Cost Analysis and Estimating
for Engineering and Management

Chapter 8
Product Estimating

Overview

- Processes for Determining Price
  - –Bottom Up and Top Down
- Using Productive Hour Costs
- Learning in Product Cost Estimating
- Methods to Establish Price
- Purchasing Contracts
- Benchmarking

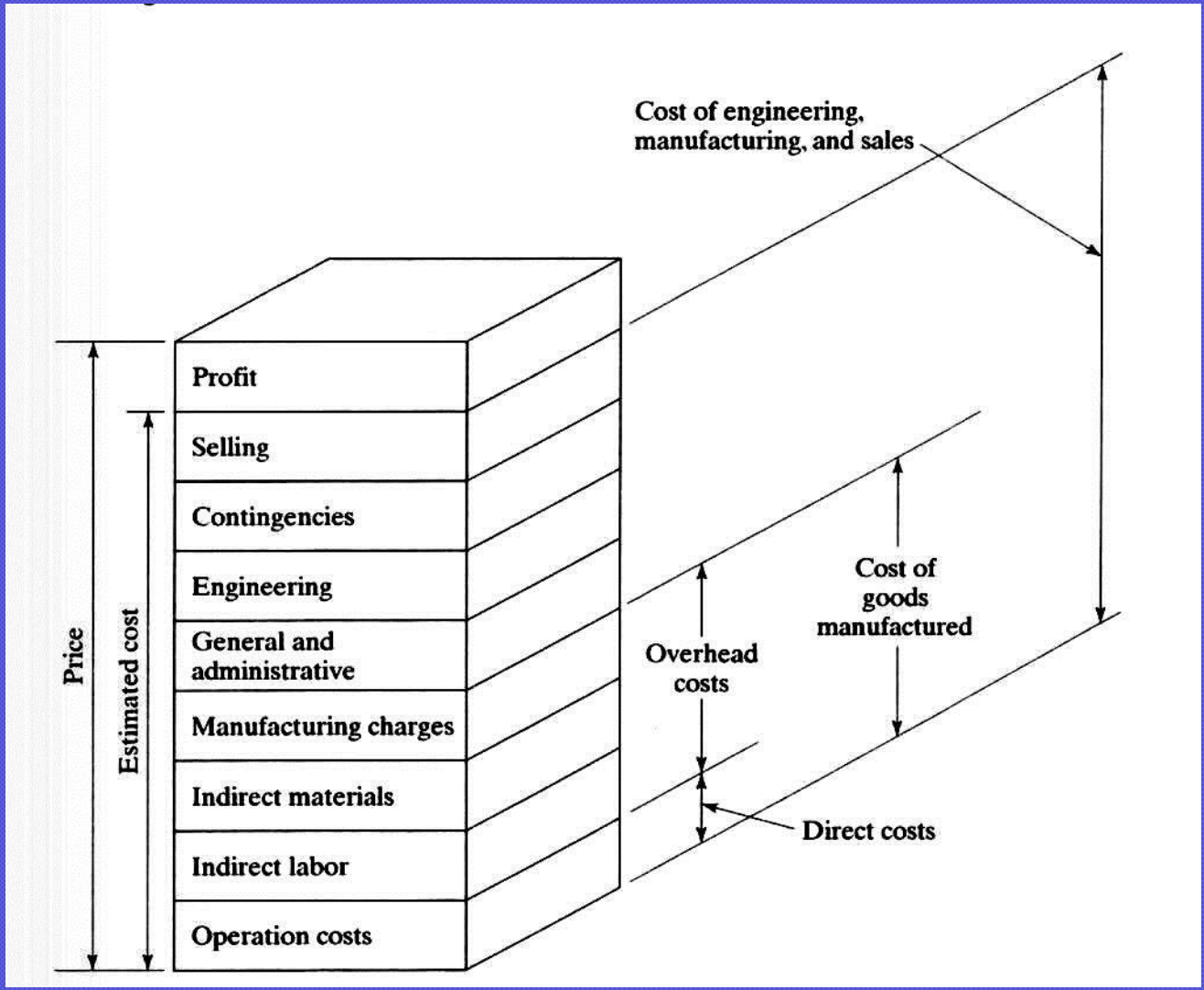
The Product Estimate

- Must Include All Parts
  - –All Operations, Direct and Indirect
  - –Overhead, Engineering, Sales
- Determines
  - –Price, Cost, Profit
  - –Cash Flow, Rate of Return
  - –Labor Requirement, Scheduling

Market Place

- Market Determines Price Paid
- Attainable Price Should Exceed Cost
- Price Also Determines Quantity Sold
- Price from the "Top Down"
  - Sets Allowable Costs

