The Economic Justification of Telecommunications Projects

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Learning Objectives

- Describe these concepts
  - Present value
  - Future value
  - Interest
- Perform simple computations involving these concepts

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Definition

Cost of a resource is the decrease in wealth that results from committing this resource to a particular alternative (before benefits from the alternative are computed)

Types of cost

- Past vs. future costs
- Joint costs
- Direct and indirect
- Fixed and incremental
- Long and short run
- Opportunity costs
- Sunk costs
- Postponable cost
- Replacement cost

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Mathematics of Money

- Value of money changes with time
  - Inflation causes future dollars to be worth less than today's dollars
  - Investment risk devalues future dollars proportionately to the risk
- Elements
  - Future value (F)
  - Present value (P)
  - Rate (i)
  - Annuity (A) - A sequence of uniform payments

Formulation

- If an amount of money (P) were invested such that it grew at precisely the rate of inflation (i) for one time period, then
  - $F = P + Pi = P(1 + i)$
  - That is, F is the equivalent future value of P
- For n time periods,
  - $F = P(1+i) + P(1+i)i = P(1+i)(1+i)$
  - Generalizing, $F = P(1+i)^n$
  - This is referred to as the future worth of a present amount

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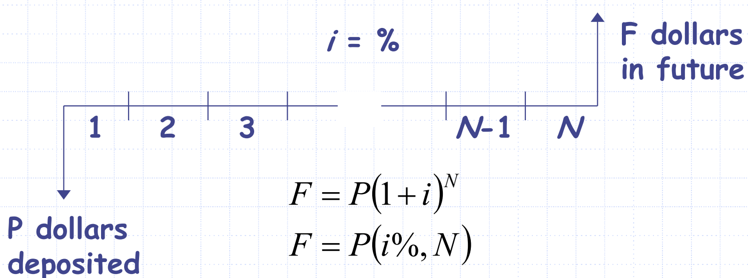
Cash Flow Diagrams



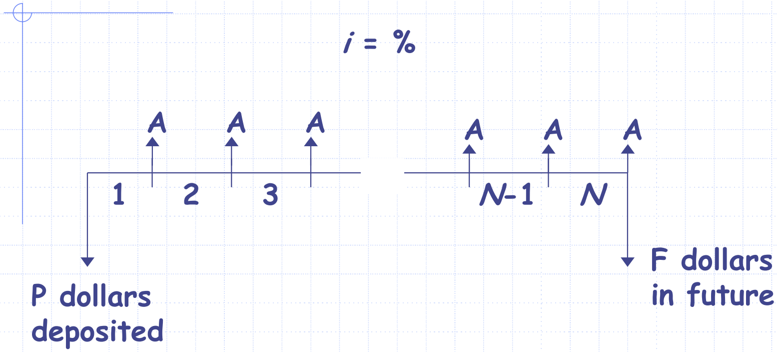
$$F = P(1+i)^N$$

$$F = P(i\%, N)$$

$$P = F\left(\frac{1}{1+i}\right)^N$$

$$P = F(i\%, N)$$

Cash Flow Series



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Cash Flow Series

- Payments of *A* made at regular intervals
- Compute

$$F = A\left[1 + (1+i) + (1+i)^2 + \ldots + (1+i)^N\right]$$

$$= A\left[\frac{(1+i)^N - 1}{i}\right]$$

$$F = A\left(F / A; i\%, N\right)$$

Cash Flow Series

- Computing *P*

$$F = A\left[\frac{(1+i)^N - 1}{i}\right]$$

and

$$F = P(1+i)^N$$

$$\therefore P = A\left[\frac{(1+i)^N - 1}{i}\right]\left(\frac{1}{1+i}\right)^N = \left[\frac{(1+i)^N - 1}{i(1+i)^N}\right]$$

