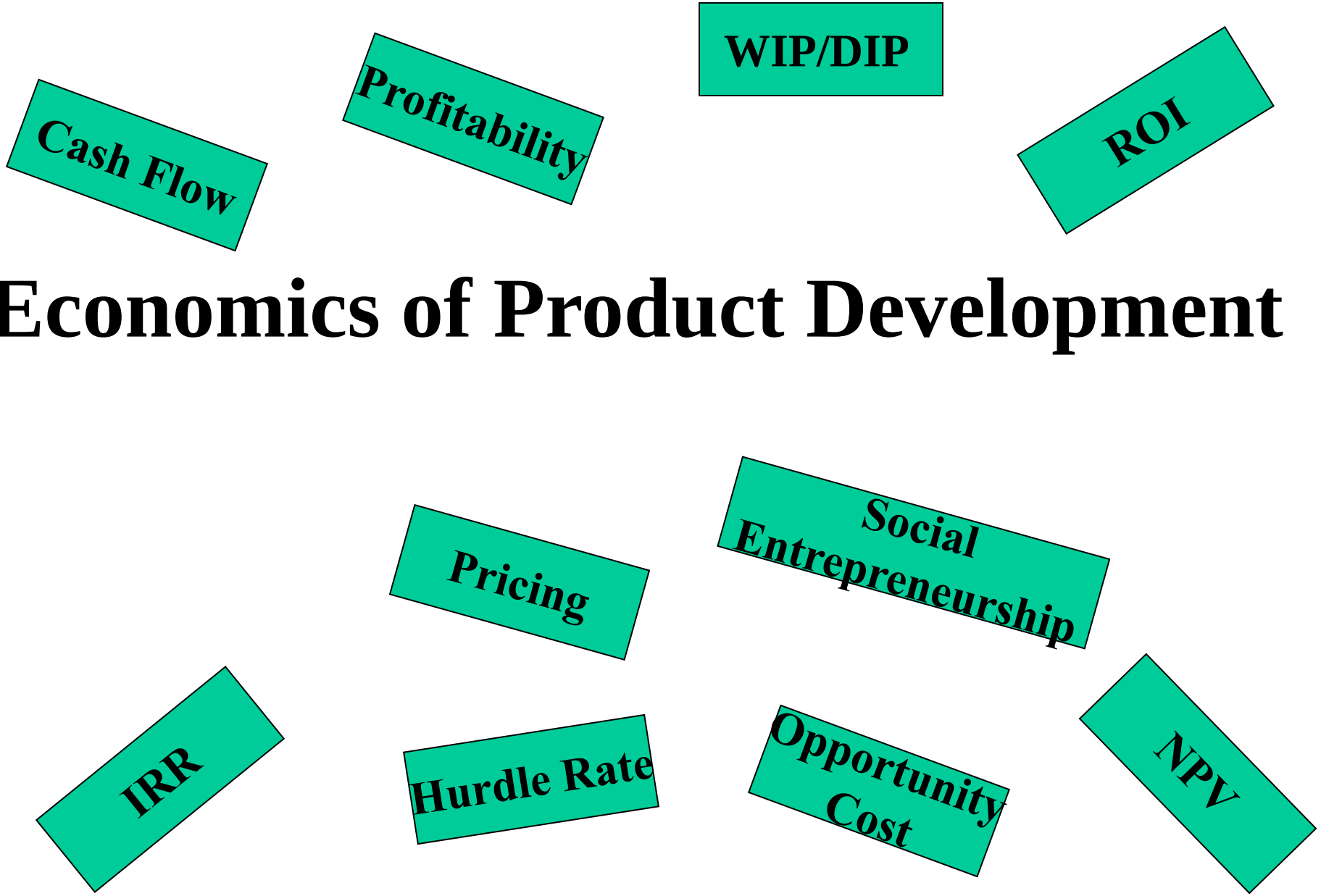

Cash Flow
Profitability
WIP/DIP
ROI
Economics of Product Development
Pricing
Social Entrepreneurship
IRR
Hurdle Rate
Opportunity Cost
NPV

# Engineering Economics

- Purpose of a business
- Applicability to a developing country
- Principal of Equivalence
- Strategic Considerations
- Net Present Value

# Today's existential questions

Why are we designing products for the developing world?

Why be profitable?

# Profit

**The purpose of building a Product for the Developing World is to produce a good or service that will improve the lives of the customer**

- **Assumption 1: To create the greatest good over the longest times, the business as well as the product, should be sustainable**
- **Assumption 2: No one is smart enough to figure out in advance with any degree of certainty what it is that a group of people really want. This is especially true if the customer is remote in distance, culture and needs from the product designer**
- **Assumption 3: People make rational economic choices and are the best judges of what is good for them**

**From the above, profit is the best way**

- **To validate the usefulness of the product**
- **To make the product availability sustainable. If the product is of use to the customer, depending upon their ability to pay, customers will pay a sufficient price for to assure a profit**

# Profit

- What if you know of something that is good for people but customer can’t afford?
- Should they be deprived of what is obviously good for them?

# Profit

- **Gross Profit=Price - Direct Cost**
- **Net Profit= Gross profit - allocated expenses**

  ***Note: Don't underestimate the amount of allocated expenses required to build and sell the product***

- **To assure a profit, a for-profit company will act to produce products that can command the highest prices and cost the least to make**
- **Any exceptions?**

# Profit

How much profit is enough?

The Rocks and the Hard Places in Pricing

- Danger of giving it away and not knowing whether it was useful or not
- Danger of under-pricing because you did not take into account all associated costs
- Danger of “Gouging”

# Profit

- Which do you worry about in your product??

