Economics 416 – A01: Cost Benefit Analysis: Principles and Application

Spring term 2014: MR 10:00-11:20 in Cornett A225; Course number 20901

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Course description: This course introduces students to the principles of cost benefit analysis including consideration of welfare economics, the treatment of intangibles, non-efficiency considerations, time discounting, evaluation criteria, uncertainty and risk. Selected applications relate to such areas as human resource economics, natural resource and recreation economics, economic development and urban planning.

Course outline:

Jan. 6 to Jan. 20 Part One: Conceptual Foundations of Cost Benefit Analysis (5 classes)
(a) Program evaluation and cost benefit analysis (CBA)
(b) The positive net social benefits criterion
(c) Consumer surplus and producer surplus
(d) Measuring costs and benefits in undistorted markets
(e) Elasticities, incidence effects and deadweight losses
(f) Compensating variation and equivalent variation
(g) Measuring costs and benefits with distorted markets
(h) Unemployed labour and CBA
(i) The shadow price of labour

Jan. 23 to Feb. 17 Part Two: Net Present Value and the Choice of Discount Rate (6 classes)
(a) The timing of benefits and costs
(b) Comparing projects of different length
(c) The social discount rate
(d) The social opportunity cost of capital
(e) Sensitivity analysis and the discount rate
(f) The shadow price of capital
(g) Expected surplus and option price
(h) Information and quasi-option value
(i) Public-private partnerships and CBA
(j) Worst case, best case scenarios
(k) CBA and distributional issues

Feb. 10 to Feb. 14 Family Day and Midterm Break (no classes)

Feb. 20 First midterm examination (25 marks)
Feb. 24 to Mar. 10  Part Three: Urban Transportation Issues and CBA
(5 classes)
(a) Modelling the urban economy
(b) The opportunity cost of travel time
(c) The statistical value of life
(d) Congestion externalities and the private automobile
(e) Transportation infrastructure decisions
(f) Recent transportation examples

Mar. 13 to Apr. 3  Part Four: Environmental Valuation Issues and CBA
(5 classes)
(a) Harvest, amenity, ecosystem-service and existence values
(b) Recreational amenities: the travel cost method
(c) Externalities: the hedonic pricing method
(d) Avoided costs and defensive expenditures
(e) Existence values and the contingent valuation method
(f) Benefit transfer: shadow prices from secondary sources
(g) Multiple accounts, cost-effectiveness analysis and CBA
(h) Cost-effective abatement incentives
(i) Land use planning, recreational resources and CBA
(j) Adventure tourism and recreation: the contribution of nature

Mar. 17  Second midterm examination (25 marks)
Mar. 20  Class cancelled due to prior commitment
Apr. xx  Final Examination (50 marks)

Workshop Assignments, Examinations, and Grading Equivalencies:

Students are urged to work, either individually or in groups, on the assigned workshop problems outlined below prior to the discussion of these problems in class. Some of these assigned problems are related to questions in the Boardman textbook. Assignments will not be marked, and course grades will depend entirely upon examinations, as follows:

Midterm exam one: 25%  Midterm exam two: 25%  Final examination: 50%

A+ = 90-100%  A = 85-89%  A- = 80-84%  B+ = 77-79%
B = 73-76%  B- = 70-72%  C+ = 65-69%  C = 60-64%
D = 50-59%  F = 0-49%

Plagiarism and cheating: Students are expected to observe the same standards of scholarly integrity as their academic and professional counterparts. Students who are found to have engaged in unethical academic behaviour, including the practices described in the Calendar, are subject to penalty by the University. Inclusivity and diversity: The University of Victoria is committed to providing an environment that affirms and promotes the dignity of human beings of diverse backgrounds and needs. Travel plans: Students are advised to study the final examination timetable before making any end-of-term travel plans.
Workshop Problems:

Problem One (to be discussed in class on Thursday, January 16):

A country imports 3 billion barrels of crude oil per year and domestically produces another 3 billion barrels of crude oil per year. The world price of crude oil is $18 per barrel. Assuming linear schedules, economists estimate the price elasticity of domestic supply to be 0.25 and the price elasticity of domestic demand to be -0.10 in the neighbourhood of the current equilibrium.

(a) Assuming that the world price of crude oil does not change when the country imposes a $6 per barrel import duty on crude oil, determine the domestic price, and the three quantities: domestic consumption, domestic production, and import volume after the imposition of the import duty.

(b) Calculate the impact on producer surplus, consumer surplus, and government revenues. Also calculate the net social benefits associated with the imposition of the import duty.

(c) and (d) Redo the calculations under (a) and (b) on the assumption that the reduction in the country’s demand for crude oil reduces the world price by $2 per barrel.

(e) By how much does the “terms of trade effect” of the import duty (i.e., the import price reduction impact) offset the efficiency losses (i.e., what are the net social benefits to the importing country)? If foreign exporters were also given standing in the cost-benefit calculation, would overall welfare be increased?

