Announcements

• UT Energy Symposium: Student Showcase
  – Craig Andrew Milroy, PhD student in Chemical Engineering, "Lithium-sulfur batteries"
  – Daniel Urieli, PhD student in Computer Science, "A Learning Agent for Heat-Pump Thermostat Control"
  – Krystian Perez, PhD student in Chemical Engineering, "Smart Use of Smart Meters: Disaggregation of A/C Loads from Residential Homes"
LATIN AMERICA ENERGY LECTURE SERIES
Mexico’s Energy Reforms
...a challenging road ahead.

1938-2013

President Lazaro Cardenas

President Enrique Peña Nieto

Dr. Peter M. Ward, Professor C.B. Smith, Sr. Centennial Chair in United States-Mexico Relations Department of Sociology and at the Lyndon B. Johnson School of Public Affairs. He was the Director of the Mexican Center of the Institute of Latin American Studies at UT Austin from 1992-96 and 2000-05.

Dr. Kenneth F. Greene, Associate Professor of Government at UT Austin. He is the author of Why Dominant Parties Lose: Mexico’s Democratization in Comparative Perspective (2007) and is currently Principal Investigator on the Mexico 2012 Panel Study that includes nationwide studies of public opinion.


Monday, September 16, 2013, 12:00 Noon
Mexico’s Independence Day – Grito de Dolores Hidalgo
Student Activity Center SAC Room 1.106

Aguas Frescas will be served
Event information/contact jsmith@jsg.utexas.edu
Interest

- Compensation paid to lender for use of borrowed capital
- Lender could have invested the money elsewhere and made a profit had he not loaned it, so interest is his compensation for otherwise lost profit
- Depends on scarcity of money, risk, alternative investments, etc.
Simple Interest

• Interest accumulated is only based on the principal

\[ I = P \cdot i \cdot n \]
\[ F = P + I = P + P \cdot i \cdot n \]
\[ F = P(1+i \cdot n) \]

• Example: Borrow $1,000 at 10% annual simple interest. After 5 years, balance = $1,500.
Compound Interest

- Interest is paid on principal plus accumulated interest. Interest is reinvested.

<table>
<thead>
<tr>
<th>Period</th>
<th>Amount available at beginning of period</th>
<th>Interest accumulated during period</th>
<th>Amount available at end of period</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>$P$</td>
<td>$P(i)$</td>
<td>$P(1+i)$</td>
</tr>
<tr>
<td>2</td>
<td>$P(1+i)$</td>
<td>$P(1+i)i$</td>
<td>$P(1+i)^2$</td>
</tr>
<tr>
<td>3</td>
<td>$P(1+i)^2$</td>
<td>$P(1+i)^2i$</td>
<td>$P(1+i)^3$</td>
</tr>
<tr>
<td>$n$</td>
<td>$P(1+i)^{n-1}$</td>
<td>$P(1+i)^{n-1}i$</td>
<td>$P(1+i)^n$</td>
</tr>
</tbody>
</table>
Compound Interest

• The amount available at the end of any period is $F_n = P(1+i)^n$, where $(1+i)^n$ is the discrete single-payment compound factor

• The process can be reversed to find $P$ from $F$
APR vs. APY

- APR—annual percentage rate
- APY—annual percentage yield
- APR ≠ APY unless the compounding period is the same as that on which the nominal interest is based.
• APR = 6%, what is APY if interest in compounded monthly \((m = 12)\)?

\[
F_1 = P \left(1 + \frac{i_{\text{nom}}}{m}\right)^m = P \left(1 + i_{\text{eff}}\right)
\]

\[
i_{\text{eff}} = \left(1 + \frac{i_{\text{nom}}}{m}\right) - 1
\]

\[
i_{\text{eff}} = 6.17\%
\]
Annuities

• Definition: Series of equal payments occurring at equal time intervals
• Examples: House loan payments, IRA savings plan, Life insurance policies
You Decide Which Option You Prefer If You Are The Winner Of The Sweepstakes:

Option 1
$2,000,000 NOW.
Payable immediately.

OR

Option 2
$1,000,000 NOW.
PLUS $137,932 a year for 29 years.

OR

Option 3
$167,000 a year for 30 years.

Tell us your choice. Read the instructions on the reverse to learn how you can activate your Grand Prize Option.

