05 - Net Present Value (NPV)

Econ 331: Environmental Economics

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UNIVERSITY
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Fall 2025

Learning Outcomes/Goals

1. Translate verbal description of costs and benefits into a timeline diagram.
2. Derive one or more equations in order to determine whether the benefits of an economic policy or project outweigh the costs based on the timeline diagram and verbal description.
   - Using either the NPV or LAC method.
   - Using either discrete or continuous time-discounting.
3. Evaluate the equations with the aid of a scientific or 4-function calculator.
4. Predict how the calculation would change based on
   - Changes in the discount rate.
   - Changes in the time horizon/timing of costs and benefits.
   - Changes in the amounts of costs and benefits.

Where We Are

- We know how to use the discount rate/interest rate to calculate present value of future amounts.
- BUT, we have so far only done this for a limited number of periods with only one amount.
- AND even this was a bit tedious, 3 periods meant 3 different calculations (one for each period).
- If we want to evaluate environmental policies:
  - There will be multiple amounts and many more periods.
  - Some benefits/costs may extend into the infinite future!

Present Value Recap

- Suppose the discount rate is r%.
- Using the present-value formula for some future value t-periods in the future, the present value is calculated as

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

$$PV = FV \cdot e^{-rt} \tag{2}$$

- where Equation 1 is for discrete time discounting, and Equation 2 is for continuous time discounting.

Discrete PV of Infinite Streams

- Suppose you received *FV* every period from tomorrow (t+1) until period infinity.

- Using a geometric series rule (since $\frac{1}{1+r} < 1$), we get

$$PV = \sum_{t=0}^{\infty} \frac{FV}{(1+r)^t} = \frac{1}{1+r} \cdot \frac{FV}{1 - \frac{1}{1+r}} = \frac{FV}{r}$$

- where r is the discount rate and FV is the amount you receive in each period.

Discrete PV of Finite Streams

- Suppose instead you received *FV* every period from tomorrow (t+1) until some period T (finite final period).
- We can use a modification of the geometric series rule (which you do not need to memorize) to get the following formula:

$$PV = \sum_{t=0}^{T} \frac{FV}{(1+r)^t} = FV \frac{(1+r)^T - 1}{r(1+r)^T}$$

- I will not ask you to derive this, so feel free to simply use this formula on your cheat sheet!
- We will not cover the continuous discounting version of this in our class.

Net Present Value (NPV)

- Now we can use these formulae to look at future (or present) costs and benefits and calculate the present value in order to decide how a project's or policy's benefits compare to the costs.
- We can calculate **net benefit** as benefits-costs.
- The present-value (or net-present value or net-present benefits) is the present value of benefits minus the present value of costs.
- We say a project **makes economic sense** if the net-present benefits are greater than 0.

NPV Problems and a Timeline Diagram

- Typically, NPV problems are long verbal descriptions of a project's costs, benefits, timing of costs and benefits, and the discount rate.
- This can be a lot of information to remember, so it is often helpful to organize this information into a timeline.
- This also makes it easier to understand when costs and benefits happen, and to ensure appropriate present value discounting.

NPV Problems and a Timeline Diagram: Example

Example: New York State (NYS) wants to install solar panels on its state office building. The installation cost is $150,000 and takes one year. The solar panels require maintenance costing $1,000 every 5 years. Starting in the next year NYS saves $10,000 in energy costs per year. By installing these panels, NYS reduces the impact of climate change by $100 worth every year for the infinite future. The panels last for 15 years, at which point NYS will need to pay $2,000 to have the solar panels removed and recycled for other use. **Question**: Using the net-present value method with an interest rate of 3%, do the solar panels make economic sense for NYS to install?

- Let's break this down sentence by sentence and include the timing.
- I will also go over a drawing of this timeline diagram in class.

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- ◇ Year 0: Installation cost of $150,000. No present discounting needed.

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- Year 5 and 10: Cost of $5,000. Need to present discount each separately.

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- Year 1-15: Benefit of \$10,000 in each year. Finite present-value formula.
- Year 1-∞: Benefit of \$100. Infinite present-value formula.

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- ⋄ Year 15: Cost of $2,000 to remove/recycle solar panels.

NPV Problems and a Timeline Diagram: Reduced-Form Example

- Discount rate: 3%.
- Year 0: Installation cost of \$150,000. No present discounting needed.
- Year 5 and 10: Cost of \$5,000. Need to present discount each separately.
- Year 1-15: Benefit of \$10,000 in each year. Finite present-value formula.
- Year 1-∞: Benefit of \$100. Infinite present-value formula.
- Year 15: Cost of \$2,000 to remove/recycle solar panels.
- **This is a much easier way to read the information in the paragraph!**

NPV Example Solution

- Year 0 Installation cost: Net-present value of \$150,000.
- Year 5/10 cost: $\frac{5000}{(1.03^5} = 4313$, $\frac{5000}{1.03^{10}} = 3,720$.
- Year 1-15 benefit: $10,000 \cdot \frac{1.03^{15}-1}{0.03(1.03^{15})} = 119,379$.
- Year 1-∞ benefit: $\frac{100}{0.03} = 3,333$.
- Year 15 cost: $\frac{2{,}000}{1.03^{15}} = 1,284$.
- Net-Present Value: -36,605.
- **Project does not make economic sense!**