functions exhibit diminishing marginal returns: studying more improves your grade, but at a diminishing rate.

What is the optimal amount of study time for the exam? It depends on how we value it.

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Let's compare marginal value with marginal cost...

Time Studying Econ	Econ Grade	Marginal Grade Value	Marginal Grade Cost
0	-1.0	-	-
1	0.0	1.0	0.1
2	0.5	0.5	0.2
3	1.2	0.7	0.3
4	1.9	0.7	0.4
5	2.5	0.6	0.5
6	3.0	0.5	0.6
7	3.4	0.4	0.7
8	3.7	0.3	0.7
9	3.9	0.2	0.5
10	4.0	0.1	0.0

Marginal value (MV) is usually falling, and marginal cost (MC) is usually rising – but not always.

If our goal is to maximize our grade average, then we keep studying more for economics as long as $MV > MC$.

If $MC > MV$, then we should study less.

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Suppose you grade in ECON was worth three times as much to you as your grade in CH?

Time Studying Econ	Econ Grade	Marginal Grade Value	Marginal Grade Cost
0	-1.0	-	-
1	0.0	3.0	0.1
2	0.5	1.5	0.2
3	1.2	2.1	0.3
4	1.9	2.1	0.4
5	2.5	1.8	0.5
6	3.0	1.5	0.6
7	3.4	1.2	0.7
8	3.7	0.9	0.7
9	3.9	0.6	0.5
10	4.0	0.3	0.0

In this case, your marginal value is always worth more than the marginal cost, and you will get an A in Econ but an F in CH.

If the Econ grade was worth only twice as much, you would get a B+ in Econ and a D+ in CH.

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Decision Making

There are two basic types of decisions:

Either/or (discrete): purchasing a car, registering for a class, et cetera.

How much (continuous): how much to drive, how much to study, how often to eat out, et cetera.

In either case, we look at the costs and benefits, but the second type is best analyzed on the margin.

In the real world, we have imperfect information. A discrete choice might be based on a best guess, while a continuous choice often begins with a rule-of-thumb, and experimentation.

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Should you register for ECON 102?

Assume you value your time at \$5/hour, after taxes, and credits costs \$100 each.
 Past experience (from high school, perhaps) tells you that you can get a B with 4 hours per week of studying, and a B is worth \$700 to you.

Should you register? This is an either/or choice.

- > Marginal Value = \$700.
- > Marginal Cost = 3 cred. x \$100 + 15 wks. x 4 hrs. x \$5 = \$600.
- > Yes.

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Adjusting your Decision

It is suddenly the 5th week of school, and you want to know if you should study more or study less – a continuous choice – or drop, a discrete choice.

New information: you have now learned that a B takes you 6 hours per week, not 4 (which gets you a C).

Would you have registered had you known? No, because $\$700 < 3 \times \$100 + 15 \times 6 \times \$5 = \$750$.

Should you drop? If tuition and time already spent are sunk costs, then No because $\$700 > 10 \times 7 \times \$5 = \$350$.

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So you have decided to remain in the class anyway...

How much should you study? Right now you are on track to get a C with 4 hours per week, and suppose a C is worth only \$400 to you.

An average of 6 hours (5 weeks x 4 hours + 10 weeks x 7 hours) will get you a B, which is worth \$700. Since 3 extra hours per week will cost you $10 \times 3 \times \$5$, then the Marginal Benefit (\$300) exceeds the Marginal Cost (\$150). You should study for at least a B.

Suppose a B+ is worth \$800 to you, but this takes an average of 7 hours per week. Once you are on track for a B, then a B+ has a marginal benefit of \$100 and a marginal cost of \$75 (15 hours x \$5). You should study for at least a B+.

Suppose an A- is worth \$850 to you, but this takes an average of 8 hours per week. Once you are on track for a B+, then an A- has a marginal benefit of \$50 and a marginal cost of \$75 (15 hours x \$5). You should stop, and settle for a B+.

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Opportunity Cost and Decisions

An **explicit cost** is a cost that involves actually laying out money.

An **implicit cost** does not require an outlay of money; it is measured by the value, in dollar terms, of the benefits that are forgone.

Costs can be monetary (pecuniary) or not. Nonpecuniary costs are still real, but harder to measure. One approach is "willingness to pay" based on observed behavior. How does one value marriage or children?