FIGURE 3.1
Options for potential sweepstakes winners. Which option provides the optimal value?
\[ i = \frac{5}{12} = 0.4167 \]

\[
\begin{array}{ccccccc}
0 & 1 & 2 & \cdots & 10 & 11 & 12 \\
\downarrow & \downarrow & \downarrow & \cdots & \downarrow & \downarrow & \downarrow \\
\downarrow P & \downarrow \text{PMT} & \downarrow \text{PMT} & \cdots & \downarrow \text{PMT} & \downarrow \text{PMT} & \downarrow \text{PMT} \\
\$1000 & \$100 & \$100 & \cdots & \$100 & \$100 & \$100 \\
\end{array}
\]

\[ F = ? \]

**FIGURE 3.4**
The transactions for the example placed on the time line.

**FIGURE 3.5**
Cash flow transactions for a proposed plant placed on the time line.
Annuities

\[ F = R \frac{\left[ (1+i)^n - 1 \right]}{i} \]

\[ F = P(1+i)^n \]

\[ P = R \frac{\left[ (1+i)^n - 1 \right]}{i(1+i)^n} = R \frac{1-(1+i)^{-n}}{i} \]
Annuities

• Example: The purchase price of a home is $100,000. With a 6% APR, compounded monthly, what will be the monthly payments for a 30-year and 15-year loan? What will be the total amounts paid?
EXAMPLE 3.4 PAYING OFF A LOAN

You borrow $35,000 from a bank at 10.5% interest to purchase a multicone cyclone rated at 50,000 ft³/min. If you make monthly payments of $325 (at the end of the month), how many payments will be required to pay off the loan?

Solution  The diagram on the time line in Figure E3.4a shows the cash flows. Because the payments are uniform, we can use Equation (3.5), but use $325 per month rather than $1.

\[ i = \frac{0.105}{12} \]

\[ 35,000 \]

\[ \text{PMT} \]

\[ -325 \]

\[ n = ? \]

FIGURE E3.4a

\[ 35,000 - 325 \left[ \frac{(1 + i)^n - 1}{i(1 + i)^n} \right] = 0 \]  

(a)
A synthetic methane plant from coal is to be constructed at a cost of $4 billion dollars. It requires 14,000 tons/day of coal (10,000 Btu/lb and $15/ton mining cost) and will produce 130 MMSCF/day of synthetic methane. What is the thermal efficiency? What is the cost of coal in the produced methane ($/MMBtu)? What is the equivalent fixed cost of the plant capital cost in $/MMBtu? Assume that the plant operates 320 days per year with a 30 year life, and the selling price of the synthetic methane is $9/MMBtu. You should calculate an annualized (yearly) cost for the capital cost using an interest rate of 8%. Would you invest in this plant?
Light Bulb Economics

- Building and home lighting directly affects our economy. As a nation, we spend approximately one-quarter of our electricity budget on lighting – or more than $37 billion annually.

An incandescent light bulb is highly inefficient because it converts only a small amount of the electrical energy into light; the rest is converted to heat. In spite of this inefficient conversion of energy, the relatively inexpensive purchase price of incandescent bulbs when compared to fluorescent lighting accounts for their popularity among consumers.
Heat transfer calculations indicate that the 75W incandescent bulb has a heat loss of 55W while a 20W fluorescent bulb delivers 1200 lumens with essentially no heat loss. The 75W incandescent bulb has a 750 hour life, while the 20W compact fluorescent bulb averages 10,000 hours before failing. Find out the cost of both bulbs from a local supplier and calculate the rate of return for replacing the equivalent of 20 75W lights (typical house), which are turned on an average of 4 hours/day. For an electricity price of 8 cents/kwhr and interest rate of 5%, use net present value to compare the two alternatives, and a basis of 10,000 hours of service for both types of bulbs.
Table 3.2 Formulas for Evaluating Profitability

<table>
<thead>
<tr>
<th></th>
<th>Lumped initial investment, ( I_0 ) and Constant Cash Flow, ( F )</th>
</tr>
</thead>
<tbody>
<tr>
<td>Payback period, PBP, years</td>
<td>( PBP = \frac{I_0}{F} )</td>
</tr>
<tr>
<td>Return on Investment (ROI)</td>
<td>( ROI = \frac{NI}{I_0} )</td>
</tr>
<tr>
<td>Internal Rate of Return (IRR), Discounted Cash Flow</td>
<td>( i = \frac{F}{I_0} \left(1 + \frac{1}{(i+1)^n} - 1\right) ) (solve for ( i = IRR ))</td>
</tr>
<tr>
<td>Net Present Value (NPV), $</td>
<td>( NPV = F \left[ \frac{(1 + i')^n - 1}{i'(1 + i')^n} \right] - I_0 )</td>
</tr>
</tbody>
</table>