Problem Two (to be discussed in class on Thursday, January 23):

Consider a low-wage labour market. Workers in this market are not presently covered by minimum wage legislation, but the government is considering implementing such legislation. If implemented, legislation would require employers in the market to pay workers a $5 hourly wage.

Suppose that all workers are equally productive, that the current market-clearing wage rate is $4 per hour, and that at this market-clearing wage there are 600 employed workers. Suppose further that under the minimum wage legislation, only 500 workers would be employed and 300 workers would be unemployed, although just 100 of these workers would newly become unemployed. (The other 200 were not in the labour market at the $4 per hour wage rate.) Finally, assume that the market demand and supply schedules are linear and that the market reservation wage, the lowest wage at which any worker would be willing to work, is $1.

Compute the dollar value of the impact of the policy

(a) on employers,

(b) on the 500 workers who remain employed,

(c) on the 100 workers who newly become unemployed, and

(d) on society as a whole.
Problem Three (to be discussed in class on Thursday, January 30):

A town’s recreation department is trying to decide how to use a piece of land. One option is to put up basketball courts with an expected life of 8 years. Another option is to install a swimming pool with an expected life of 24 years. The basketball courts would cost $180,000 to construct, and yield net benefits of $40,000 at the end of each of the 8 years. The swimming pool would cost $2.25 million to construct, and yield net benefits of $170,000 at the end of each of the 24 years. Each project is assumed to have zero salvage value at the end of its life.

(a) Using a real discount rate of 4 percent, which project offers the larger net benefits?

(b) Would the answer be the same if the real discount rate were 5%?

(c) Use both the equivalent annual net benefit (EANB) method and the roll-over method to generate your answers, and demonstrate that the two methods provide the same answer.

To facilitate your NPV calculations, please note that the annuity factors (the present value of one dollar per annum) for 24 years at 4% and 5% discount rates are 15.2470 and 13.7986, respectively, and that the annuity factors for 8 years at 4% and 5% discount rates are 6.7327 and 6.4632, respectively. In addition, the present value of $1, taken 8 years hence, at 4% is 0.7307, and at 5% is 0.6768, while the present value of $1, taken 16 years hence, at 4% is 0.5339, and at 5% is 0.4581.

Problem Four (to be discussed in class on Thursday, February 6):

The initial capital cost of constructing a permanent dam (i.e. a dam that is expected to last forever) is $425 million. The annual net benefits, measured in constant dollars, begin to accrue at the end of the first year, and depend upon the amount of rainfall: $18 million in a ‘dry’ year, $29 million in a ‘wet’ year, and $52 million in a ‘flood’ year. Meteorological records indicate that over the last 100 years there have been 86 ‘dry’ years, 12 ‘wet’ years, and 2 ‘flood’ years.

(a) Use the meteorological records to calculate the expected annual net benefits from operating the dam.

(b) Calculate the expected surplus (net present value) generated by the dam project if the real discount rate is 5% per annum and, alternatively, if it is 4% per annum.

(c) Calculate the internal rate of return (i.e., the break-even discount rate) associated with the dam project, and explain why the dam should only be constructed if the discount rate is less than the internal rate of return.

Problem Five (to be discussed in class on Monday, February 17):

A resource development project in a sparsely populated region has the following characteristics:

- Capital costs incurred by the private operating firm: $30 million (year zero)
- Road construction costs incurred by government: $20 million (year zero)
- Operating period: years one to twenty
Annual revenues received from the sale of resource products: $12 million
Annual royalty transferred to government: $1.5 million
Annual non-labour operating costs: $1 million
Annual number of operating employees: 100
Annual wages and benefits per operating employee: $60,000
Annual recreational benefits of access road to local residents: $0.4 million
Terminal land reclamation costs incurred by operating firm: $16 million (year 20)
Discount rate applicable to all stakeholders: 8% per annum.

(a) Calculate the net present value (NPV) of the project from the perspective of the private operating firm, and demonstrate that the project is marginally viable from this perspective.

(b) and (c) Calculate the net present value of the project from a social cost-benefit analysis perspective under the following two scenarios, and explain why these scenario-specific NPVs differ:
   (b) the alternative market wage and benefit package that could have been earned by all 100 operating employees is $60,000; and
   (c) half of the operating employees could alternatively have earned $60,000, but the other half would have had smaller incomes (or a reservation wage) of $50,000, thus implying a “shadow wage rate” of $55,000.

(d) For each of these scenarios, prepare a cost-benefit table of NPV values that shows:
   (i) Producer surplus accruing to the private operating firm,
   (ii) Producer surplus accruing to operating employees,
   (iii) Consumer surplus accruing to recreational users of the road,
   (iv) Financial consequences of the project for government, and
   (v) Net social benefits bottom line.

(e) On the basis of the usual cost-benefit criterion, under which of these scenarios would it be desirable for society to proceed with the project? Does this example suggest that a “roads to resources” program can sometimes be interpreted as a disguised wage subsidy?

To facilitate your NPV calculations, please note that the present value of one dollar per annum for twenty years at an 8% discount rate is $9.818, and that the present value of one dollar in year twenty at an 8% discount rate is $0.2145.