Even free goods may have opportunity costs: See the reading on subsidized water for farmers versus consumers or the environment.

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Opportunity Cost and Decisions

Should you go to graduate school for a year after you graduate from college?

What are the costs of doing so?

Obviously the cost of tuition, books, a computer etc are part of the overall costs. These costs are explicit, monetary costs. But other costs need to be considered.

Suppose you are offered a job paying \$35,000 upon graduation. If you decide instead to go to graduate school, you are giving up that amount of money per year of graduate school as an implicit cost.

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Opportunity Cost and Decisions

TABLE 7-1

Opportunity Cost of an Additional Year of School

	Explicit cost		Implicit cost
Tuition	\$7,000	Forgone salary	\$35,000
Books and supplies	1,000		
Home computer	1,500		
Total explicit cost	9,500	Total implicit cost	35,000
Total opportunity cost = Total explicit cost + Total implicit cost = \$44,500			

Table 7-1
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Profit and Cost

Firms must also take into consideration these implicit costs when they determine their profit.

Profit is defined as what is left over after all costs have been taken from the total revenue. We will look at two kinds of profit.

Explicit costs to a firm are the actual cash payments for resources. These include

- Wages for labor
- Rent for the resources used
- Taxes to governments
- Capital costs, etc.

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Implicit Costs to a Firm

But a firm also incurs implicit costs.

These costs are the opportunity costs of using resources owned by the firm or provided by the firm's owners.

These costs require no cash payment and no entry in the firm's accounting statement, which only records the firm's revenues and explicit costs.

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Different Kinds of Profits

There are two kinds of profit

- Accounting profit
A firm's total revenue minus its explicit costs and depreciation.
- Economic profit
A firm's total revenue minus its opportunity costs which may include implicit as well as explicit costs

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Alternative Measures of Profit

To explain the differences among the two types of profit, look at the following example of an entrepreneur who starts her own business.

Wanda Wheeler currently earns \$50,000 in her current job as an aeronautical engineer.

Wanda has an idea about a new design for a more friction-resistant airplane wheel. She decides to start her own business making these wheels. She calls her new company *Wheeler Dealer*.

She quits her job and withdraws \$20,000 from her savings account to purchase materials and equipment.

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Alternative Measures of Profit

She hires an assistant at \$21,000 and uses a spare bay in her garage that she could rent out for \$1,200 a year.

The first year, she makes \$105,000 in sales.

Her accounting profit is \$64,000 [$\$105,999 - (\$21,000 + \$20,000)$].

However, accounting profit is not the total story. She also must consider her implicit costs.

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Opportunity Costs

The opportunity costs for Wanda's business are

- \$50,000 foregone business salary;
- \$1,000 foregone interest on the \$20,000 she withdrew from her savings (5%); and
- \$1,200 foregone rental from her garage bay.

Implicit costs are \$52,200, and her economic profit is $\$64,000 - \$52,200 = \$11,800$.

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Opportunity Costs

Her actual economic profit has to take these costs into account.

The actual economic profit is the difference between her accounting profits and her opportunity costs.

A company that meets its opportunity costs is sometimes said to have earned a **normal** profits.

The following slide shows the results after the first year

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Accounts of Wheeler Dealer 2004

Total revenue		\$105,000
Less explicit costs:		
Assistant's salary	-\$21,000	
Material and equipment	-\$20,000	
Equals accounting profit		\$64,000
Less implicit costs:		
Wanda's forgone salary	-\$50,000	
Forgone interest on savings	-\$1,000	
Forgone garage rental	-\$1,200	
Equals economic profit		\$11,800

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Economic Profit

As long as Wanda is making an economic profit, she should continue to run the firm.

If her revenue drops to \$90,000, she will have made an accounting profit of \$49,000, but her economic profit would be negative.

She would be better off going back to her old job, unless we expect her revenue to rise again in the future or unless there are nonpecuniary benefits from running her own company.

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Marginal Analysis

Marginal analysis requires us to compare the benefit of doing a little bit more of an activity with the cost of doing that little bit more.

Marginal analysis is called that because we always make decisions at the margin.

We push the edge farther out and see if it is a good move.

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Marginal Cost

Suppose Felix owns a lawn mowing company and is able to mow one lawn per hour.

His only costs are the opportunity costs of his time and the maintenance costs of his lawnmower.

Suppose that the cost of his time is \$10 per hour because that is what he could earn in his next best choice of employment.

