

EC371 – Environmental Economics

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Practice Problems for Unit 2: Cost-Benefit Analysis

There are three problems. Please read and think about them carefully, and work through them before looking at the solutions. If you are having trouble, you can seek clarification and help from classmates and during my office hours, but it is highly recommended that you struggle through the questions yourself first. Your goal should be both to learn the mechanics and to grasp the intuition and think more deeply about the issues. Solutions will be posted around the afternoon of Thursday, October 13, 2011. If you would like comments on your work and solutions, you can submit them to me at any time.

1. Consider a coastal area that is currently not in use and on which society does not place intrinsic value. The government is considering developing the area, and has two projects in mind. The first project is to build a marine amusement park. The initial construction cost of the park will be \$970, and there will additionally be annual maintenance costs of \$130 each year that the park operates after the year in which it is built. The government also wants to consider the fact that people who use the park will not undertake other forms of leisure that they would have undertaken in the absence of the park; they estimate the value of this foregone recreation as \$20 per year beginning the year after the park is built; this represents an additional recurring annual cost. The government expects that \$300 in tourism revenue will be earned per year beginning the year after the park is built, representing the recurring annual benefit of the project. The second project is to mine the coral reef off of the coast for limestone. The extraction cost (paid once in year 0) is \$3,200, and revenues of \$4,500 are realized once only, immediately in year 0. However, the removal of the reef will set in motion a process of continuous coastal erosion, and this damage is estimated at \$200 per year beginning the year after extraction. (The two projects are mutually exclusive because the removal of the reef will destroy the value of the area for marine recreation.)

a) Suppose the government sets a 10-year time horizon (i.e. years 1 through 10 inclusive, but also considering the initial year 0) for comparing the two projects. (The government places zero weight on future periods in which a new administration will be in place.) Suppose further that the government requires use of a discount rate equal to 5% for performing cost-benefit analyses. Calculate the net present value of the two projects. On this basis, would you recommend that the government undertake one project over the other? Is either of the projects preferred to the status quo according to the net present value criterion?

b) Suppose instead that the government requires use of a 10% discount rate. Still using the 10-year time horizon, re-calculate the net present value of each project. Would you make a different recommendation to the government compared to part a) based on this calculation? Give some intuition about why this is the case.

c) Now suppose that the government cares about all future periods and so requires the use of an indefinite time horizon. Calculate the net present value of each project using both a 5% and a 10% discount rate. Does the choice of these two discount rates have any effect on the recommendation that you would give to the government on the basis of the net present value criterion?

2. (Adapted from *Economics and the Environment* by Eban S. Goodstein.) Consider a hotel owner who is taking a 40-year perspective on renovating the hotel. There are two options for light bulbs to be used in each of the 1,000 fixtures in the hotel. Suppose that each fluorescent bulb costs \$15 and each

incandescent bulb costs \$1, and that fluorescent bulbs last 40 years but incandescent bulbs last only 4 years. The annual electricity cost of using 1,000 incandescent bulbs would be \$2,800 while the annual electricity cost of using 1,000 fluorescent bulbs would be \$800.

a) What (conceptually) would the hotel owner want to use for a discount rate and why? Supposing that the owner decides to use a discount rate of 5%, calculate the present value of costs for each type of light bulb. The annual electricity cost will be borne each year starting in year 1 and continuing through year 40. Bulbs will be purchased once, in year zero (either the one set of fluorescents or the ten sets of incandescents required for the full time horizon). On the basis of a lower present value of costs, what type of bulb would you recommend that the hotel owner install?

b) Repeat the calculation, but this time consider the possibility that there is some uncertainty in the energy efficiency of incandescent bulbs. Specifically, suppose that there is a 60% chance that the bulbs will be of regular efficiency (annual electricity costs will be \$2,800) and a 40% chance that the bulbs will be of a higher efficiency (annual electricity costs will be \$1,300). Does this change your recommendation?

c) Now suppose that, instead of a private hotel owner, an identical decision is being made by the government concerning, for example, a building that is open to the public. Will the government want to do anything differently in undertaking the cost analysis?

3. (Adapted from *Environmental and Natural Resource Economics: A Contemporary Approach* by Jonathan M. Harris.) The World Bank is considering a proposal from the country of Equatoria for a large dam project. Construction costs will be \$500 million per year in each of “year -2”, “year -1” and year 0. Operating costs as of year 1 will be \$50 million per year. In addition, there will be costs associated with lost agricultural land of \$40 million per year and associated with lost forest lands of \$20 million per year, again beginning with dam operation in year 1. There will also be costs associated with displaced villagers, watershed damage and ecosystem destruction, but estimates of the monetary value of these costs are not available. The benefits as of the beginning of dam operation will be annual production of 3 billion kilowatt hours of electricity (valued at the market price of \$0.05 per kilowatt hour) and 5 billion gallons of water available for irrigation (valued at the market price of \$0.015 per gallon).

a) Suppose that the time horizon of the project is 20 years and that the discount rate to be used for evaluating the project is 12%. In the 21st year, the dam and all of the affected land will be sold to a private oil exploration company for \$9.6 billion. Calculate the net present value of the dam project taking into account all quantifiable costs and benefits. On this basis, should the World Bank approve Equatoria’s proposal, reject it or explore it in more detail? (Hint: it will be easiest to bring the construction costs in years -2 and -1 up to present value as of year 0. Just do this by multiplying by the discount factor raised to the appropriate power. Convince yourself that it makes sense that \$500 paid two years ago is more costly than \$500 paid today. This is a simple way to compress all start-up values into year 0, then proceed as we usually would.)

b) Suppose the World Bank eventually rejects the proposal, but suggests the following alternative project: several small-scale dams will be constructed instead of a single large dam. This alternative project will lead to virtually zero costs due to lost agricultural and forest land, as well as to displacement and watershed and ecosystem damage. Electricity and water production will be half as much per year as with the large dam (while their respective prices will remain constant), but annual operating costs will also be halved. Construction will still be spread over years -2, -1 and 0, but costs will be only \$210 million in each of these years for this alternative project. It will no longer be possible to sell the land with this alternative project, so the government would be required to adopt an infinite planning horizon. Still using a discount rate of 12%, calculate the net present value of this alternative project. Does it seem desirable?