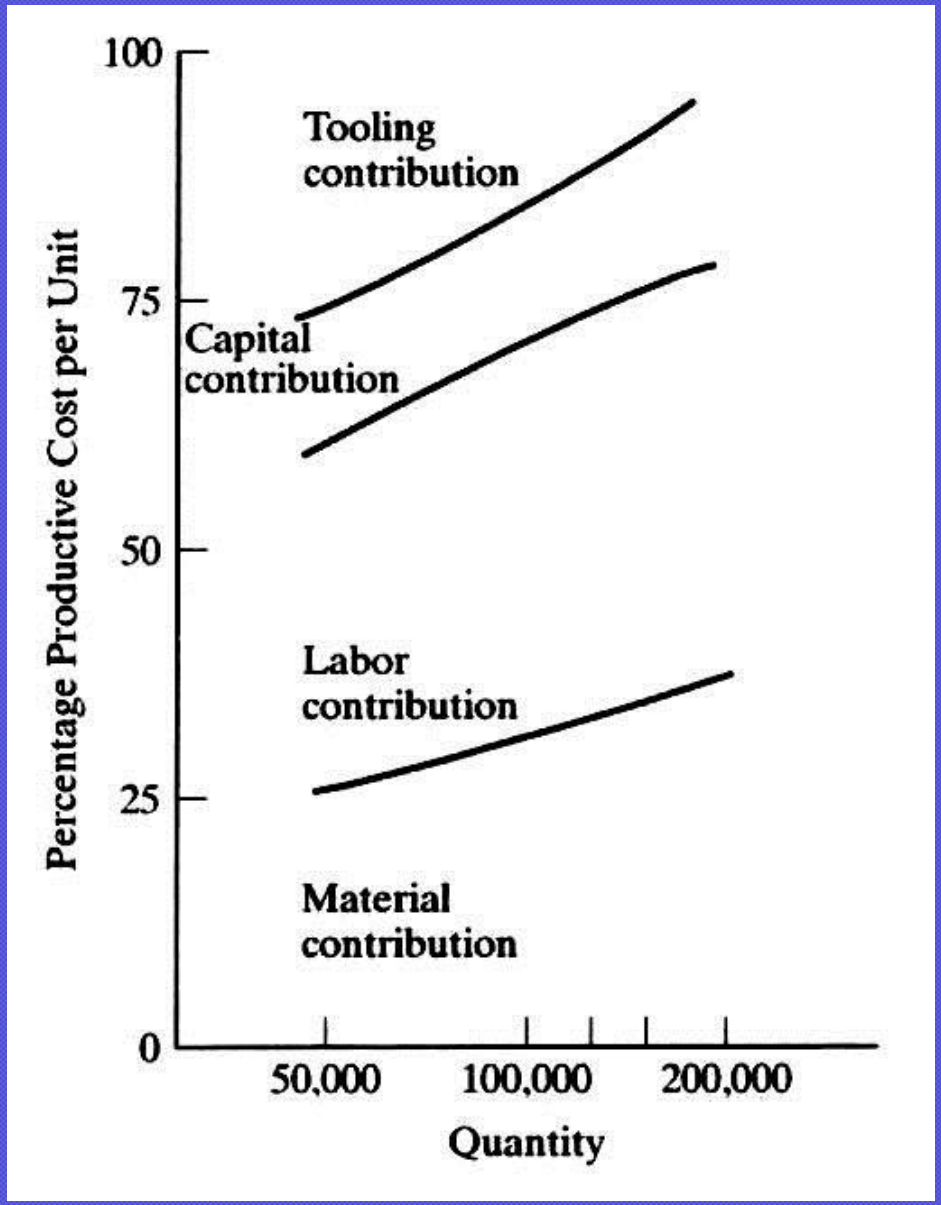
Price Elements



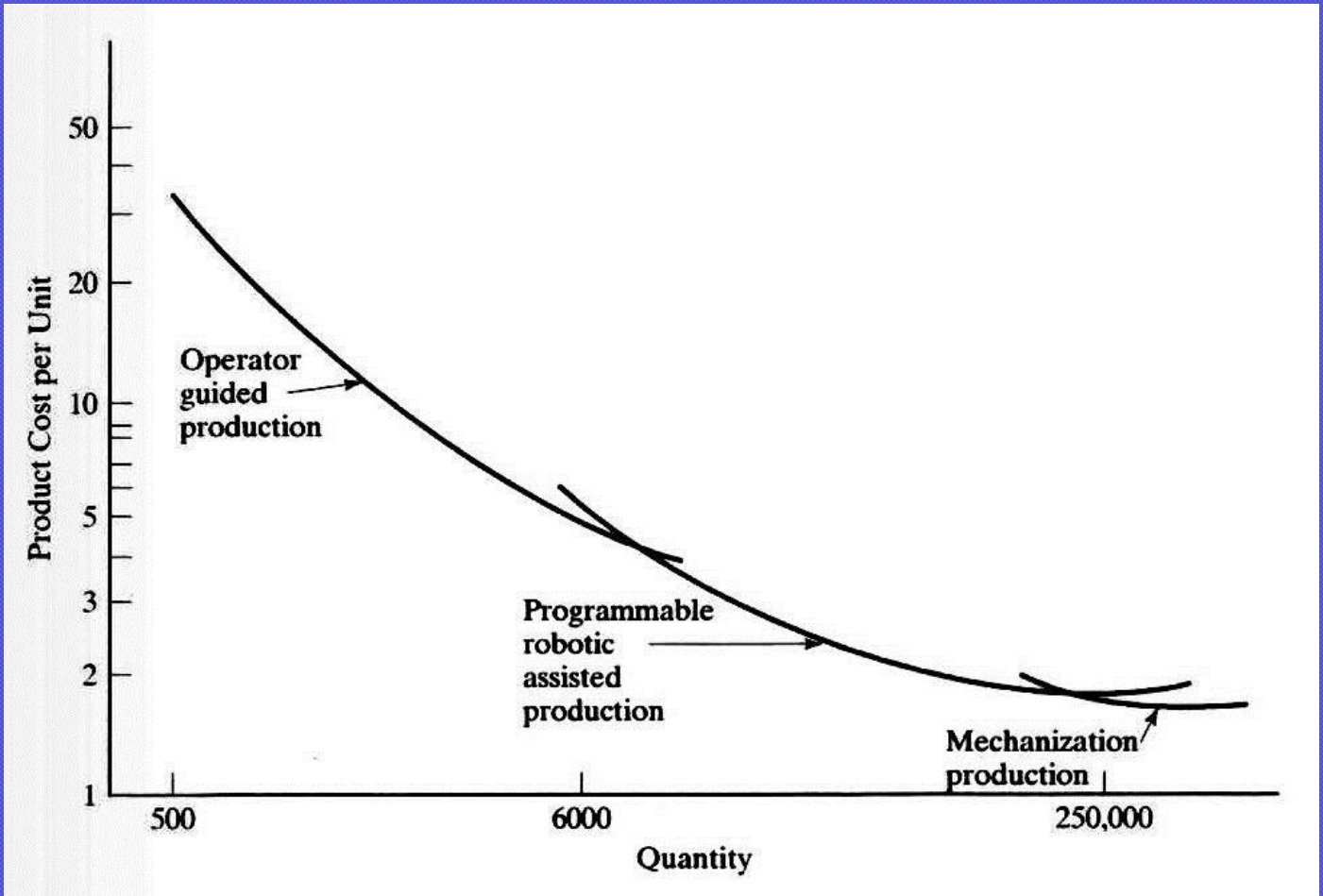
Estimated Cost

- Components of “Cost of Goods Manufactured” and Overhead (Gen & Admin) Previous Discussions
- Engineering and Sales
- Contingencies
  - Provides for Unknowns
  - Radically New Products/Processes
  - Not for “Pad” or Poor Estimates

Product Cost Elements



Selecting Method vs Quantity



Engineering Costs

- Design of the Product
- R & D
- Engineering for Products Not Produced
- Support Engineering
  - Manufacturing, Industrial
  - Test, QC

Handling Engineering Costs

- Overhead
  - –Mass Production, Few New / Changes
- Separate Line Item(s)
  - –High Tech, Services
- Amortize to Products Produced

$$C_e = \frac{\text{total engineering expenses}}{\text{product quantity}}$$

Eq 8.1

Finding Engr Costs

- Include All Elements
  - –Salaries
  - –Expenses
  - –Overhead
  - –Fees Paid

$$C_e = \Sigma S + \Sigma E + \Sigma OH + \Sigma F \qquad \text{Eq 8.2}$$

Example of Engr Costs

Work Category	Hr	Rate / hr	Totals
Engineer, senior design	40	$33.00	$1,320
Engineer, design	800	30.00	24,000
Designer/engineering. aide	160	18.75	3,000
CAD operator	80	17.00	1,360
Total Engineering Labor	1080		$29,680

Information for Estimating

- Need to Know:
  - –What Does It Look Like?
  - –How Many? (Will Be Made)
- Determines:
  - –Manufacturing Processes
  - –Labor Requirements