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Marginal Cost

The maintenance costs of his lawnmower are minor if he cuts one lawn, only \$0.50.

His total cost to mow one lawn is \$10.50.

If he mows a second lawn, his opportunity cost is the same but his maintenance costs will increase to \$1.25.

Total cost of mowing two lawns is \$21.75.

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Marginal Cost

His marginal cost for mowing the second lawn is \$11.25.

For each additional lawn, his maintenance costs will increase more.

He has to add more oil, sharpen the blade, etc.

A table of his marginal costs follows.

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Marginal Cost

The **marginal cost** of an activity is the additional cost incurred by doing one more unit of that activity.

Felix's Marginal Cost of Mowing Lawns

Quantity of lawns mowed	Felix's total cost	Felix's marginal of lawn mowed
0	\$0	
1	10.50	\$10.50
2	21.75	11.25
3	35.00	13.25
4	50.50	15.50
5	68.50	18.00
6	89.25	20.75
7	\$113.00	23.75

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Increasing Marginal Cost

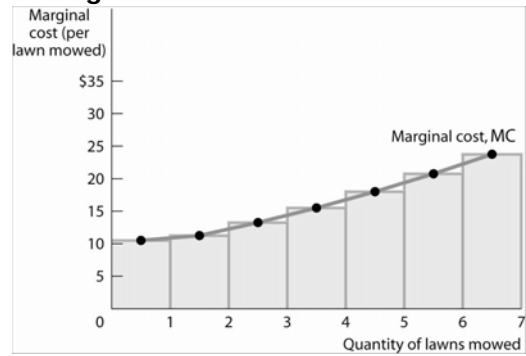
Felix's marginal cost is greater the more lawns he has already mowed.

That is, each time he mows a lawn, the additional cost of doing yet another lawn goes up.

There is **increasing marginal cost** from an activity when each additional unit of the activity costs more than the previous unit.

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Felix's Marginal Cost of Mowing Lawns: The Marginal Cost Curve



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Marginal Benefit

The other side of the coin are the benefits that Felix receives for his lawn mowing services.

Some people are willing to pay more than others so on any particular day people will pay him \$35 for the first lawn he mows, \$30 for the second, \$26 for the third and so on.

His marginal benefit will be the additional amount he receives for mowing another lawn.

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Marginal Benefit

The **marginal benefit** from an activity is the additional benefit derived from undertaking one more unit of that activity.

Felix's Marginal Benefit of Mowing Lawns

Quantity of lawns mowed	Felix's total benefit	Felix's marginal benefit of lawn mowed
0	\$0	
1	35.00	\$35.00
2	65.00	30.00
3	91.00	26.00
4	114.00	23.00
5	135.00	21.00
6	154.00	19.00
7	\$172.00	18.00

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Decreasing Marginal Benefit

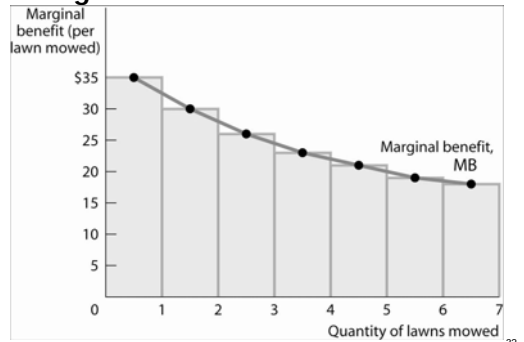
Each additional lawn mowed produces less benefit than the previous lawn

With decreasing marginal benefit, each additional unit produces less benefit than the unit before.

There is **decreasing marginal benefit** from an activity when each additional unit of the activity produces less benefit than the previous unit.

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Felix's Marginal Benefit of Mowing Lawns: The Marginal Benefit Curve



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Marginal Analysis

So how many lawns should Felix mow?

The **optimal quantity** of an activity is the level that generates the maximum possible total net gain.

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Marginal Analysis

The **principle of marginal analysis** says that the optimal quantity of an activity is the quantity at which the Marginal Value (or benefit) **is equal to** the Marginal Cost.

(With discrete choices, we choose to do something as long as the $MV > MC$.)