# What other financial issues drive companies besides profits?

**<u>Valuation</u>**

- **Future earnings**
  - **Products in the pipeline**
- **Acquisition potential**
  - **Strategic fit of products with another company**
- **Break-up potential**
  - **Value of a conglomerate as the sum of its parts**
- **Tax consequences**
- **Etc.**

***Limited relevance to Developing Countries***

# What other financial drives companies besides profits?

- **Cash Flow**
  - **Required for business continuity**
    - **To pay expenses**
    - **To pay interest on debt**
    - **To pay dividends to stockholders**
  - **To grow business**
    - **To invest in new programs, technologies**
    - **Equipment**
    - **Inventory and Receivables**
    - **Acquisitions etc.**

***Highly relevant to Developing Countries***

# What other product issues drive companies besides profits?

## Understanding Cash Flow.....

Activities which bring cash into the business
- Operating
- Financing

Activities which remove cash from the business
- Operating
- Financing

| Business Activity | Personal Activity |
|---|---|
| (+) | (+) |
| • Receiving payments from customers<br>• Borrowing money<br>• Selling shares of the company | • Cashing our paychecks<br>• Receiving a car loan/home mortgage |
| (-) | (-) |
| • Paying our expenses for<br>– Salaries<br>– Materials<br>– Equipment<br>• Paying interest on debt<br>• Paying dividends to shareholders | • Paying monthly expenses<br>– Food<br>– Utilities<br>– Insurance<br>• Paying monthly car payment/ mortgage |
| = | = |
| **Cash Flow of Business** | **Cash in the Bank** |

# In a start-up “company” with little or no sales

Cash flow is typically a negative quantity

Central riveting thought

cash in bank/monthly negative cash flow

= number of months until you are

out of business

The horror! The horror!

# Managing Cash Flow to avoid extinction

- **Raise the largest amount of money you can as early as you can**
- **Reduce monthly expenses to the minimum**
  - **People**
  - **Materials**
  - **Overhead**
- **Decrease time to market**
- **Decrease time to cash**

# Investment Alternatives for Funder of Social Programs e.g., an NGO

- **What is the mission of the funder?**
- **What motivates them?**
- **What have they funded recently?**
- **What is their "sweet spot"?**

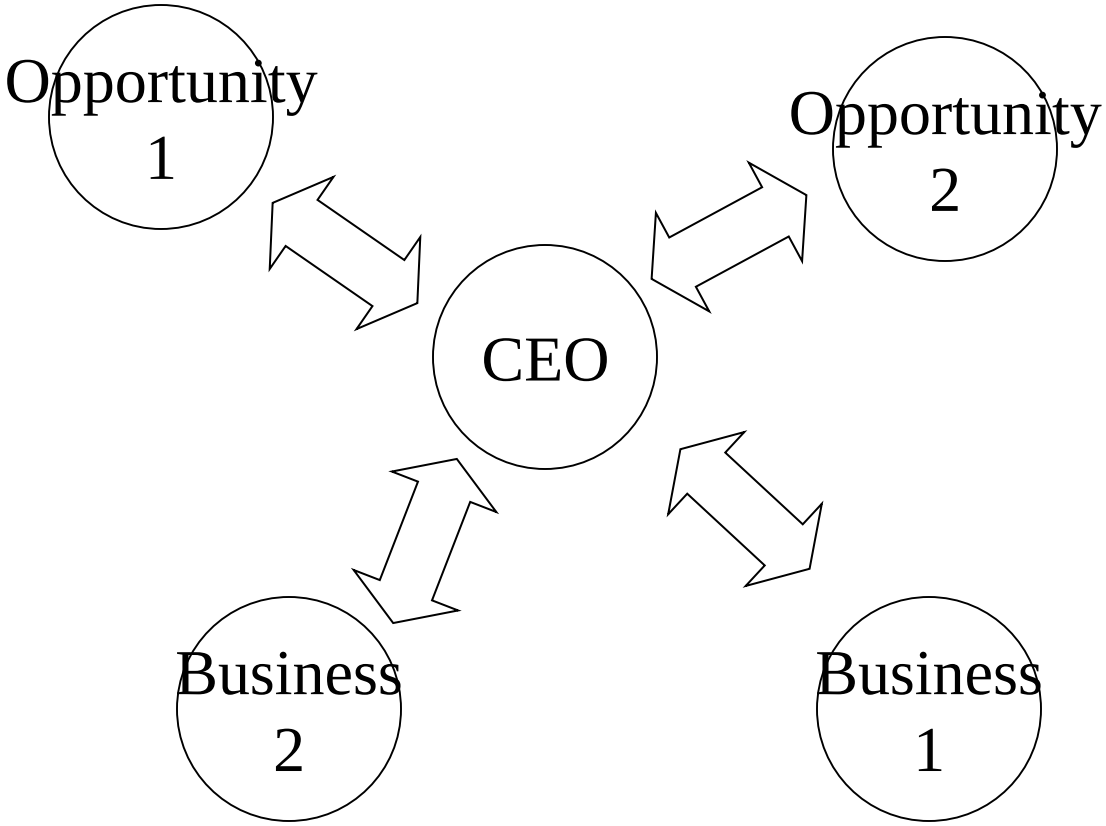
**Think of the NGO as your customer**

***Note: More applicants than money!***

# What are typical investment alternatives. . .

- For the Developing World
  - Opportunity a
  - Opportunity b
  - Opportunity c

# What CEOs (or NGOs) do for a living



# Social Entrepreneurship

***Applying business principles to nonprofits***

***Nonprofits have to recognize that they're businesses, not just causes. There's a way to combine the very best of the not-for-profit, philanthropic world with the very best of the for-profit, enterprising world. This hybrid is the wave of the future for both profit and nonprofit companies."***
**Bill Strickland**

# Principal of Equivalence

- **The state  of being equal in value**
  - **amount**
  - **discount assumptions**
  - **Time transactions occur**

***All investments must be normalized to give equivalence***

# Net Present Value of an Investment

- Holds for all investments
- Takes into account inflation, cost of capital, expectations of return
- Reduces all times to a common point