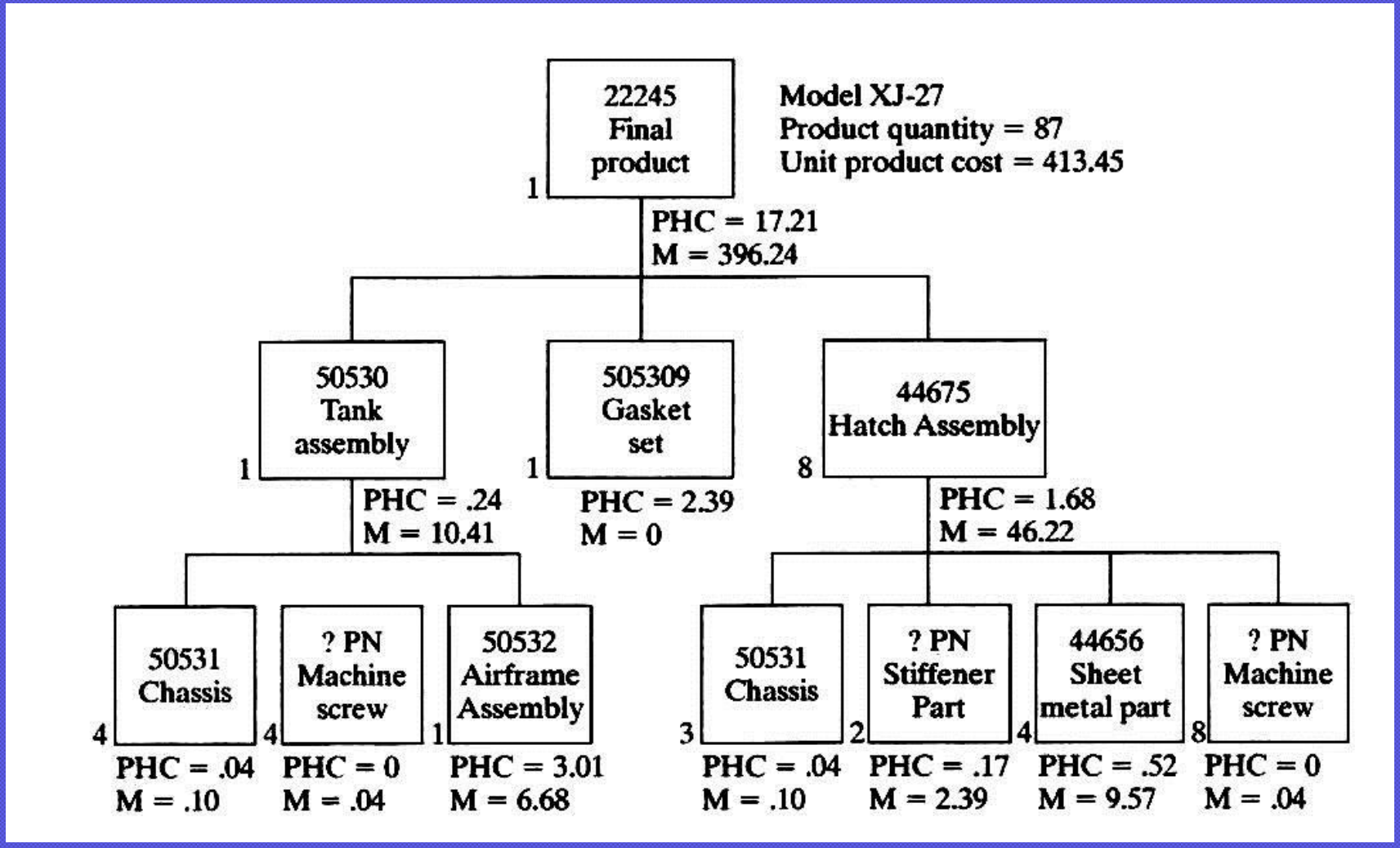
RFE Should Include

- Engineering Documents
  - –Drawings, BOM Specs
- Schedule Dates
  - –Estimate, Production
- Build Quantities

Bill of Material

- One for Every Part and Assembly
- Collect from the Top Down
- Include Quantities
- Assemble a Structure (Tree) to Collect Estimates - From the Bottom Up
- Estimate Individual Parts and Assembly

Product Tree with Costs



Costed Bill of Material

Lvl	Desc	Qty Next	Unit Matl	Unit Labor	Total Unit	Cost to Next
1	Top	N/A	$396.24	$17.21	$413.45	----
2	Gskt	1	0	2.39	2.39	2.39
2	Tank	1	10.41	.24	10.65	10.65
3	Chas	4	.10	.04	.14	.56
3	Screw	4	.04	0	.04	.16
3	Assy	1	6.68	3.01	9.69	9.69
2	Hatch	8	46.22	1.68	47.90	383.2
3	Sheet	4	9.57	.52	10.09	40.36
3	Stiffer	2	2.39	.17	2.56	5.12
3	Chas	3	.10	.04	.14	.42
3	Screw	8	.04	0	.04	.32

Compiling the Estimate

- Need to Determine Full Cost
  - –Includes Overhead Allocations
- Two Methods
  - –Productive Hour Cost (PHC)
  - –Activity Based Costing (ABC)
- The Product Estimate is a Formal Document

PHC Method

- Labor Estimates in Hours
- Need “Rate” to Multiply for Cost
- PHC Rate (Section 4.9.5)
- Labor Including
  - –Wages, Fringes, Overhead, Indirect
- Machine Costs

Calculating PHC Costs

- Total Unit Cost

$$C_u = \sum_i^n PHC_i \left(\frac{SU_b}{N} + H_b\right)_i + C_{dm} + C_t$$

Eq 8.3

- Total Product Cost

$$C_p = \Sigma C_u + \Sigma C_e + C_c + C_s$$

Eq 8.6

PHC Cost Example

TABLE 8.3 Worksheet for productive hour method of product estimating

Part no. 22245	Part name XJ-27	Subassembly Part no.	Material cost	
Quantity. 87	General notes	50530	10.65	
Estimator TM	Three Subassemblies	5053099	2.39	
Date 3/12		44675	383.20	
Estimate expires on 6/9		Total →	396.24	

Work Station	Operation no.	Description of operation (list tools and gauges)	Setup hours	Cycle minutes	Lot hours	PHCR	Cost of lot
Bench assembly 10	Assemble		0.75	31.561	46.51	32.19	1497.27

1. Total productive hour cost (for top assembly)	1497.27
2. Material cost (Fig. 8.4 top assy, M = 396.24 × 87)	35,970.15
3. Engineering cost (Table 8.1)	29,680.00
4. Contingencies	———
5. Selling costs	———
6. Total lot cost of manufacturing, development, and sales	$65,650.15
7. Unit cost	$754.60

Activity Based Costing (ABC)

- PHC Ties Overhead to All Products without Regard for What Is Used
- ABC Attempts to Allocate Overhead to Products Usage
  - –What Is Used
  - –How Much Is Used

ABC Concepts

- Associate Overhead Costs to Activities
- Predetermine O/H Costs per Unit of Activity
  - –Units May Not Always Be Hours
  - –Total Expected Cost Divided by Total Expected Units of Activity for Rate
  - –e.g. Purchasing Dept Cost / No. of POs