Nomenclature

1. \( i' \) is the interest value of money in NPV, generally taken as the opportunity interest that the company must forego by not investing in the next best alternative. \( i \) is the internal rate of return. ROI, \( i' \), and \( i \) are fractions; to obtain %, multiply by 100.
2. \( n \) is the total number of time periods (normally years) between startup (which is time zero) and end of operation of the equipment.
3. \( NI \) = net income after taxes.
<table>
<thead>
<tr>
<th>Payback period (PBP)</th>
<th>Net present value (NPV)</th>
<th>Internal rate of return (IRR)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Definition</strong></td>
<td><strong>Definition</strong></td>
<td><strong>Definition</strong></td>
</tr>
<tr>
<td>Number of years for the net after-tax income to recover the net investment without considering time value of money</td>
<td>Present worth of receipts less the present worth of disbursements</td>
<td>IRR equals the interest rate $i$ such that the NPV of receipts less NPV of disbursements equals zero</td>
</tr>
<tr>
<td><strong>Advantages</strong></td>
<td><strong>Advantages</strong></td>
<td><strong>Advantages</strong></td>
</tr>
<tr>
<td>Measure of fluidity of an investment</td>
<td>Works with all cash flow patterns</td>
<td>Gives rate of return that is a familiar measure and indicates relative merits of a proposed investment</td>
</tr>
<tr>
<td>Commonly used and well understood</td>
<td>Easy to compute</td>
<td>Treats variable cash flows</td>
</tr>
<tr>
<td></td>
<td>Gives correct ranking in most project evaluations</td>
<td>Does not require reinvestment rate assumption</td>
</tr>
<tr>
<td><strong>Disadvantages</strong></td>
<td><strong>Disadvantages</strong></td>
<td><strong>Disadvantages</strong></td>
</tr>
<tr>
<td>Does not measure profitability</td>
<td>Is not always possible to specify a reinvestment rate for capital recovered</td>
<td>Implicitly assumes that capital recovered can be reinvested at the same rate</td>
</tr>
<tr>
<td>Ignores life of assets</td>
<td>Size of NPV ($) sometimes fails to indicate relative profitability</td>
<td>Requires trial-and-error calculation</td>
</tr>
<tr>
<td>Does not properly consider the time value of money and distributed investments or cash flows</td>
<td></td>
<td>Can give multiple answers for distributed investments</td>
</tr>
</tbody>
</table>
### NPV Example

<table>
<thead>
<tr>
<th>Condensers</th>
<th>Life: 12 years</th>
<th>MARR = 8%</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Initial Cost</td>
<td>Year Operating Cost</td>
</tr>
<tr>
<td>Air cooled</td>
<td>$23,000</td>
<td>$1,200</td>
</tr>
<tr>
<td>Water cooled</td>
<td>$12,000</td>
<td>$3,300</td>
</tr>
</tbody>
</table>

MARR = Minimum acceptable rate of return
NPV Example

• \( \text{NPV}_{AC} = -\$32,043 \)
• \( \text{NPV}_{WC} = -\$36,869 \)
You Decide Which Option You Prefer If You Are The Winner Of The Sweepstakes:

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OR

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PLUS $137,932 a year for 29 years.

OR

Option 3
$167,000 a year for 30 years.

Tell us your choice. Read the instructions on the reverse to learn how you can activate your Grand Prize Option.

FIGURE 3.1
Options for potential sweepstakes winners. Which option provides the optimal value?
$F \approx \frac{\$}{yr}$  (steam generated)

$I_0 \approx \text{area} ($25/ft^2$)

\[ \text{NPV} = \frac{(1 + i)^n - 1}{i(1 + i)^n} \cdot F - I_0 = \frac{F}{r} - I_0 \]

$T_2^{opt} (w, r, c_p, U)$
Figure 6

Plot of Profit vs. Oil Outlet Temperature for Steam Generator
In the previous section we only briefly mentioned the financial assumptions used in profitability analysis. Any detailed analysis of a project requires specifying the following parameters:

1. initial investment
2. future cash flows
3. salvage value
4. economic life
5. depreciation
6. depletion
7. investment tax credit
8. taxes
9. inflation
10. debt/equity ratio
Figure 3.3 Computation of Cash Flow
TABLE B.3
Preliminary operating cost estimates

A. Direct production cost
   1. Materials
      a. Raw materials: estimate from price lists, government and trade group reports
      b. Byproduct and scrap credit: estimate from price lists
   2. Utilities: from literature or similar operations
   3. Labor: from historical data, manning tables, literature, or similar operations
   4. Supervision: 10–25% of labor
   5. Fringe benefits and FICA: 30–45% of labor plus supervision
   6. Maintenance: 2–10% of investment per year
   7. Operating supplies: 0.5–1.0% of investment per year, or 6–10% of operating labor
   8. Laboratory: 10–20% of labor per year
   9. Waste disposal: from literature, similar operations, or separate estimate
  10. Royalties: 1–5% of sales
  11. Contingencies: 1–5% of sales