# Calculation of Net Present Value

$$NPV = \sum_{t=0}^{n} \frac{A_t}{(1+k)^t}$$

Where k is the expected rate of return

A sub t is the cash flow in the period t

***Choose the programs whose NPV is highest consistent with strategy, risk, resource, etc.***

# Example of Net Present Value
## Calculate 2006 value of a future cash stream

| **Year** | **2007** | **2008** | **2009** | **2010** |
|---|---|---|---|---|
| **Cash** | **-200** | **-200** | **200** | **300** |
| **NPV in 2006. Assume 10%** | **-200/1.1 = -181.8** | **-200/(1.1)(1.1) =-165.3** | **200/(1.1) (1.1)(1.1) =150.3** | **300/(1.1) (1.1)(1.1) (1.1) =204.9** |

Undiscounted NPV (2004)=-200-200+200+300= **100**
Discounted NPV (2004)= -181.8-165.3-150.3+204.9= **-8.1**

# Calculation of Payback Period

$$\sum_{t=0}^{n}\left[\frac{A_t}{(1+r)^t}\right]=0$$

Where r=rate

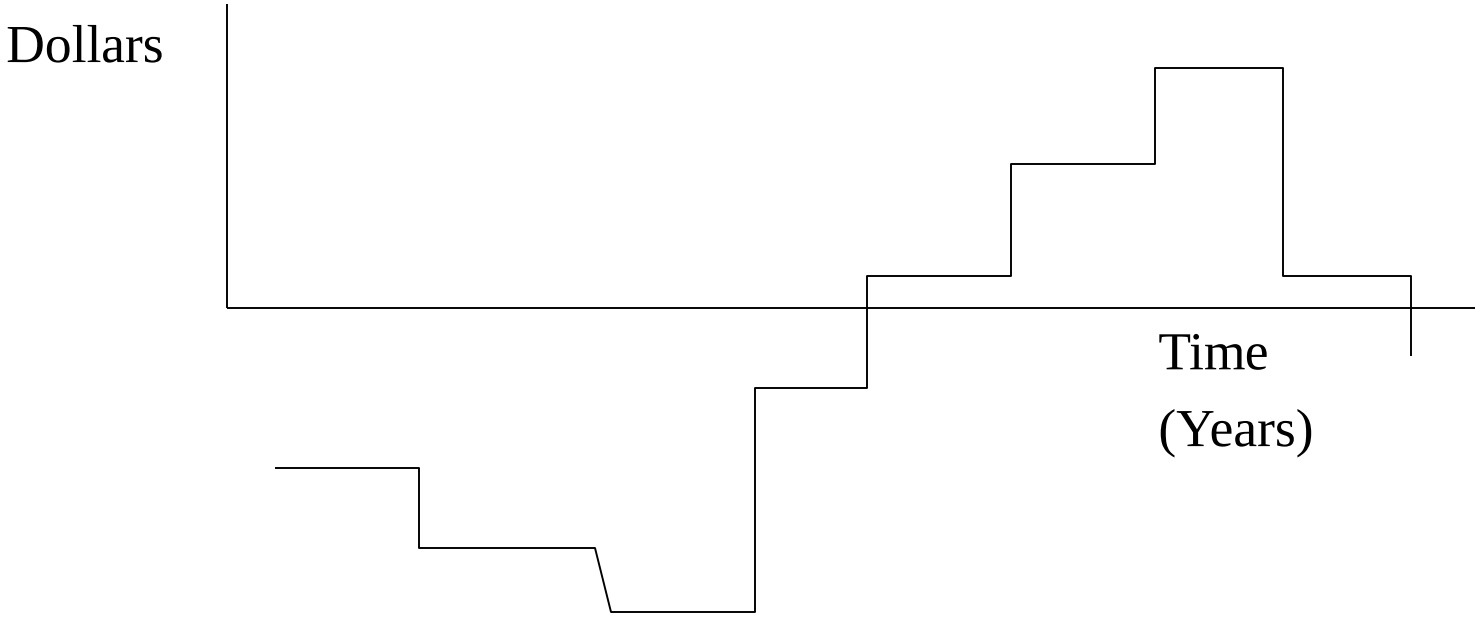
$A_t$ is the cash flow in period t

Thus payback period is the time in years to pay off the investment. Total inflow equals total out flow

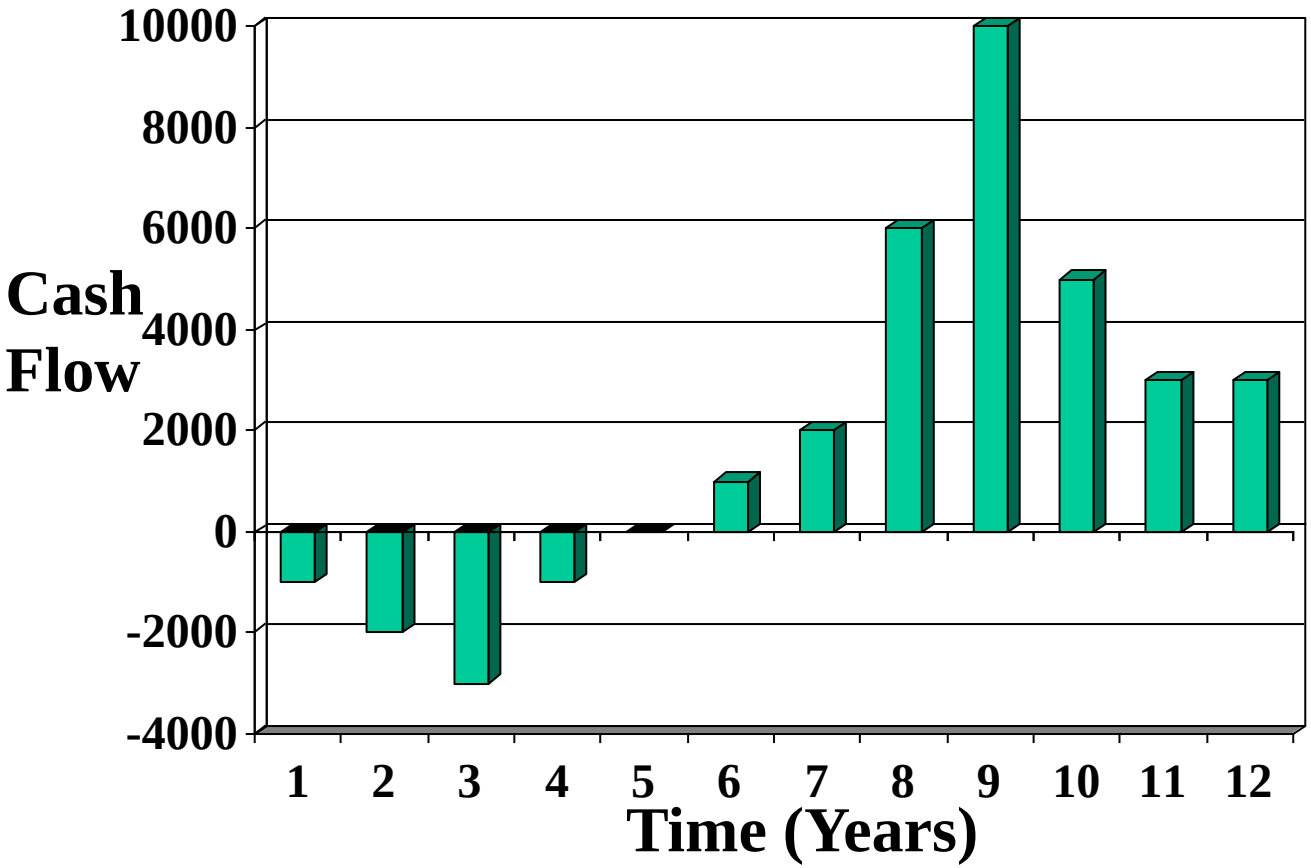
# Preparing an economic feasibility study