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Felix's Net Gain from Mowing Lawns

Quantity of lawns mowed	Felix's marginal benefit of lawn mowed	Felix's marginal cost of lawn mowed	Felix's net gain of lawn mowed
0			
1	\$35.00	\$10.50	\$24.50
2	30.00	11.25	18.75
3	26.00	13.25	12.75
4	23.00	15.50	7.50
5	21.00	18.00	3.00
6	19.00	20.75	-1.75
7	18.00	23.75	-5.75

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Total Net Benefits

Felix will continue to mow lawns until it no longer pays him to do so.

- ❖ At 4 lawns, his total benefits are \$114 and his total costs are \$50.50 which is a \$63.50 difference.
- ❖ At 5 lawns, his total benefits are \$135 and his total costs are \$68.50 which is a \$66.50 difference. He would mow the 5th lawn because his net benefits increase.
- ❖ For the 6th lawn, total benefits are \$154 and costs are \$89.25 which is a difference of \$64.75. Net benefits have decreased so Felix will stop mowing after the 5th lawn.

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Marginal Analysis

The same result occurs when we look at marginal costs.

When he mows the 5th lawn, he will make an additional \$3 but if he mows a 6th lawn, he will lose \$1.75.

Therefore, Felix will stop mowing after the 5th lawn.

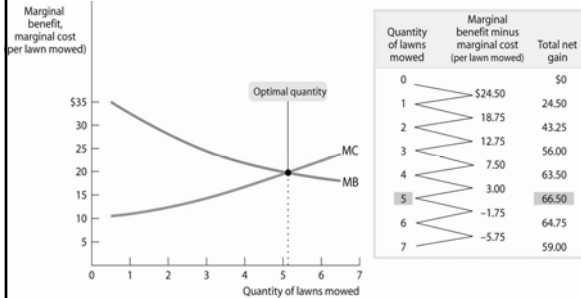
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Felix's Net Gain from Mowing Lawns

Quantity of lawns mowed	Felix's marginal benefit of lawn mowed	Felix's marginal cost of lawn mowed	Felix's net gain of lawn mowed
0	\$35.00	\$10.50	\$24.50
1	30.00	11.25	18.75
2	26.00	13.25	12.75
3	23.00	15.50	7.50
4	21.00	18.00	3.00
5	19.00	20.75	-1.75
6	18.00	23.75	-5.75

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The Optimal Quantity



The optimal quantity of an activity is the quantity at which the *marginal benefit curve* and the *marginal cost curve* intersect.

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Sunk Cost

In making decisions for future actions, some costs should be ignored.

These costs are called **sunk costs**.

A sunk cost is a cost that has already been incurred and is not recoverable.

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Sunk Cost

For example, suppose Felix spends \$600 to replace the brakes on the truck he uses to get his lawnmower from job to job.

He then learns that his engine must be overhauled. He has a choice of overhauling it for \$2000 or buying another truck for \$2200. What should he do?

With the brake job and overhaul, his total outlay is \$2,600 compared to \$2200 for purchasing the other truck.

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Sunk Cost

Should he buy the other truck rather than overhauling the one he has?

If he had known about the engine before the brakes were fixed, he would have chosen the option of replacing his old truck.

However, that cost is already paid and can't be gotten back.

It may be frustrating that he paid the money for the brakes but that is a sunk cost that should not be considered in his present decision.

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What if the outcome is uncertain?

What if raising your grade from a B to an A leads to a 1% better chance of getting a better job after graduation that earns \$10,000 more per year. The expected marginal value of this is \$100 per year.

In general, expected Value = sum of all probabilities times value of all outcomes, or:

$$EV = p_1 \times O_1 + p_2 \times O_2 + p_3 \times O_3 + \dots + p_n \times O_n$$

where $p_1 + p_2 + p_3 + \dots + p_n = 1$

If there is a 80% chance of losing \$1, a 15% chance of making \$2, a 4% chance of making \$5, and a 1% chance of making \$20, then the expected value = -10 cents per dollar gambled. This is how casinos make money at video poker.

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Time Decisions

Many decisions have an element of time in them.

Usually it means that a payout of costs occurs now but the benefits received will not occur until some time in the future.

Sometimes, there will be decisions that receive immediate benefits for which costs must be paid in the future.

Which is more valuable? \$1000 received immediately or \$1000 received a year from now?

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Time Decisions

For most people, the money received now is more valuable because it is available immediately to spend.

Most people would require some kind of inducement before they would be willing to postpone receiving that money.