B. Indirect costs
   1. Depreciation: 10–20% of investment per year
   2. Real estate taxes: 1–2% of investment per year
   3. Insurance: 0.5–1.0% of investment per year
   4. Interest: 10–12% of investment per year
   5. General administrative overhead: 50–70% of labor, supervision, and maintenance, or 6–10% of sales

C. Distribution costs
   1. Packaging: estimate from container costs
   2. Shipping: from carriers or 1–3% of sales

# APPENDIX B: Cost Estimation

## TABLE B.4
Rates for industrial utilities, 1998

<table>
<thead>
<tr>
<th>Utility</th>
<th>Cost ($)</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Steam</td>
<td></td>
<td></td>
</tr>
<tr>
<td>500 psi (250°C)</td>
<td>8.00–9.00</td>
<td>1000 kg</td>
</tr>
<tr>
<td>(200°C)</td>
<td>6.00–8.00</td>
<td>1000 kg</td>
</tr>
<tr>
<td>Exhaust (100°C)</td>
<td>5.00–7.00</td>
<td>1000 kg</td>
</tr>
<tr>
<td>Electricity</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Purchased</td>
<td>0.03–0.08</td>
<td>kWh</td>
</tr>
<tr>
<td>Self-generated</td>
<td>0.02–0.06</td>
<td>kWh</td>
</tr>
<tr>
<td>Cooling water (30°C)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Well</td>
<td>8.6–46</td>
<td>1000 m³</td>
</tr>
<tr>
<td>River or salt</td>
<td>6.0–17</td>
<td>1000 m³</td>
</tr>
<tr>
<td>Tower</td>
<td>6.0–8.0</td>
<td>1000 m³</td>
</tr>
<tr>
<td>Process water</td>
<td></td>
<td></td>
</tr>
<tr>
<td>City</td>
<td>5.00–8.00</td>
<td>1000 m³</td>
</tr>
<tr>
<td>Boiler feed</td>
<td>1.70–2.70</td>
<td>1000 m³</td>
</tr>
<tr>
<td>Compressed air</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Process air</td>
<td>1.60–4.80</td>
<td>1000 m³</td>
</tr>
<tr>
<td>Instrument</td>
<td>3.20–10.00</td>
<td>1000 m³</td>
</tr>
<tr>
<td>Natural gas</td>
<td>2.00–4.00</td>
<td>10⁶ Btu</td>
</tr>
<tr>
<td>Fuel oil</td>
<td>0.30–0.50</td>
<td>gal</td>
</tr>
<tr>
<td>Coal</td>
<td>4.00–5.00</td>
<td>mton</td>
</tr>
<tr>
<td>Refrigeration (−30°C)</td>
<td>2.00–3.00</td>
<td>ton/day (288,000 Btu removed)</td>
</tr>
</tbody>
</table>
FIGURE B.4
History of selected cost indexes pertinent to chemical process construction (1950–1998)
\[ \Delta T = T \text{ (hot fluid)} - T \text{ (air)} \]

**FIGURE E3.3**
Heat loss from an insulated pipe

where \( \Delta T \) = average temperature difference between pipe fluid and ambient surroundings, K

\( A \) = surface area of pipe, m\(^2\)

\( x \) = thickness of insulation, m

\( h_c \) = outside convective heat transfer coefficient, kJ/(h)(m\(^2\))(K)

\( k \) = thermal conductivity of insulation, kJ/(h)(m)(K)

\( Q \) = heat loss, kJ/h
Values of energy saved

Insulation cost

**FIGURE E3.6**
Cash flows for insulating a pipe.

- \( Y \) 8000 operating hours/year
- \( H_t \) 3.80/10^6 kJ fuel cost, 80% thermal efficiency (boiler)
- \( k \) 0.80 kJ/(h)(m)(°C), insulation
- \( C_1 \) $34/cm insulation for 1 m² of area, cost of insulation
- \( h_c \) 32.7 kJ/(h)(m²)(°C), heat transfer coefficient (still air)
- Life of the insulation = 5 years
- Annual discount rate \((i) = 14\%\)
- \( L \) 100 m, length of pipe