- Compare product Returns on Investment

example: Sample business plan pro forma



# To calculate NPV, first assume a cash flow



# Calculation of NPV and Payback Period of an investment

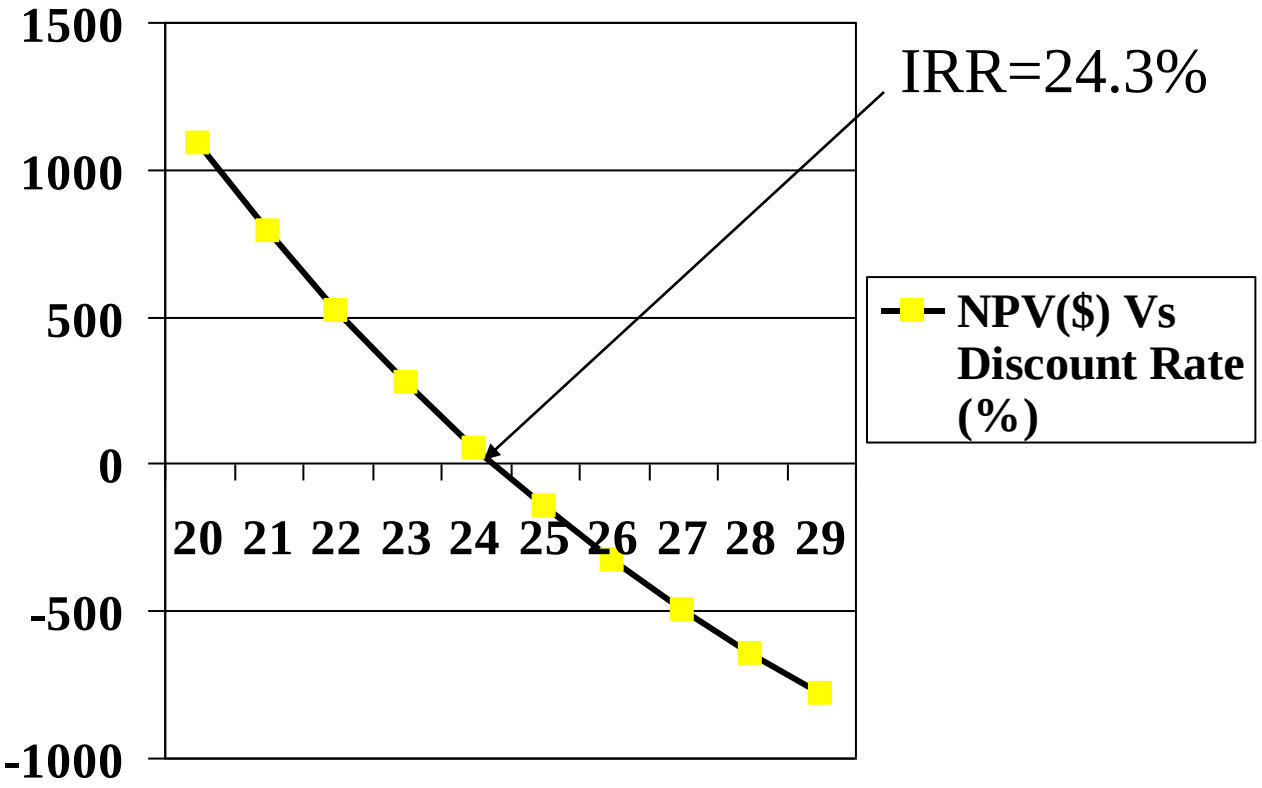
| Year | Cash | Discounted | Cash Flow | | Discou |
|---|---|---|---|---|---|
| 1 | -1000 | $ (952) | $ (952) | | |
| 2 | -2000 | $ (1,814) | $ (2,766) | | |
| 3 | -3000 | $ (2,592) | $ (5,358) | | |
| 4 | -1000 | $ (823) | $ (6,181) | | |
| 5 | 0 | $ - | $ (6,181) | | |
| 6 | 1000 | $ 746 | $ (5,434) | | |
| 7 | 2000 | $ 1,421 | $ (4,013) | | |
| 8 | 6000 | $ 4,061 | $ 48 | | |
| 9 | 10000 | $ 6,446 | $ 6,494 | | |
| 10 | 5000 | $ 3,070 | $ 9,564 | | |
| 11 | 3000 | $ 1,754 | $ 11,318 | | |
| 12 | 3000 | $ 1,671 | $ 12,988 | | |
| | | | | | |
| Net Present Value= | | $ 12,988 | | | |
| Payback | | | | | |
| | | | | | |
| Assume all cash is spent at end of period | | | | | |

# Calculation of Internal Rate of Return (IRR) for a project

- Calculate a discount rate (k) that reduces the NPV of a project to zero

$$NPV = 0 = \sum_{t=0}^{n} \frac{A_t}{(1+k)^t}$$

# Calculation of Internal Rate of Return IRR) of an investment



# Net Present Value

- What are the Problems with this analysis methodology?

