Lesson 3-2 – Cost Models

Learning Objectives

- Apply various cost and revenue estimating models, including the learning curve
- Draw cash flow diagrams to show project costs and benefits

Types of Estimates

- Rough Estimates (gut level)
  - Quick/easy, high-level estimates where accuracy varies widely (-30% to 60%)
- Budget Estimates / Semi-Detailed (based on historical records)
  - Reasonably sophisticated and accurate (15% to +20%)
- Detailed Estimates
  - Estimates made from detailed designs using quantitative models and vendor quotes. High level of accuracy
  - Difficulties arise when the future is uncertain

Difficulties in Estimation

- One-of-a-Kind Estimates
  - First-time projects and projects that have never been done before; No previous experience of costs
  - Few such projects in engineering economic analysis (Example: First NASA mission)
- Resource Constraints
  - Time and Effort Available (human factors)
  - Quality and accuracy of estimates are adversely affected
- Estimator Experience
  - Experience and knowledge → better quality (and more reliable) estimates (conversely limited experience decreases accuracy)

Estimating Models

1. Per-Unit Model
   - Uses a per-unit factor (e.g., cost per square foot)
2. Segmenting Model
   - Divide problem into items, estimate each and add together
3. Cost Indexes
   - Historical change in costs as a ratio relationship

$$\frac{\text{Cost at Time A}}{\text{Cost at Time B}} = \frac{\text{Index value at Time A}}{\text{Index value at Time B}}$$

Cost Index Example

- Construction Costs:
  - City of New Westminster proposed a new pool circa 2010. Construction costs at the time were estimated to be about $55 million. The city recent redid the feasibility study. Based on the construction price index, what would you expect the cost to be now?
  - Construction Price Index in 2010: 135.8 2017: 175.3
    - Source: Stats Canada Table 327-0043

Cost Index Example

- $C_{2017}/C_{2010} = CPI_{2017}/CPI_{2010}$
- C_{2017} = \$55M*175.3/135.8 = \$71M

- The 2017 feasibility study estimated the cost to be \$83-\$100 million. What could explain the difference?

Per Unit Example

- Read "The robots are killing Tesla" by Linette Lopez

- Suppose Tesla attempts to automate 50% of final assembly tasks as per the example given in the article.
  - Savings of 5 hours at $30 per hour in assembly labour (save $150 per car)
  - Costs of $100 per car in robot technician labour (cost $100 per car)

- If Tesla is producing 25,000 cars per year, how much would they save by automating the process?

Per Unit Example

- Per unit savings:
  - Save $150 in labour
  - Add $100 in cost
- Net savings of $50 per car

- 25,000 cars per year

- Net savings of $50*25,000 = $1,250,000 per year

Estimating Models Cont'd…

4. Power-Sizing Model
   - Used to "scale up" or "scale down" known costs

$$\frac{\text{Cost of A}}{\text{Cost of B}} = \left(\frac{\text{Capacity of A}}{\text{Capacity of B}}\right)^{x}$$

Where *x* is the power-sizing component

   - $x = 1.0$ shows a linear power sizing component
   - $x < 1.0$ shows the "economies" of scale (Example: the more you buy, the cheaper per unit)
   - $x > 1.0$ shows a "diseconomies" of scale

Estimating Models Cont'd…

5. Learning Curve (tracking cost improvements)
   - A percentage or rate at which output is increased due to repetition

$$T_N = T_{initial} \times N^b$$

   - T_N = time required for Nth unit of production
   - $T_{initial}$ = time required for the first unit of production
   - N = number of completed units
   - b = learning curve exponent

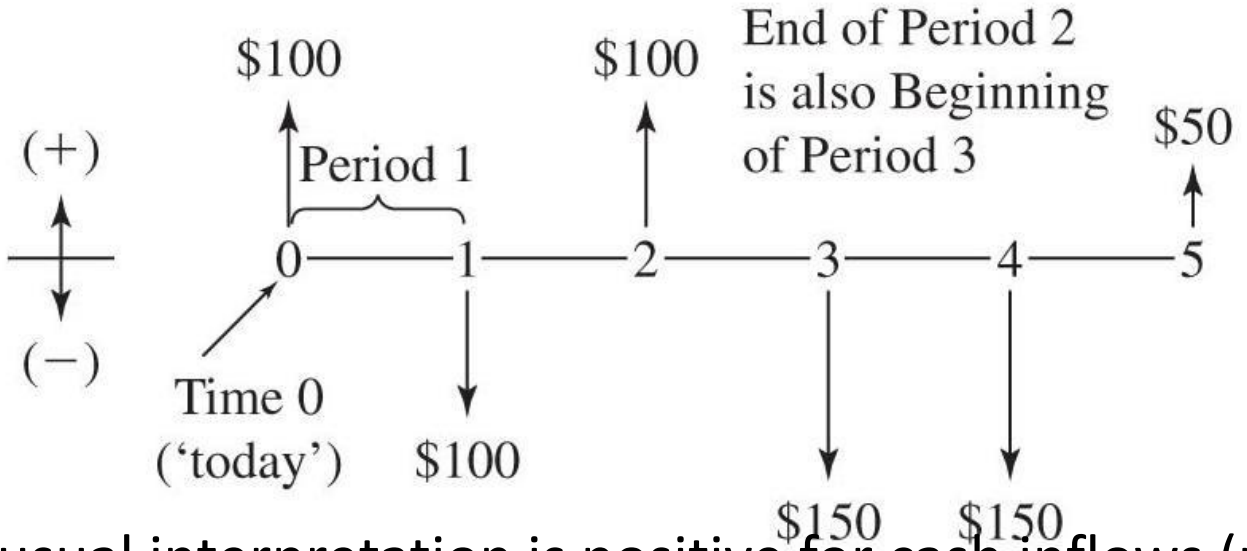
$$b = \frac{\log(\text{learning curve expressed as a decimal})}{\log 2.0}$$