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Other Formulations

- Present worth of a future amount $P = \frac{F}{(1+i)^n}$
- Annuity of a future amount $A = \frac{i}{(1+i)^n - 1} F$
- Future worth of an annuity
  $F = \frac{(1+i)^n - 1}{i} A$
  - Spreadsheet formula: @FV(*A*,*i*,*n*)
- Present worth of an annuity
  $P = \frac{(1+i)^n - 1}{i(1+i)^n} A$
  - Spreadsheet formula: @PV(*A*,*i*,*n*)
- Annuity from a present amount
  $A = \frac{i(1+i)^n}{(1+i)^n - 1} P$
  - Spreadsheet formula: @PMT(*P*,*i*,*n*)

Project Justification Techniques

- Net future value (NFV)
  - The difference between the future value of your project and the future value of alternative investments
  - NFV = $F - F^* = F - P(1+i^*)$
    - i^* is the rate of return of an alternative investment
    - Use money market rates, bond rates, return on equity
- Internal Rate of Return
  - Ratio of the value change and the present value

    $IRR = \frac{F-P}{P}$

    This is useful when a minimum RoR is required

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Application of these Concepts

- Compare the financial implications of implementing the project to not implementing the project
- Case 1: *P* consists of
  - The cost of implementing the project
  - The PV of maintenance costs over the life of the project
- Case 2: Compute the PV of an annuity, where the annuity is the estimated cost of waiting, retry behavior, and other productivity decreasing factors
- Compare PVs

Depreciation

- Definitions of Depreciation
  - *A System of Accounting which Aims to Distribute Cost or Other Basic Value of Tangible Capital Assets, Less Salvage Value, Over the Estimated Useful Life of a Unit in a Systematic and Rational Manner for the Purpose of Allocation* (Paraphrased from AICPA)
  - Loss in Service Value Not Restored by Maintenance
  - Due to Normal Wear and Tear, Exposure and Decay, Technological Obsolescence, *etc*.
- Depreciation Does Not Involve Actual Cash Outlays

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Computing Depreciation Expense

- Original Cost of Equipment
- Estimated Service Life of Equipment
- Estimated Net Salvage Value of the Equipment
  - Remaining Value at the End of the Service Life
  - Can Include the Cost of Removal
- Depreciation Method
  - Retirement/Replacement
  - Age-Life

Retirement/Replacement Methods

- Not Widely Used Because Operating Expenses Vary Widely from Year to Year
- Retirement Accounting
  - Carrys Original Cost until the Equipment is Retired
  - Full Cost is Charged as an Operating Expense at Retirement
- Replacement Accounting
  - Similar to Retirement Accounting
  - Replacements and Retirements Without Replacements are Charged to Operating Expense

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Age-Life Methods

- Designed to Provide More Consistent Expense Accounts from Year to Year
- Straight-Line Depreciation
  - Depreciation Charge is Computed for Each Retirement Period
  - Draw a Straight Line Between Original Cost and Salvage Value, and Allocate the Difference over Service Life

$$\text{Depreciation Charge} = \frac{\text{Original Cost - Salvage Value}}{\text{Service Life}}$$

Age-Life Methods

- Accelerated depreciation allows higher depreciation early in the equipment life than straight line method
- Sum-of-the-Year's-digits

$$\text{Depreciation Expense} = \frac{\text{\# Years Remaining at Beginning of Year}}{\text{Total of the Digits of the Year's Life}} \text{ x (Original Cost - Salvage Value)}$$

  - Subtract from current value (undepreciated value)
  - Repeat next year
- Double declining balance
  - Double the depreciation rate of straight line
  - Subtract from current value
  - Depreciate remaining balance by straight line