# What's wrong with this picture?

- **Predictions are very difficult- especially when they involve the future.**
  - **Extrinsic**
    - **Markets change**
    - **Competitors change**
    - **Macro-economic conditions change**
    - **Strategic considerations**
  - **Intrinsic**
    - **The analyses are based on flawed assumptions**
      - **Program delays**
      - **Manufacturing snafus**
      - **Technologies not ready**
      - **Externalities (out of your control)**
      - **Many other reasons**

# How to account for Social Value?

Then why is NPV a universal way of measuring product worth?

# Advantages of a quantitative methodology

# Sensitivity Analysis

- Recall Gross Profit=Price-Direct cost
- Can improve Profit by
  - Increasing (Reducing?) Price
  - Reduce Cost
- Shorten Product Development Time
- Increase sales ramp
- Decrease costs
- Change discount rate?

# Some thoughts on how to increase profits
# P=SP-C

## 1. Increase Selling Price

**Increase Customer Value**

- **Put extra features in product which require little marginal cost**
- **Provide extra service**
- **Target less competitive segment of the market**
- **Get to market before competition**
- **Price at the maximum the customer is willing/able to pay**

***Price models should reflect customer value and customer willingness/ability to pay***

# Some thoughts on how to increase profits
# P=SP-C

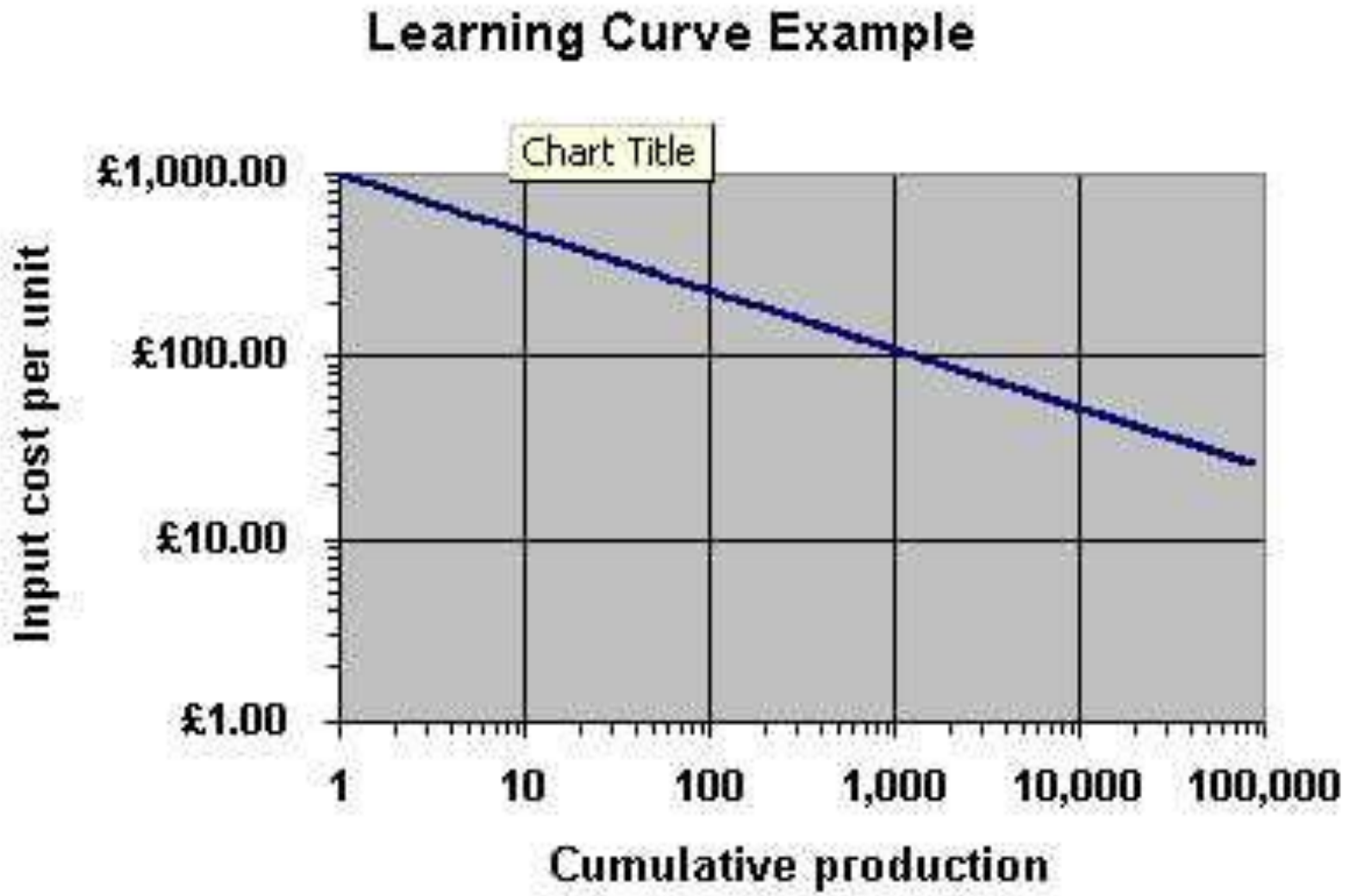
## 2. Decrease Selling Price

- How can this be effective in increasing profits?

# Learning Curve

The cost of building a product will decrease by a constant percentage each time the production quantity is doubled.

