ENG 3PX3 - Engineering Economics

McMaster University

Unit Conversions

L2 Recap: Constraints and Conversion Factors

→When doing an economic analysis (i.e., creating a NVF and substituting in alternatives to make an economics decision), **anything that's relevant & important** enough to mention in the analysis **needs to be either**:

- **Explicitly incorporated** into the NVF **by giving it a conversion factor** to turn amounts of it into a common unit (i.e., money) so you can compare relative benefits & costs of different levels of it to those of any other relevant parameters, **AND/OR**
- **Included as a hard constraint**, a requirement that the solution is rejected if it is not within certain range of values of the parameter
  - E.g., If the solution weighs more than 10 kg, we will reject it

Conversion Factors

→The NVF should include every relevant variable with an impact on net value (otherwise you won't believe that the valid solution with the best NV is truly best)

→To add & subtract variables they need to be in the same units

→Therefore, to create the NVF (and evaluate NV of a potential solution) you need to determine *conversion factors* that convert benefits & costs into a common unit (usually $)

→Tip: Write units in your calculations to keep track of conversions

→Note: "conversion rate" is another term for "conversion factor"

Example: Nanoparticle Net Value Function

$$NV = \frac{\$896}{\text{week}} - \left(\frac{\$5}{100\ \text{mL}} \times q_{ingred} + \frac{\$12.5}{\text{hr}} \times t_{FumeHood} + \frac{\$100}{\text{hr}} \times t_{SEM} + \frac{\$15}{\text{hr}} \times t_{GradStudent} + C_{other} \right)$$

→**Do you see any conversion factors in the nanoparticle example NVF from L2? If so, what are they?**

Determining Conversion Factors

→**Determining conversion factors can be hard!**

- (But it's important to be able to make quantitative comparisons)

→**We'll present some techniques for determining conversion factors and considerations to make along the way to understand how to use them**

→**Today:**

- Time conversions, Cost of Labour, Opportunity Cost
- Marginal NV and quantity-dependent conversion factors

→**Next Lecture:**

- Environmental & ethical impact

Cost of Labour

→**Cost of performing work usually the following components:**

- Wages: How much you need to pay to have someone complete work for you
    - Refers only to hourly rate you need to pay for the labour
- Materials (consumables)
- Overhead
    - HR
    - Tools/Equipment

→**If you have an existing labour structure, you can determine the total cost of labour**

- Based on the existing structure, you can estimate the cost of adding more labourers

Cost of Labour

→**Cost of labour considerations:**

- Hours worked (OT?)
- Skill (higher skilled work required more $, but can do the job quicker)
- Overhead
  - Hiring cost
  - Training
  - Rooms, HR, Managers (how does it scale)?
  - Utilities
- Tools/Equipment
  - Cost (buying vs rental)
  - Maintenance
  - Depreciation

Cost of Time

→**How much do you value your time?**

- Should you work an overtime shift this weekend?
- Cook dinner at home for an hour or get delivery and spend the extra hour saved on something else?
- Go to the concert on the bus and arrive later or the taxi/uber and arrive earlier?
- Paint the house yourself or hire someone?

→**Additional considerations**

- Happiness
- Time already spent
- Context: Not all time is equal

Office Chair Example

→**You are looking for an office chair:**

- You find one you love for $149.99 + $49 shipping.
- The store is 50 km away from you and it will take 1 hour for you to get there by car.
- The gas mileage of your car is 8.0 L/100 km. Gas currently costs $1.50/L.
- You currently make $20/hr at your part-time job. Assume this value for the cost of time.

→**Is there more net value to you to ship the chair, or go get it yourself?**

Office Chair Example

→**Option 1 (Ship it)**

- Total Cost = \$149.99 + \$49 = \$198.99

→**Option 2 (Drive)**

- Total Cost = \$149.99 + Your Time + Gas
- Total Cost = \$149.99 + 2 hr × \$20/hr + 8.0 L/100 km × 100 km × \$1.5/L
- Total Cost = \$149.99 + \$40 + \$12 = \$201.99

→**Option 1 is cheaper**

→**Are there other considerations that are not accounted for?**

Opportunity Cost

→**Opportunity cost:** the negative impact from having to give up the best alternative benefit you could have gotten from spending resources on something else

- Considering the opportunity cost can help with determining the conversion rate
- For example, to determine how much a block of time worth, you may want to consider how valuable is the best thing you could with that time

Opportunity Cost and Decision Making

→You should consider opportunity cost when deciding whether to go forward with a project.