Using ABC for an Estimate

- Determine O/H Activities Needed
- Determine Amount of Each Activity
- Use Rate for Each Activity

$$C_{uabc} = \frac{\Sigma(H \times WR)_i + \Sigma(SU \times WR)_i / N_d + \Sigma(H_d \times WR_w)_j}{N_d + \Sigma(H_s \times WR_s)_k + \Sigma C_e / N_a + C_{dm}}$$

Eq 8.7

Learning at the Product Level

- Performance Improves with Experience
- First Unit Labor Hours Depend on
  - Company Experience
  - Amount of Preparations
  - Product Characteristics
- Apply Learning Factor per Cost Element

$$\text{cost element} = C_f + C_v \times T_c \qquad \text{Eq 8.8}$$

Sources for Improvement

- Operator (15%)
- Design (50%)
- Manufacturing Engineering (35%)
- Requires Specific Effort
- Best Candidate Products
  - –High Cost, Low Volume

Learning Uses

- Price Negotiations
- Make-Buy Decisions
- Product Cost Based on Prototype
- Costs for Additional Orders
  - –Follow-On Procurement
  - –Engineering Change Orders
  - –Breakeven Analysis

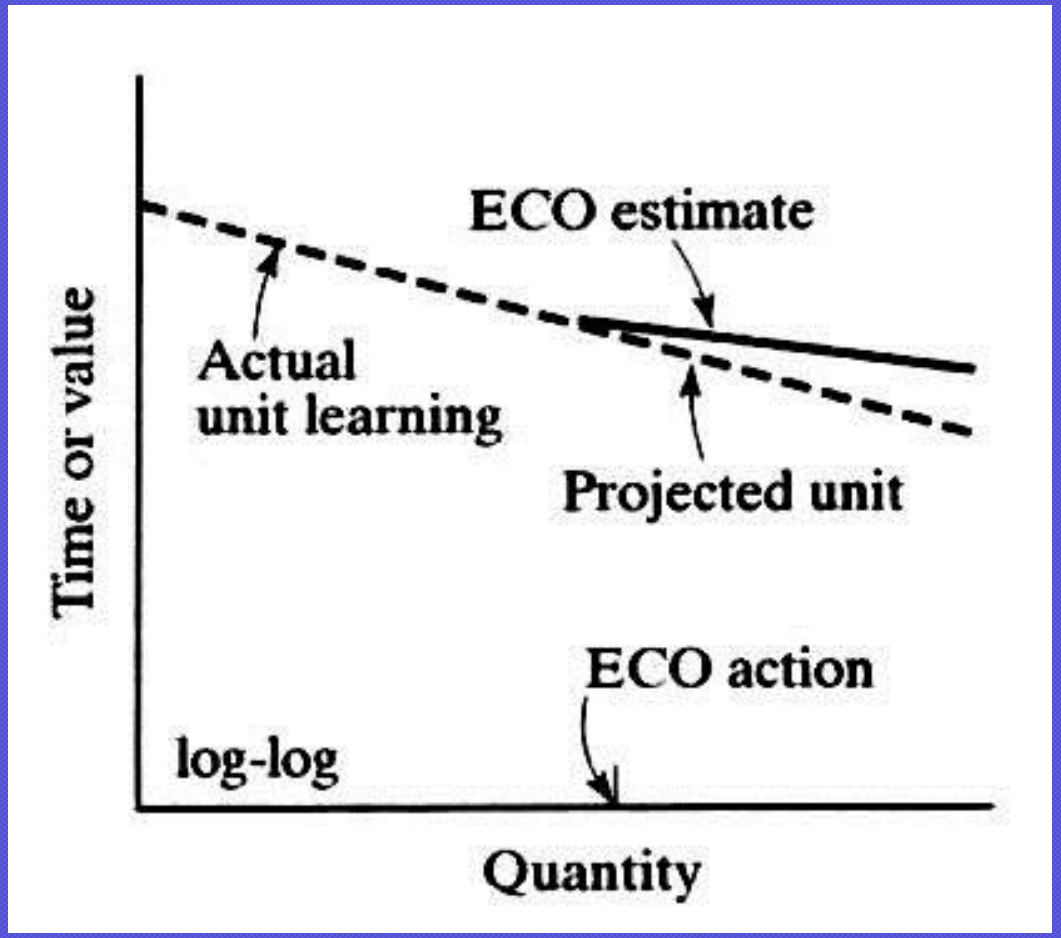
Follow-On Procurement

- Ref. Chapter 6 (Learning)
- Determine a Learning Curve (K, s)
- Calculate Total Costs
- Subtract Cost for First Units from Cost of All Units Through Follow On Build