If the rate of improvement is 20% between doubled quantities, then the **learning percent** would be 80% (100-20=80)


Learning Curve Example
Chart Title
£1,000.00
£100.00
£10.00
£1.00
Input cost per unit
1
10
100
1,000
10,000
100,000
Cumulative production

# Learning Curve

- Is this applicable to your product?

# Some thoughts on how to increase profits

# P=SP-C

## 3. Decrease Product Development (NRE) and Manufacturing (RE) costs

- **Fast and approximate in developing country products**
- **Build a manufacturable product. Think of manufacturing issues early**
- **Don’t overload with features that the customer doesn’t want that are costly to develop. Be cheap and simple!**
- **Manage tightly to schedule with appropriate risk and risk reduction plans**

**All of these consistent with Fast Cycle Time**

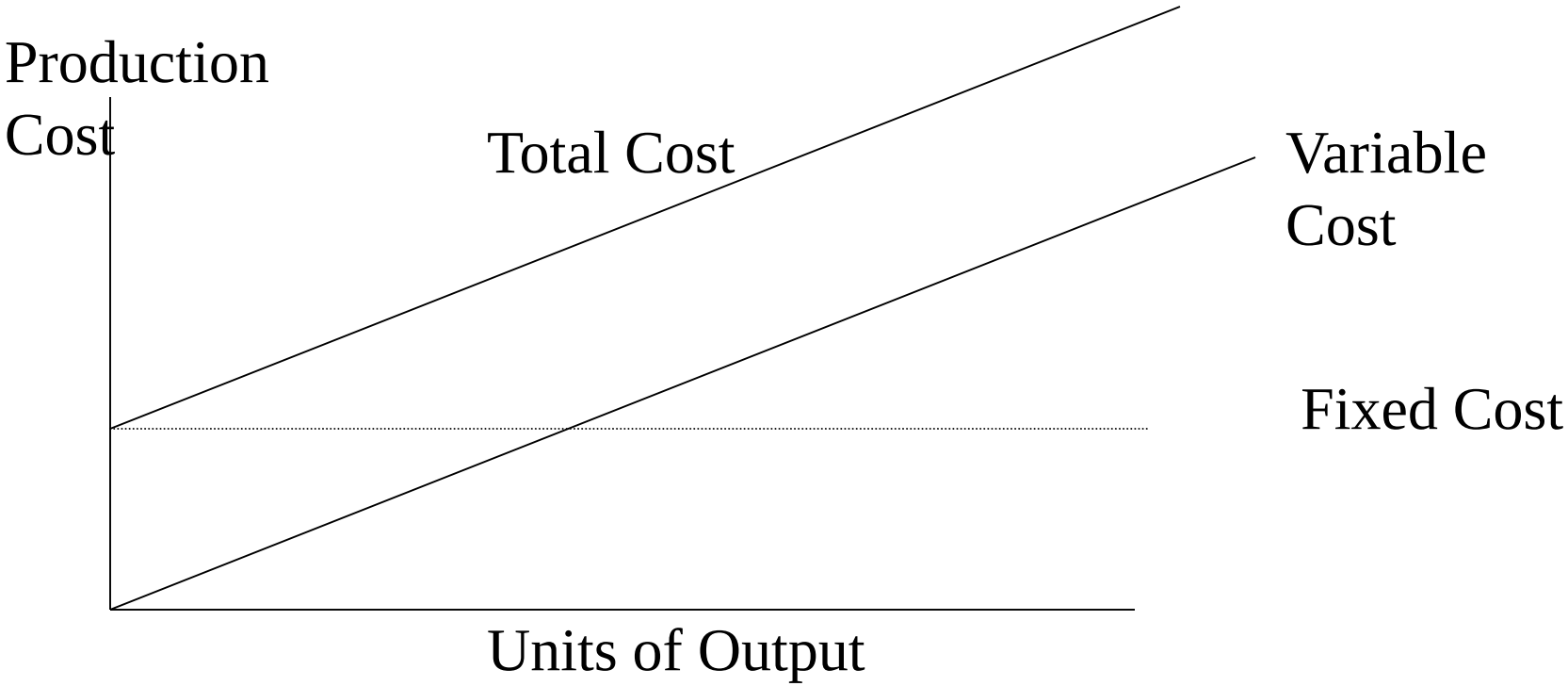
## Some thoughts on how to increase profits
## P=SP-C

### 4. Decrease Cycle Time for product Development

- Effect on learning market needs
- Effect on total revenue of turning out product faster
- Effect on Cost of product

# How do you speed things up?

# Costs- Fixed and Variable



# Costs

Fixed (Volume insensitive)

- Equipment and Tooling
- Utilities
- Rent
- Taxes on property
- insurance
- Management salaries

Variable (Volume Sensitive)

- Direct Labor
- Direct Materials
- Consumable Chemicals
- Other expenses which scale directly with volume

**How does product design effect these costs?**

# Create "Bill of Materials" to calculate costs and communicate with manufacturing

Indented bill of materials showing cost estimates for the original intake manifold and related components. The EGR (exhaust gas recirculation), PCV (positive crankcase ventilation), and vacuum block components are included here to facilitate comparison with the redesigned manifold assembly.

| Component | Purchased Materials | Processing (Machine + Labor) | Assembly (Labor) | Total Unit Variable Cost | Tooling and Other NRE, K$ | Tooling Lifetime, K units | Total Unit Fixed Cost | Total Cost |
|---|---|---|---|---|---|---|---|---|
| Manifold machined casting | 12.83 | 5.23 | | 18.06 | 1960 | 500+ | 0.50 | 18.56 |
| EGR return pipe | 1.30 | | 0.15 | 1.45 | | | | 1.45 |
| PCV assembly | | | | | | | | |
| Valve | 1.35 | | 0.14 | 1.49 | | | | 1.49 |
| Gasket | 0.05 | | 0.13 | 0.18 | | | | 0.18 |
| Cover | 0.76 | | 0.13 | 0.89 | | | | 0.89 |
| Screws (3) | 0.06 | | 0.15 | 0.21 | | | | 0.21 |
| Vacuum source block assembly | | | | | | | | |
| Block | 0.95 | | 0.13 | 1.08 | | | | 1.08 |
| Gasket | 0.03 | | 0.05 | 0.08 | | | | 0.08 |
| Screw | 0.02 | | 0.09 | 0.11 | | | | 0.11 |
| Column Totals (Direct Costs) | 17.35 | 5.23 | 0.95 | 23.53 | 1960 | | 0.50 | 24.03 |
| Overhead Charges | 2.60 | 9.42 | 1.71 | | | | 0.75 | 14.48 |
| **Total Cost** | | | | | | | | **38.51** |