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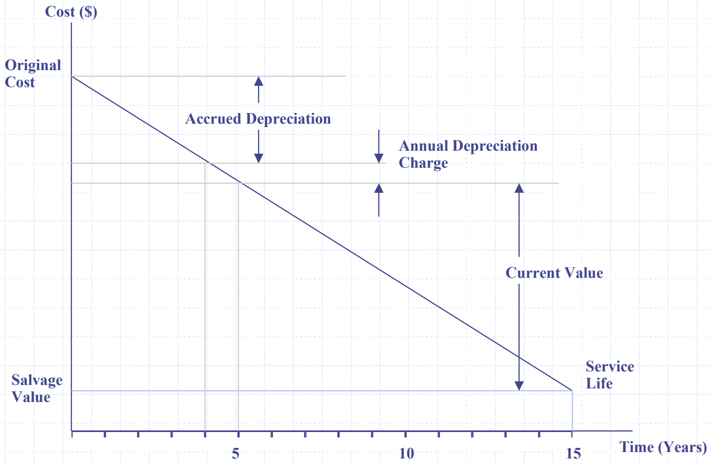
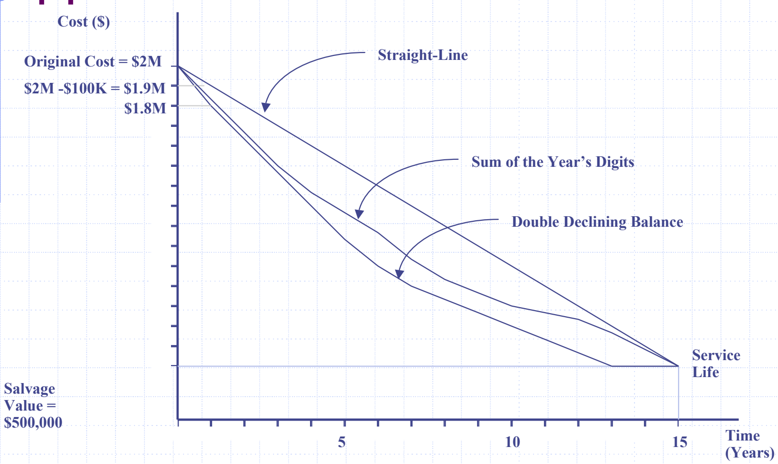
Deprecation Concepts



Comparison of Depreciation Approaches



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Comments on Depreciation

- Size of depreciation charge depends on
  - Service Life
  - Salvage value
- Estimating both parameters in advance is difficult
  - Service life must take technological *and* usage factors into account
  - Actual salvage value depends on costs and prices at the time of decommissioning

Review

- Money has time value
- This value is called *interest*
  - Simple interest – Interest is not earned/paid on interest
  - Compound interest – Interest is computed on principle as well as accrued interest

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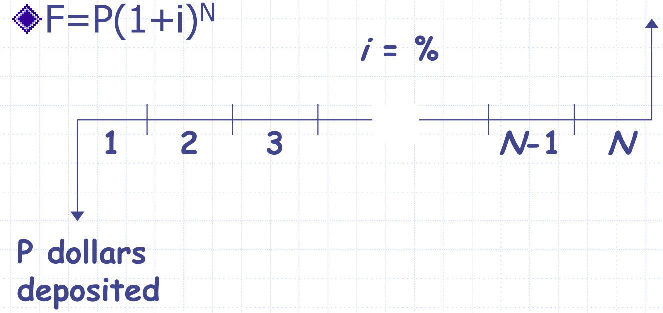
Types of Cash Flows

- Single
- Uniform series
- Linear gradient series
- Geometric gradient series
- Irregular series

Single

- Studied earlier
- F= P(i;N)
- $F=P(1+i)^N$



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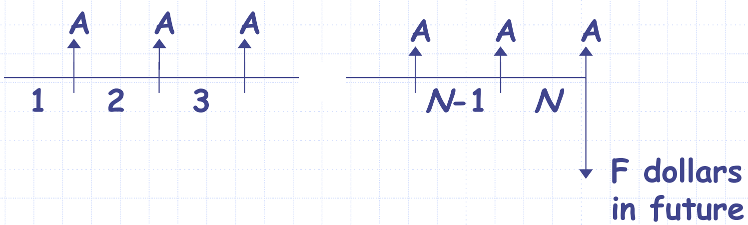
Uniform

- Constant series of payments
- $F = \left[\frac{(1+i)^N - 1}{i}\right] = F(F/A;i;N)$



Applications

- Sinking Fund- Interest bearing account into which money is paid on a regular basis, usually for replacing a fixed asset
- Capital recovery