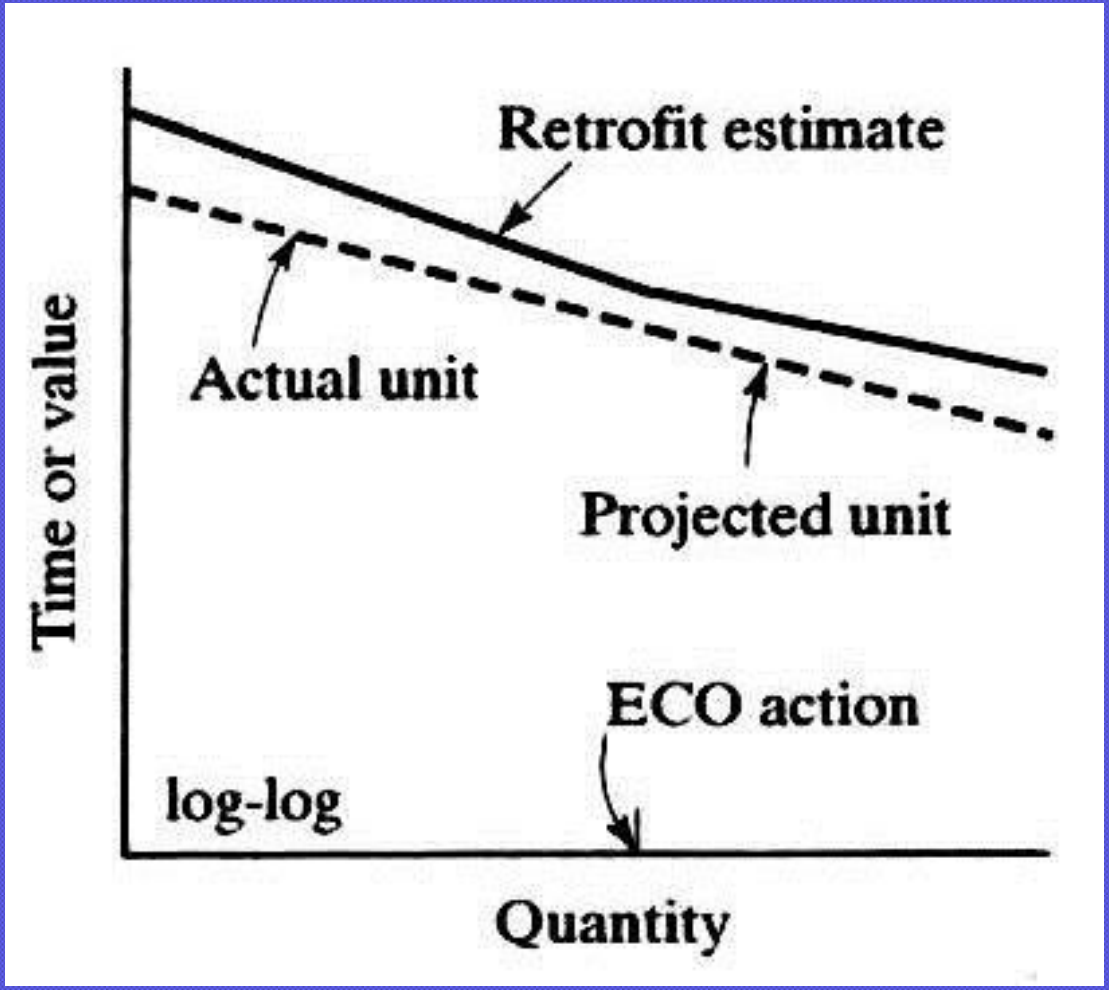
Engineering Change Order (ECO)

- Design Change(s) to Existing Product
- ECO Affects Future Units
- Does ECO Require Change (Retrofit) to Existing Units (Prior Production)?
- Is There a Change to Cost?

Simple ECO (No Retrofit)



ECO with Retrofit



Calculating a Retrofit ECO

1) Find Cost for Production of Existing
2) Find Retrofit Cost
3) Find Cost for Continuing Production
   From ECO Incorporation to End of Run
4) Sum 1-3 Above
5) Compare to Cost without ECO

Breakeven with Learning

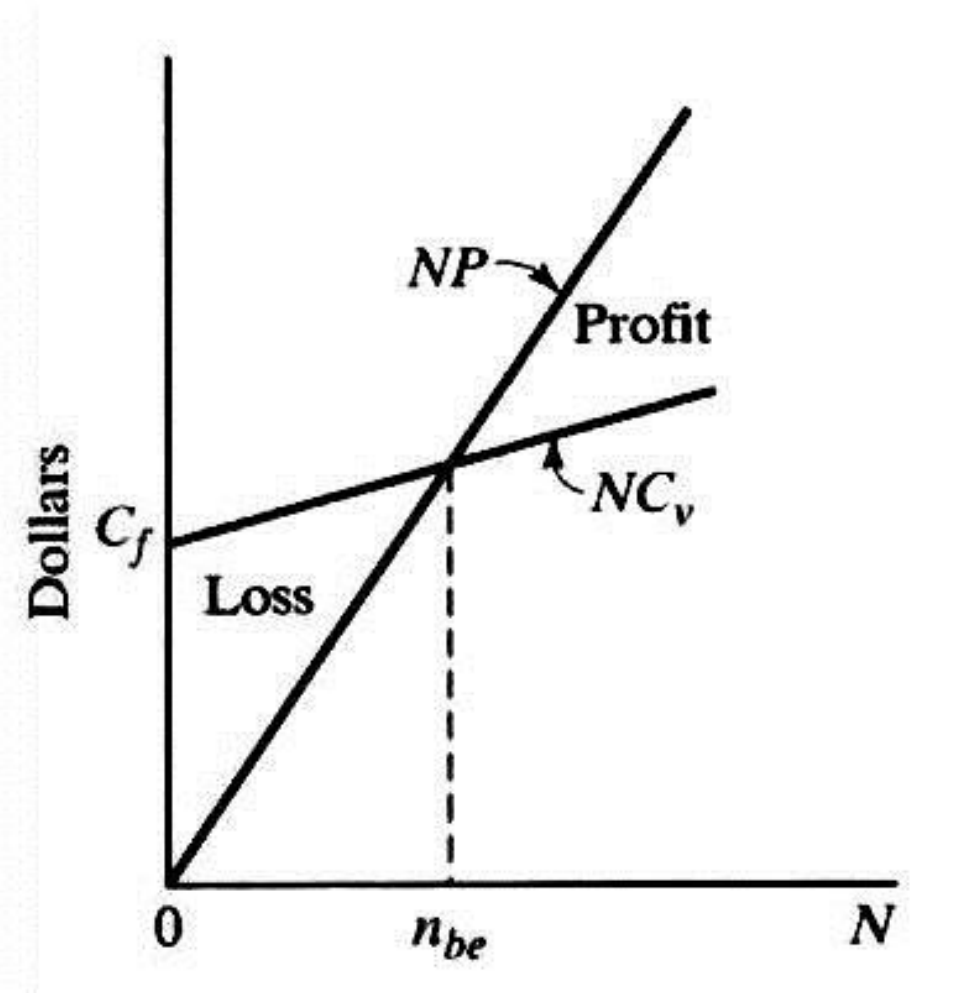
- Conventional Breakeven Assumes Variable Cost Is Constant