# Bill Of Materials

| | | |
|---|---|---|
| **Variable Cost** | | |
| Materials | 5.7 kg aluminum at $2.25/kg | $12.83 |
| Processing (casting) | 150 units/hr at $530/hr | 3.53 |
| Processing (machining) | 200 units/hr at $340/hr | 1.70 |
| **Fixed Cost** | | |
| Tooling for casting | $160,000/tool at 500K units/tool (lifetime) | 0.32 |
| Machine tools and fixtures | $1,800,000/line at 10M units (lifetime) | 0.18 |
| **Total Direct Cost** | | **$18.56** |
| Overhead charges | | $12.09 |
| **Total Unit Cost** | | **$30.65** |

Cost estimate for the original intake manifold. Note that the processing costs for casting and machining reflect the costs for a complete casting line and several machining stations.

# Effect of Design on Factory Productivity

- **Need to minimize changes**
  - **excessive numbers of different products running in line**
  - **Long set-ups**
- **High Inventory due to lack of re-use**
  - **Make Vs Source**
- **Low first pass yield due to mismatch of product design with process capability**
  - **“hidden factory”**
  - **Scrap**

- Incorporate financial thinking into your Term Project
  - Consider financial objectives
  - Consider financial outflow to create a product
  - Consider  Price and ramp-up

# Reference

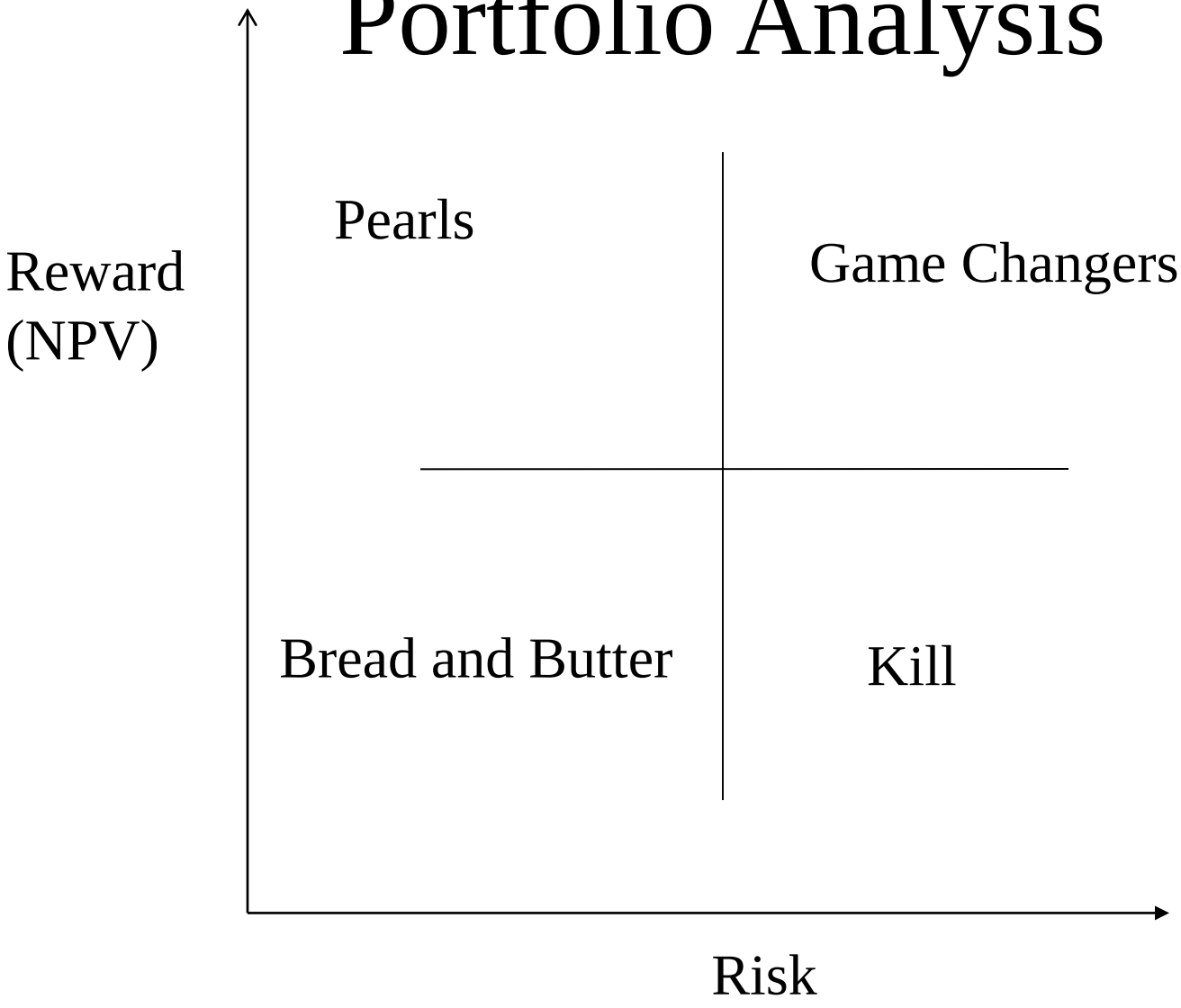
- Financial Performance Measures for Technological Corporations