Problem Six (to be discussed in class on Thursday, February 27):

A newly-established ski-resort is contemplating building several ski-lifts, whose initial capital cost would be $10 million. The lifts are expected to remain in service for ten years before replacements are required, after which there would be a $2 million decommissioning cost before new lifts could be put in place.

The net operating revenues that could be earned by the ski-resort operator are dependent upon snow conditions. It is anticipated that there is a 10% chance of a no snow year, which would generate a net operating loss of $2 million, a 70% chance of a normal snow year, which would generate net operating income of $2 million, and a 20% chance of a big snow year, which would generate net operating income of $3 million.

(a) Calculate the expected net operating income for the “average” year.
(b) Find the expected surplus associated with the ski-lift project assuming an 8% cost of capital discount rate.

(c) Find the maximum rental payment that the ski-resort operator would be willing to pay to the government on an annual basis over the ten year period in order to secure its tenure holding of the ski-resort lands.

(d) Would the cumulative rental payments be sufficient to cover the decommissioning costs should the operator “cut bait” after ten years, but before decommissioning occurs?

(e) How would the order in which the no snow, normal snow and big snow years occurred affect the present value calculation underlying the expected surplus concept, which implicitly assumed that each of the ten years is an “average year”?

(f) Calculate the net present value in the worst case scenario in which the no snow year occurs first, and the two big snow years occur last.

(g) Calculate the net present value in the best case scenario in which the two big snow years occur first, and the no snow year occurs last.

*Note: the present value of $1 per annum for 10 years at an 8% discount rate is equal to 6.7100, and that the present value of $1 paid in year ten at an 8% discount rate is equal to 0.4632. Additional present value numbers need to be calculated in order to answer questions (f) and (g).*

**Problem Seven (to be discussed in class on Thursday, March 6):**

A 40-kilometre stretch of suburban road is used by regional commuters and business travellers to move between two major town centres. The legal speed limit on the road is 55 km per hour (km/h) and the estimated average speed is 61 km/h. Traffic engineers predict that if the speed limit were raised to 65 km/h and enforcement levels were kept constant, the average speed would rise to 70 km/h.

On average, 7,000 one-way trips per day are made by vehicles that use the stretch of road. Vehicles using the road carry, on average, 1.6 people, half of whom are commuters and half are business travellers. Traffic engineers do not expect that a higher speed limit will attract more vehicles, but do predict that raising the speed limit on this stretch of road would result in an additional 52 vehicle crashes involving, on average, one fatality annually. They also predict that operating costs would rise by an average of $0.002 per km per vehicle.

The average hourly wage rate in the county in which the majority of road users work is $25 per hour. Business travel time saving is valued at 1.0 times the wage rate, while commuter travel time saving is valued at 0.5 times the wage rate. On average, each non-fatal accident costs $50,000, while each fatal accident costs 1.05 times the statistical value of human life, which is estimated to be equal to $4.0 million.

(a) Estimate the total number of travelers per year, the average travel time saved per person, and the total value of travel time savings from raising the speed limit.
(b) Estimate the total cost of additional accidents, including both non-fatality accidents and the single fatality accident, which result from raising the speed limit.

(c) Estimate the additional operating costs that are associated with raising the speed limit.

(d) Estimate the annual net benefits of raising the speed limit on the road from 55 km/h to 65 km/h. Should the speed limit on the road segment be increased?

(e) If the statistical value of human life were smaller, say $3.0 million, how would your answer to part (d) be changed?

Problems Eight (to be discussed in class on Thursday, March 27):

Firm X faces a marginal abatement cost schedule: \( C'(A) = 10 + 2A \), where \( A \) is the number of tonnes of abated emissions and \((100 - A)\) tonnes is Firm X’s residual volume of unabated emissions. Firm Y faces a marginal abatement cost schedule: \( C'(B) = 20 + B \), where \( B \) is the number of tonnes of abated emissions and \((200 - B)\) tonnes is Firm Y’s residual volume of unabated emissions. No fixed costs are associated with either firm’s abatement activities.

(a) If the price at which emission reduction credits can be purchased from a central agency is $100 per tonne, find the cost-effective abatement volumes for firms X and Y.

(b) Calculate total emissions costs and abatement savings for both firms. What is the overall ratio of abatement costs to emission reductions for society (i.e., the two firms) as a whole?

Now suppose that firms X and Y are the only firms in the market for emission reduction credits, and that firms X and Y are allocated tradable emission reduction credits for 50 tonnes and 80 tonnes of emissions, respectively.

(c) Find the equilibrium price of emission reduction credits, the cost-effective abatement volumes for firms X and Y, and the volume of emission reduction credits traded.

(d) Prepare cost accounting statements for firms X and Y that include the transfer of funds between the two firms. What is the overall ratio of abatement costs to emission reductions for society as a whole?

(e) Explain why cost-effective abatement requires both firms to be faced with the same price for emission reduction credits, whether or not this price is set in advance or determined in the market-place.