→A project may have a positive net value compared to alternatives, but what are you giving up to pursue the project? Maybe there is a more important/valuable project to pursue?

→How can we account for this?

1. Include the cost of those forgone opportunities in the **conversion rates** of various resources in your net value calculation,
2. Include the **cost** of not solving that other problem in your net value calculation, or
3. Directly compare the net value of solving the problem to the other one.

Spin Class Example

→**Example: the opportunity cost of going to a 7AM spin class at the gym tomorrow is the cost of losing the benefit of the best other way you could spend those 1.5 hours *tomorrow:***

- Sleeping in
- Completing a lab report
- Browsing reddit/TikTok/etc.

Opportunity Cost and Double Counting

→When considering opportunity cost, be careful of double counting

→In this example, we may be tempted to write the NVF as:

$$NV_{spin} = B_{spin} - B_{sleep\ in} - B_{lab\ report}$$

→However, we could have only used the 1.5 hour for either sleeping in or working on the lab report (i.e. they are mutually exclusive)

- This is *double counting*

→Instead, we should determine if sleeping in or working on the lab report is more valuable and only include the most valuable alternative as the opportunity cost

Opportunity Cost and Double Counting

→Another example of double counting is:

$$NV_{spin} = B_{spin} - C_{time} - B_{lab\,report}$$

→In the NVF above, we consider the cost of time spent on the spin class and then we count again the opportunity cost of working on the lab report with that lost time

→We have counted the lost time twice. The lost time should be converted to the value of the best alternative use of the time and be counted only once

Opportunity Cost and Double Counting

→Double counting can happen when we compare alternatives, consider the following NVF set up:

$$NV_{spin} = B_{spin} - B_{lab\ report}$$

$$NV_{lab\ report} = B_{lab\ report} - B_{spin}$$

→Individually the NVFs make sense but what if we try to compare the two NVFs?

$$NV_{spin} - NV_{lab\ report} = (B_{spin} - B_{lab\ report}) - (B_{lab\ report} - B_{spin})$$

$$NV_{spin} - NV_{lab\ report} = 2(B_{spin} - B_{lab\ report}) = 2NV_{spin}$$

→The conclusion that $NV_{spin} - NV_{lab\ report} = 2NV_{spin}$ doesn't make much sense. Why?

→By incorporating opportunity cost in the individual NVF, we have already performed the comparison. Therefore, we are double counting if we compare again

Spin Class Example

→To avoid double counting, we can set up the problem this way:

$$NV_{spin} = B_{spin} - C_{spin}$$

$$NV_{lab\ report} = B_{lab\ report} - C_{lab\ report}$$

$$C_{spin} = C_{lab\ report} = 1.5 \text{ hours}$$

→Now we can do the comparison:

$$NV_{spin} - NV_{lab\ report} = (B_{spin} - C_{spin}) - (B_{lab\ report} - C_{lab\ report})$$

$$NV_{spin} - NV_{lab\ report} = B_{spin} - B_{lab\ report}$$

Cost of Time of Repeated Tasks

→**Time to complete a task is not the same with each repetition**

- In general, a new person to the job will work slower and have more quality variability than one who has experience with the job
- A team starting to work together will take time to optimize their teamwork

Conversion Functions

→**Often conversion factors are not constant over all possible quantities of the parameter**

- For example, suppose that right now eating an orange gives you a benefit worth $20 to you; likely eating 5 oranges right now would not give you $100 worth of benefit
- Quantity-dependent conversion factors are also called **conversion functions:**

$$NV_{Oranges}(x) = B_{Oranges}(x) - C_{Oranges}(x)$$

Marginal Value Change

→The *marginal net value* of oranges is the extra net value obtained from one more orange:

$$\Delta NV_{Oranges}(x) = NV_{Oranges}(x + 1 \text{ orange}) - NV_{Oranges}(x)$$

→Considering the units of x (i.e., # of oranges), the marginal value change compared to the parameter change that produced it is the *current conversion rate* (of oranges into net value):

$$\frac{\Delta NV_{Oranges}}{\Delta Oranges}$$

→Alternatively,

$$NV'_{Oranges}(x) = \frac{dNV_{Oranges}}{dOranges}$$

Lecture Quiz #3 is Next!

→Any questions?

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