Dr Simon Ramo

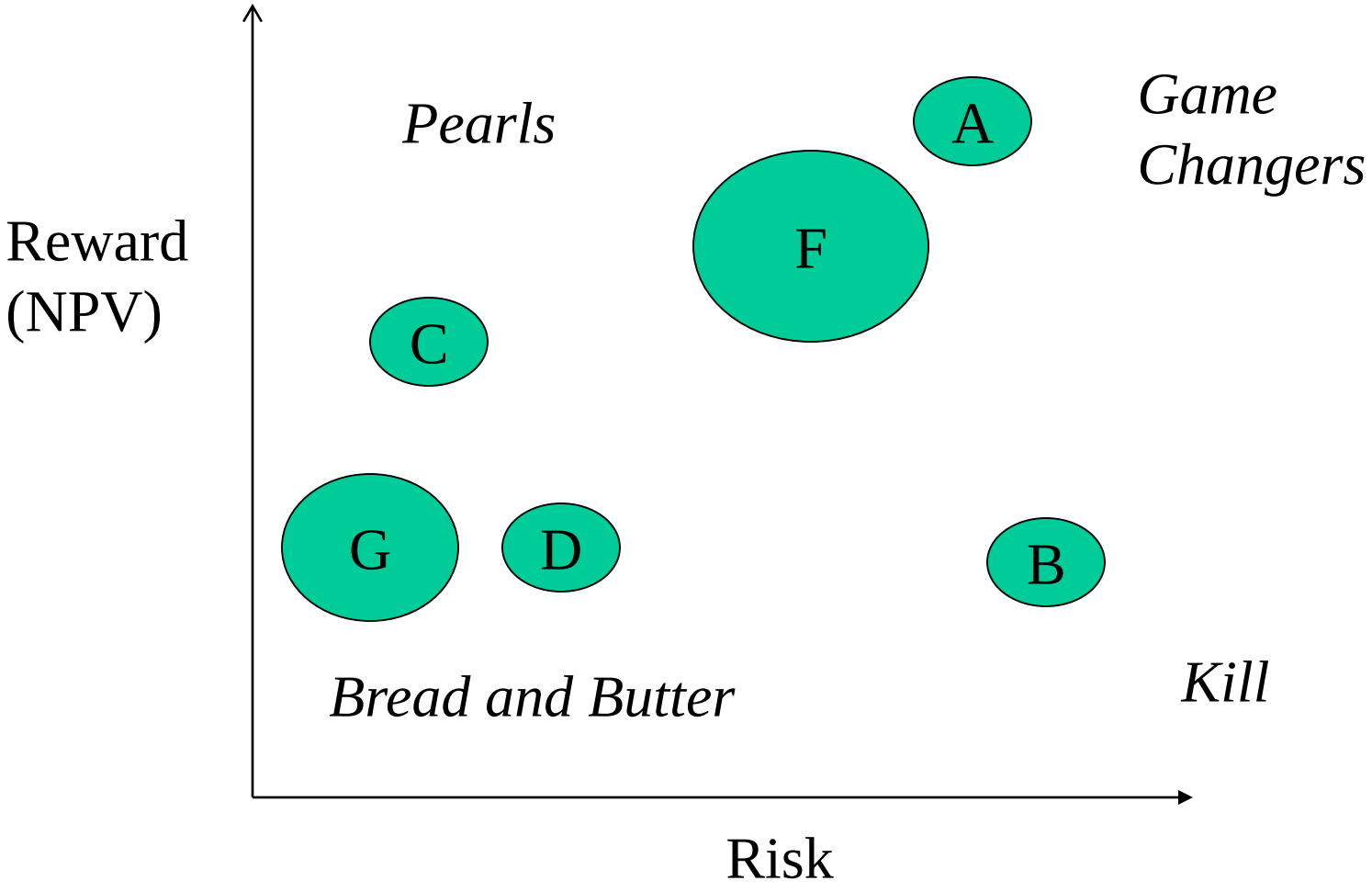
- Any Book on Engineering Economics

# Appendix
# Portfolio Analysis
# Introduction

# Portfolio Analysis



# A Portfolio of 6 alternatives




Note: area = program cost

# How do you allocate?

**Not by NPV and Payback Period alone**

**But. . .**

- **Portfolio Balance (long/short)**
- **Strategically Important vs Tactically Important**
- **Product Families and Platforms**
- **Future Sales Model**
- **Available Resource**
  - **People and Dollars**
- **Customers demands**
- **Customer learning**

# Data for Rank ordered List

| Project Name | IRR | NPV | Strategic Importance | Probability of Technical Success |
|---|---|---|---|---|
| Alpha | 20% | 10.0 | 5 | 80% |
| Beta | 15% | 2.0 | 2 | 70% |
| Gamma | 10% | 5.0 | 3 | 90% |
| Delta | 17% | 12.0 | 2 | 65% |
| Epsilon | 12% | 20.0 | 4 | 90% |
| Omega | 22% | 6.0 | 1 | 85% |

# Rank Ordered by discounting returns by probability of success

| Project Name | IRR | | NPV | | Strategic Importance | | Ranking Score | |
|---|---|---|---|---|---|---|---|---|
| Alpha | 16.0 | (2) | 8.0 | (2) | 5 | (1) | 1.67 | (1) |
| Epsilon | 10.8 | (4) | 18.0 | (1) | 4 | (2) | 2.33 | (2) |
| Delta | 11 | (3) | 7.8 | (3) | 2 | (4) | 3.33 | (3) |
| Omega | 18.7 | (1) | 5.1 | (4) | 1 | (6) | 3.67 | (4) |
| Gamma | 9.0 | (6) | 4.5 | (5) | 3 | (3) | 4.67 | (5) |
| Beta | 10.5 | (5) | 1.4 | (6) | 2 | (4) | 5.0 | (6) |

# Whatever the methodology, the choices you make have an Opportunity Cost

- Your Resource is always finite
- There are lots of “good” ideas
- Thus in this environment, allocation is a zero sum game.
- An investment that ties up resource- even a “good investment” (High NPV) can crowd out a better (sometimes much better) investment