The insulation of thickness \( x \) can be purchased in increments of 1 cm (i.e., 1, 2, 3 cm, etc.). Equation \((b)\) in Example 3.3 still applies. The value of the energy saved each year over 5 years is

\[
Q_0 - Q = \Delta T(\pi DL) \left[ h_c - \frac{1}{(x/k) + (1/h_c)} \right] (Y)(H_t) \quad \text{in \$/year}
\]

and the cost of the insulation is

\[
C_1x(\pi DL) \quad \text{in \$}
\]
<table>
<thead>
<tr>
<th>thickness x (cm)</th>
<th>Insulation cost ($)</th>
<th>Value of fuel saved ($/year)</th>
<th>Payback period</th>
<th>Return on investment</th>
<th>Net present value</th>
<th>Internal rate of return (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>2136.2812</td>
<td>4222.6063</td>
<td>0.5059</td>
<td>1.9766</td>
<td>12374.3935</td>
<td>197%</td>
</tr>
<tr>
<td>2</td>
<td>4272.5624</td>
<td>6545.9111</td>
<td>0.6527</td>
<td>1.5321</td>
<td>18221.9773</td>
<td>152%</td>
</tr>
<tr>
<td>3</td>
<td>6408.8436</td>
<td>8016.0764</td>
<td>0.7995</td>
<td>1.2508</td>
<td>21137.8106</td>
<td>123%</td>
</tr>
<tr>
<td>4</td>
<td>8545.1248</td>
<td>9030.1278</td>
<td>0.9463</td>
<td>1.0568</td>
<td>22486.2422</td>
<td>103%</td>
</tr>
<tr>
<td>5</td>
<td>10681.406</td>
<td>9771.8221</td>
<td>1.0931</td>
<td>0.8065</td>
<td>22898.7385</td>
<td>88%</td>
</tr>
<tr>
<td>6</td>
<td>12817.6872</td>
<td>10337.8943</td>
<td>1.2399</td>
<td></td>
<td>22707.7228</td>
<td>76%</td>
</tr>
<tr>
<td>7</td>
<td>14953.9684</td>
<td>10784.1183</td>
<td>1.3867</td>
<td>0.7212</td>
<td>22104.8574</td>
<td>66%</td>
</tr>
</tbody>
</table>

**Cash flows**

<table>
<thead>
<tr>
<th>thickness x (cm)</th>
<th>Year 0</th>
<th>Year 1</th>
<th>Year 2</th>
<th>Year 3</th>
<th>Year 4</th>
<th>Year 5</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>-2136.2812</td>
<td>4222.61</td>
<td>4222.61</td>
<td>4222.61</td>
<td>4222.61</td>
<td>4222.61</td>
</tr>
<tr>
<td>2</td>
<td>-4272.5624</td>
<td>6545.91</td>
<td>6545.91</td>
<td>6545.91</td>
<td>6545.91</td>
<td>6545.91</td>
</tr>
<tr>
<td>3</td>
<td>-6408.8436</td>
<td>8016.08</td>
<td>8016.08</td>
<td>8016.08</td>
<td>8016.08</td>
<td>8016.08</td>
</tr>
<tr>
<td>4</td>
<td>-8545.1248</td>
<td>9030.13</td>
<td>9030.13</td>
<td>9030.13</td>
<td>9030.13</td>
<td>9030.13</td>
</tr>
<tr>
<td>5</td>
<td>-10681.406</td>
<td>9771.82</td>
<td>9771.82</td>
<td>9771.82</td>
<td>9771.82</td>
<td>9771.82</td>
</tr>
<tr>
<td>6</td>
<td>-12817.6872</td>
<td>10337.89</td>
<td>10337.89</td>
<td>10337.89</td>
<td>10337.89</td>
<td>10337.89</td>
</tr>
<tr>
<td>7</td>
<td>-14953.9684</td>
<td>10784.12</td>
<td>10784.12</td>
<td>10784.12</td>
<td>10784.12</td>
<td>10784.12</td>
</tr>
</tbody>
</table>
Buying & Selling Energy

- NYMEX—New York Mercantile Exchange
- Buy/sell coal, crude oil (and its derivatives), natural gas, uranium, & electricity futures and options
- Electricity trading is different than the others…(10/29)
Energy Futures

• Specify
  – Commodity (e.g., WTI Light Crude)
  – Location
  – Date of fulfillment
  – Quantity
  – Price
Energy Options

• Calls
  – The right (but not obligation) to buy a specified amount at a predetermined price

• Puts
  – The right (but not obligation) to sell a specified amount at a predetermined price
SIX OPTION SPREAD COMPONENTS

BUY Underlying

profit (loss)

0

underlying price

SELL Underlying

profit (loss)

0

underlying price

BUY CALL

profit (loss)

0

underlying price

BUY PUT

profit (loss)

0

underlying price

SELL CALL

profit (loss)

0

underlying price

SELL PUT

profit (loss)

0

underlying price