Estimating Benefits

- Economic analysis often requires considering the benefits as well as the costs.
- Many of the same methods used to calculate costs can be used to calculate benefits.
- Benefits are typically in the future, which sometimes makes them more difficult to estimate.

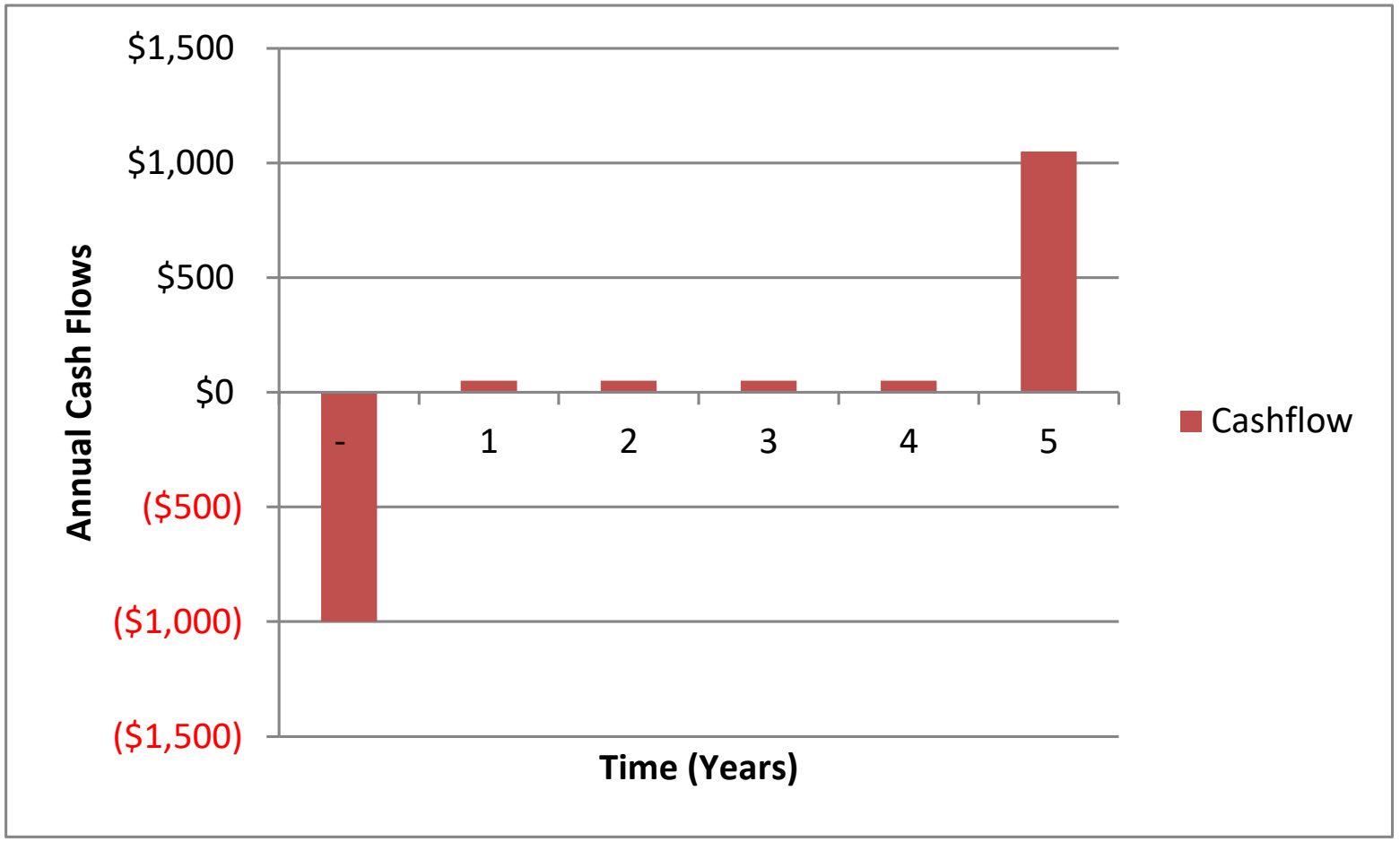
Cash Flow Diagrams

- Costs and Benefits over time can be represented by a cash flow diagram:



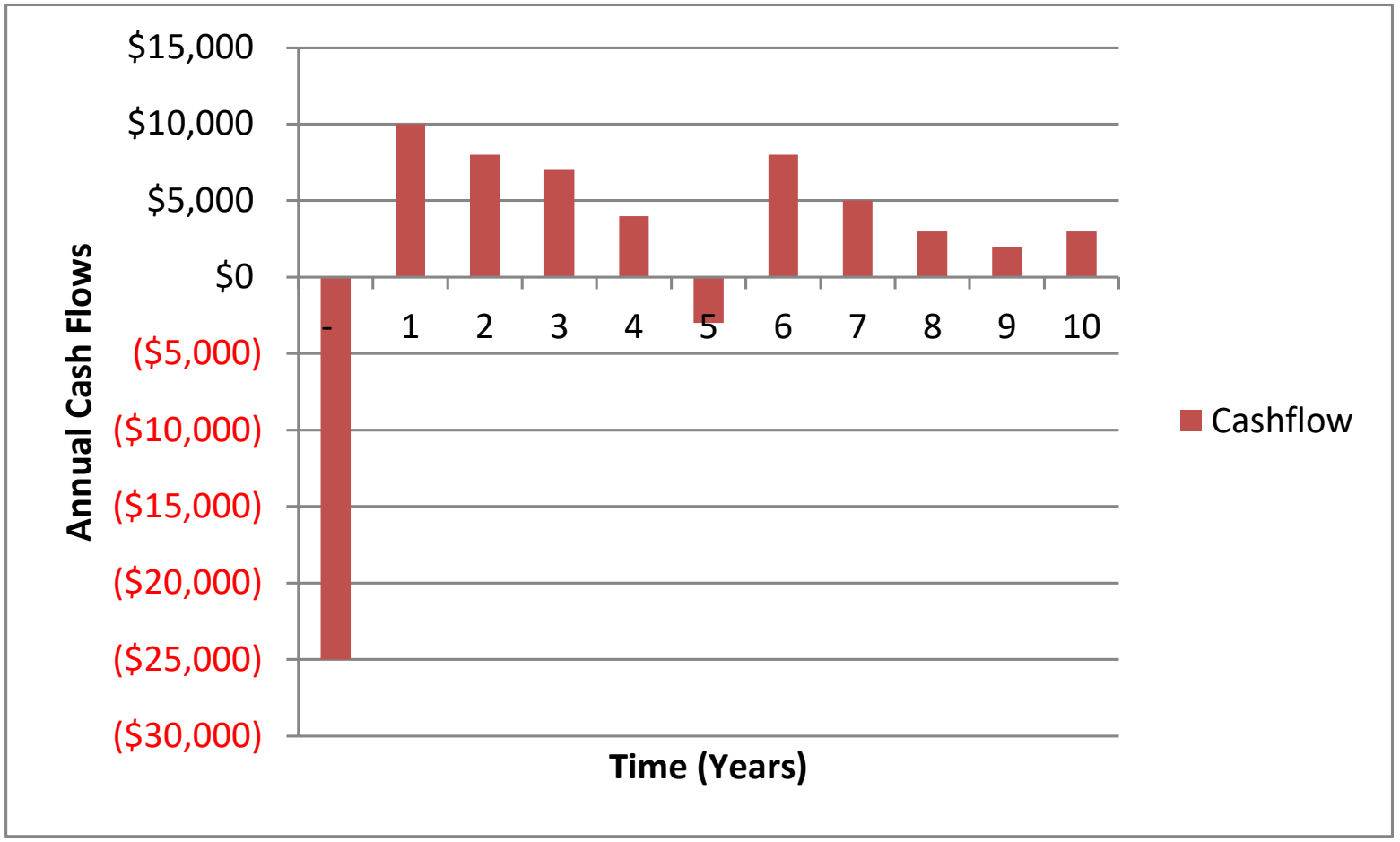
- Arrows: the usual interpretation is positive for cash inflows (revenues) and negative for cash outflows (expenses).
- The length of the arrow represents the magnitude ($) of the cash flow.
- Time dimension: points in time when the positive and negative cash flows occur

Example 1 Cash Flow: GIC



Year	Cashflow
$0	($1,000)
1	$50
2	$50
3	$50
4	$50
5	$1,050

Example 2 Cash Flow: Project or Product



Year	Cashflow
-	($25,000)
1	$10,000
2	$8,000
3	$7,000
4	$4,000
5	($3,000)
6	$8,000
7	$5,000
8	$3,000
9	$2,000
10	$3,000

Categories of Cash Flows

1. First Cost ≡ construction, purchase, or installation expense. Occurs at time Zero
2. Operations and Maintenance ≡ ongoing/recurring expense.
3. Salvage Value ≡ receipt at project termination.
4. Revenues ≡ annual receipts
5. Overhaul ≡ major capital expenditure occurring during life of asset.

Excel Demonstration

Recommended Problems

- Chapter 2:
  - 2-2, 2-4, 2-6, 2-8, 2-10, 2-14, 2-20, 2-21, 2-25, 2-27, 2-31, 2-32, 2-34, 2-35, 2-36, 2-39, 2-41, 2-43, 2-46, 2-48, 2-53, 2-54, 2-55