$$Pn_{be} = n_{be} C_v + C_f \qquad \text{Eq 8.9}$$

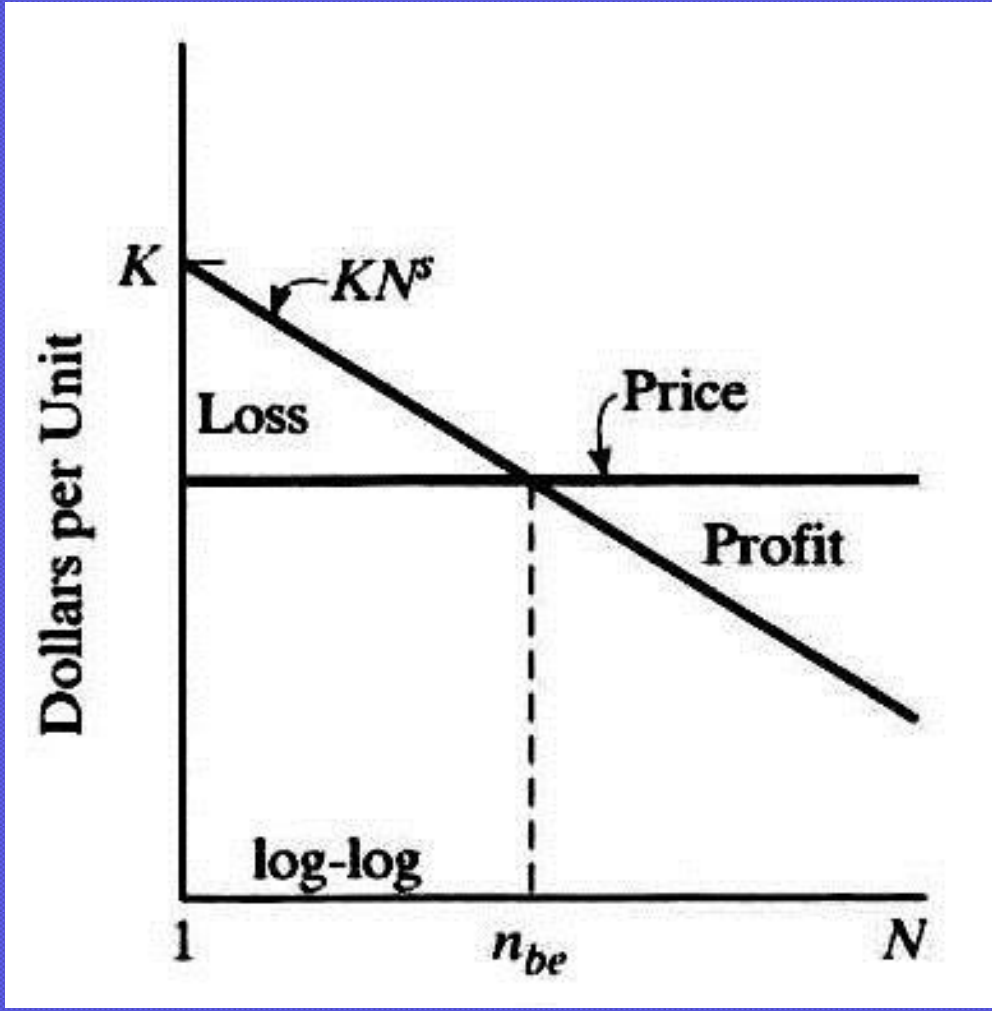
- Learning Assumes Variable Cost Decreases

$$P = KN_{be}^{s} \qquad \text{Eq 8.10}$$

Conventional Breakeven



Breakeven with Learning



Determining Price

- Market Determines "Economic Want"
- Supply and Demand
- Price Customer Will Pay
- Customer's Price Includes
  - –Vendors Price (Cost Plus Profit)
  - –Transportation Costs
  - –Wholesale & Retail Costs and Profit