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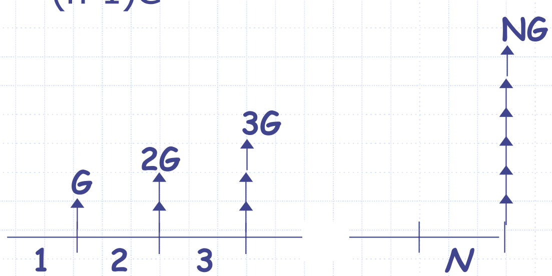
Linear Gradient

- Payment increases (or decreases) by a constant amount from period to period
- $A_n = (n-1)G$



Linear Gradient

$$P = 0 + \frac{G}{(1+i)^2} + \frac{2G}{(1+i)^3} + \cdots + \frac{(N-1)G}{(1+i)^N}$$

$$= \sum_{n=1}^{N} (n-1)G(i+1)^{-n}$$

$$= G\left[\frac{(1+i)^N - iN - 1}{i^2(1+i)^N}\right] = G(P/G;i;N)$$

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Linear Gradient

- What is the equivalent uniform payment?

$$A = G\left[\frac{(i+1)^N - iN - 1}{i\left[(i+1)^N - 1\right]}\right] = G(A/G;i;N)$$

- Also

$$F = \frac{G}{i}\left[\frac{(i+1)^N - 1}{i} - N\right] = G(F/G;i;N)$$

Geometric Gradient Series

- Payments change by a constant *percentage* over time, where *g* is the percent change
- This is also called compound growth
- Thus, $A_n = A_1(1+g)^{n-1}$

$$P = A_1(P/A_1,g,i,N) = \begin{cases} A_1\left[\frac{1-(1+g)^N(1+i)^{-N}}{i-g}\right] & i \neq g \\ \frac{NA_1}{(1+i)} & i = g \end{cases}$$

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Irregular Payments

- Bring each payment to the present (or future)
- Add the values at the same point in time

Effective Interest Rates

- Nominal interest rate – the rate that is used in computations
- Effective interest rate – interest rate that is actually experienced
- Equivalence

$$i_a = \left(1 + r/M\right)^M - 1$$

  - Where *r* is the nominal rate and *M* is the number of compounding periods

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Comparing Projects

- Net Present Value (NPV)
- Rate of Return Payback period

Net Present Value

- Data needed
  - First cost
  - Annual costs
  - Annual receipts
  - Salvage value
- Compute the present value of these streams

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NPV Example

Item	Switch A	Switch B
First cost	$10,000	$15,000
Life	5 years	10 years
Salvage	$2,000	$0
Ann. Receipts	$5,000	$7,000
Annual Costs	$2,200	$4,000

Which is Better?

- Consider i=8%

Item	Switch A	Switch B
PV of rcpts	$5K(P/A;8;10)	$7K(P/A;8;10)
PV of salvage	$2K(P/F;8;10)	$0
Cost	-$2.2K(P/A;8;10)	-$4K(P/A;8;10)
First cost	-$10,000	-$15,000
Replacement	-(10K-2K)(P/F;8;5)	

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Results

Item	Switch A	Switch B
PV of rcpts	$33,551	$46,970
PV of salvage	$926	$0
Cost	-$14,762	-$-26,840
First cost	-$10,000	-$15,000
Replacement	-$5,445	
TOTAL	$4,270	$5,130

Rate of Return

- Internal Rate of Return
  - What is the interest rate at which the PV of the cash inflow equals the PV of the cash outflow?
  - Compare this to the Minimum Attractive Rate of Return (MARR)
- External RR
  - What is the interest rate that equates the future worth of investments to the accumulation of reinvested returns?