That inducement is usually stated as some percentage of the amount that is added on to the total. That percentage is known as **interest**.

For example, if you are lending \$1000 to a bank (which you do when you make a deposit), you want some kind of payment for the use of your money.

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Time Decisions

If the interest rate is 3%, then you expect \$30 ($.03 \times \1000) at the end of a year in addition to the \$1000 loan.

So the value of \$1000 today a year from now is \$1030.

We can also look at this from the other direction

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Time Decisions

Suppose you are to receive \$1000 one year from now.

However, you would like to spend the money now so you borrow from a bank, intending to pay it back with the money you receive at the end of the year.

However, you can't simply borrow \$1000 because the bank charges interest and that \$1000 will have the interest charges added on.

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Time Decisions

Suppose you can borrow at 3% interest. How much can you borrow today such that you will owe exactly \$1000 a year from now?

Let's return to our lending the bank \$1000. After a year we got back \$1030. The formula to find that amount was $\$1000 \times (1.03)$.

This is called the **future value** (FV) formula. Generalizing:

$$FV = \text{Present Amount} \times (1+r)$$

where r is the interest rate.

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Time Decisions

We can now use this formula to find out what the value of \$1000 received a year from now is worth today.

This result is called the **present value** (PV) of future income.

$$PV = \frac{FV}{(1+r)} = FV*(1+r)^{-1}$$

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Compounding Interest over Time

These results apply to situations where there is a single time period over which interest is paid.

Suppose that you are lending your money to a bank which pays 3% interest at the end of each year and you want to leave your money there for 2 years.

After one year, you have \$1030. At the end of the second year you will have \$1030 + (.03*\$1030) = \$1030 + \$30.90 = \$1060.90.

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Compounding Interest over Time

The formula for this is

$$FV = \text{present amount (or value)} * (1.03)^2$$

In general

$$FV = PV*(1+r)^n$$

And $PV = FV*(1+r)^{-n}$

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Compounding Interest over Time

Most bank deposits today don't pay interest at the end of a year. Rather they pay daily and **compound** your interest over the year.

Suppose you deposit \$1000 in a bank which pays 3% interest compounded daily. Simple interest at the end of the year would yield \$1030; how would daily compounding be different?

Daily interest would be $.03/365 = .0000821918$.

$$FV = \$1000*(1+.0000821918)^{365}$$

$$FV = \$1030.45$$

So you would gain \$0.45 more from compounding than for simple interest.

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Discounting

Finding the present value of a sum received in the future or the future value of a present amount is called **discounting**.

Both future costs and future benefits can be discounted to their present value.

This is useful if we are trying to compare the values of different projects.

The **net present value** (NPV) of a project is the present value of current and future benefits minus the present value of current and future costs. In comparing projects, we would want to choose those that give the highest NPV.

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Net Present Value

Suppose we have three projects

Project A - We get \$100 today and nothing in the future

Project B - Pay \$10 today and get \$115 a year from now.

Project C - We get \$119 today but we have to pay \$20 a year from now.

Suppose we assume an interest rate of 10%

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TABLE 7-7

The Net Present Value of Three Projects

Project	Dollars realized today	Dollars realized one year from today	Present value formula	Net present value given $r = 0.10$
A	\$100	—	\$100	\$100.00
B	-\$10	\$115	$-\$10 + \$115/(1+r)$	\$94.55
C	\$119	-\$20	$\$119 - \$20/(1+r)$	\$100.82

Table 7-7
Krugman and Wells: Microeconomics
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Net Present Value

What would happen if the interest rate was 5% instead?

Project A – NPV = \$100 (no change)

Project B – NPV = \$99.52

Project C – NPV = \$99.95

Therefore, high interest rates lead to deeper discounts and smaller NPVs. Low interest rates lead to higher NPVs.

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Multiple Outcomes? Just add them up.

What if raising your grade from a B to an A leads to a 1% better chance of getting a better job in four years (after graduation) that earns \$10,000 more per year. The expected marginal value of this is \$100 per year for forty years. The present marginal value of raising your grade from a B to an A would be:

$$\begin{aligned}
 MV &= EV_4 (1+r)^{-4} + EV_5 (1+r)^{-5} + \dots + EV_{43} (1+r)^{-43} \\
 &= \$2115, \text{ if } r = 3\% \\
 &= \$734, \text{ if } r = 10\%
 \end{aligned}$$

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