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Example using IRR

Year	Switch 1	Switch 2	Difference
1	-10,000	-15,000	-5,000
2	2,800	3,000	200
3	2,800	3,000	200
5	-8,000		8,000
10	4,800	3,000	200-2K

Example using IRR

- PV for the difference in cash flows: - 5K + 200 (P/A,i,10) + 8K (P/F,i,5) - 2K (P/F,i,10)
- What is the value of *i* for which this equals zero?
- *i* = 12.1%
- This is greater than MARR (10%), so the larger investment (switch B) is justified

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Risk in Projects

- An investment project where the cash flows are not known with certainty
- Project risk is variability in Net Preset Worth (or IRR)
- Risk is the consequence of uncertainty, and usually implies a potential for loss

Analytical Approaches

- Sensitivity analysis
- Break-even analysis
- Scenario analysis

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Sensitivity Analysis

- An approach that can be used when some assumptions are questionable
- Useful in all branches of analysis, not just engineering economics

Basic Approach

- Vary model parameters
- Observe the outcome of the model
- Determine at what parameter values the difference in the model outcome becomes significant
- Assess whether this critical parameter value is possible or likely

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Example

- ◆Postal Service is considering purchasing a 4,000 lb forklift truck
- ◆Fuel alternatives
  - Gasoline
  - LPG
  - Diesel
  - Electric (battery)
- ◆Which power source is the better value?

Example

- ◆Assume
  - 7 year life
  - 10% interest
  - One shift = 8 hrs operation
  - 200 to 260 shifts per year

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Example

- Fuels
  - Gasoline: 11.1 gal per shift, $1.20/gal
  - LPG: 11 gal/shift, $1.02/gal
  - Diesel: 7.2 gal/shift, $1.13/gal
  - Electric: 31.25kWh, $0.05/kWh

Example

	Gas`	LPG	Diesel	Elec.
Initial	$20,107	$21,200	$22,263	$29,739
Salv.	$2000	$2000	$2200	$3000
Fuel/shift	11.1 gal	11 gal	7.2 gal	31.25 kWh
Fuel cost	$1.20	$1.02	$1.13	$0.05
Fuel/shift	$13.32	$11.22	$8.14	$1.56
Maint./yr	$1000	$1000	$1000	$500
Var./shift	$7	$7	$7	$4.5

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Computations

- Find annual costs for each alternative:
  - Gasoline: $20,170(A/P,10%,7)-$2000(A/F,10%,7) = $3,919
  - LPG: $21,200(A/P,10%,7)-$2000(A/F,10%,7) = $4,144
  - Diesel: $22,263(A/P,10%,7)-$2200(A/F,10%,7) = $4,341
  - Electric: $29,739(A/P,10%,7)-$3000(A/F,10%,7) = $5,792

Computations

- Annual operating costs
  - Gasoline: $1000 + (13.32+7)M
  - LPG:$1000 + (11.22+7)M
  - Diesel: $1000 + (8.14+7)M
  - Electric: $500 + (1.56+4.5)M

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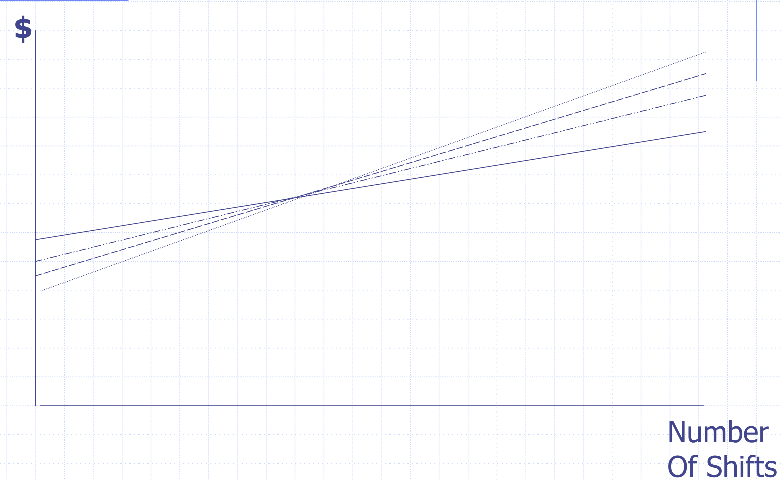
Computations

- Total Equivalent Annual Costs
  - Gasoline: \$4919+\$20.32M
  - LPG:\$5144+\$18.22M
  - Diesel:\$5341+\$15.14M
  - Electric: \$6292+\$5.06M

Plot the Lines



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