Producer's Price

- For Engineering Estimating
  - –Expected Price Minus Expected Cost
- Estimated Profit May NOT Equal Actual Profit
- Engineering Wants Costly Designs
- Manufacturing Over-Estimates Costs
- Marketing Wants Low Price
- Need "Reasonable" Compromise

Pricing Concepts

- Price Proportional to (Total) Cost
- Price Proportional to Conversion Cost
- Price Proportional to Variable Cost
- Price Determined by Market
- Price Is Not Always the Sole Basis for Competition

Judgment Pricing

- Experience
- Discussion (Opinion, Conference, Comparison)
- Future Will Not Be Like the Past

Markup on Cost

- Full Cost

$$P = C_t + R_m(C_t) \qquad \text{Eq 8.11}$$

- Value Added (Direct Labor + Overhead)

$$P = \Sigma C_{dl}(1 + R_{oh})(1 + R_m) + C_{dm} \qquad \text{Eq 8.12}$$

- Direct Cost (Labor + Materials)

$$P = (\Sigma C_{dl} + \Sigma C_{dm})(1 + R_m) + C_{oh} \qquad \text{Eq 8.13}$$

More Markup

- Return on Investment
  - –Return Must Exceed Capital Cost

$$P = \frac{\left(\frac{iI}{N_y} + C_f + C_v N \right)}{N}$$

Eq 8.14

- Markup on Sales

$$P = \frac{C_t}{1 - R_s}$$

Eq 8.15

Contribution

- Price Based on Variable Costs

$$P = \frac{C_v}{1 - R_c}$$

Eq 8.16

- Contribution Is the Amount Left After Paying Variable Costs
- Covers Fixed Costs and Profit

Price Estimating Relationships

- Prices Predicted Over a Period of Time
- Market Establishes a Price Ceiling
- Producer Establishes a Price Floor
  - –Cost Plus Profit Required
- Difference Is the Opportunity Margin
- Supply and Demand Controls

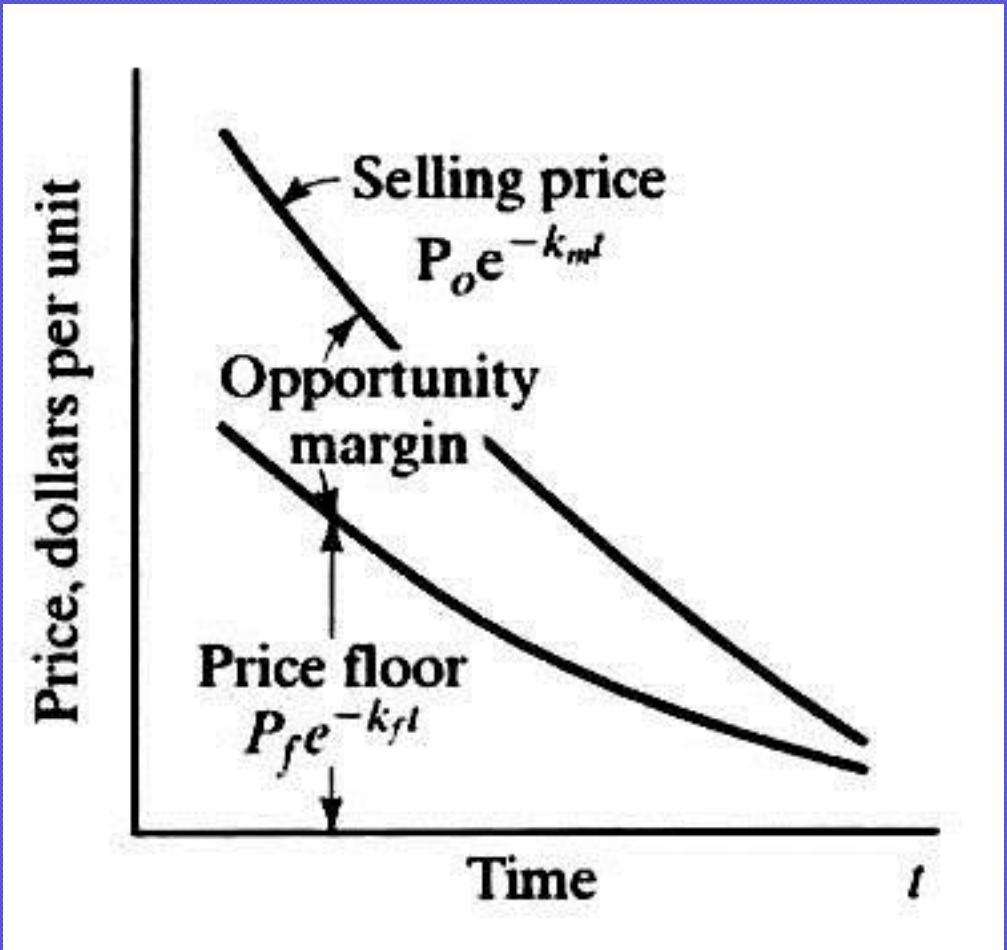
Opportunity Margin

- Can Be Used to Set Price
- Prices Usually Decline with Time
- Also Determines Life Cycle
- Market Model

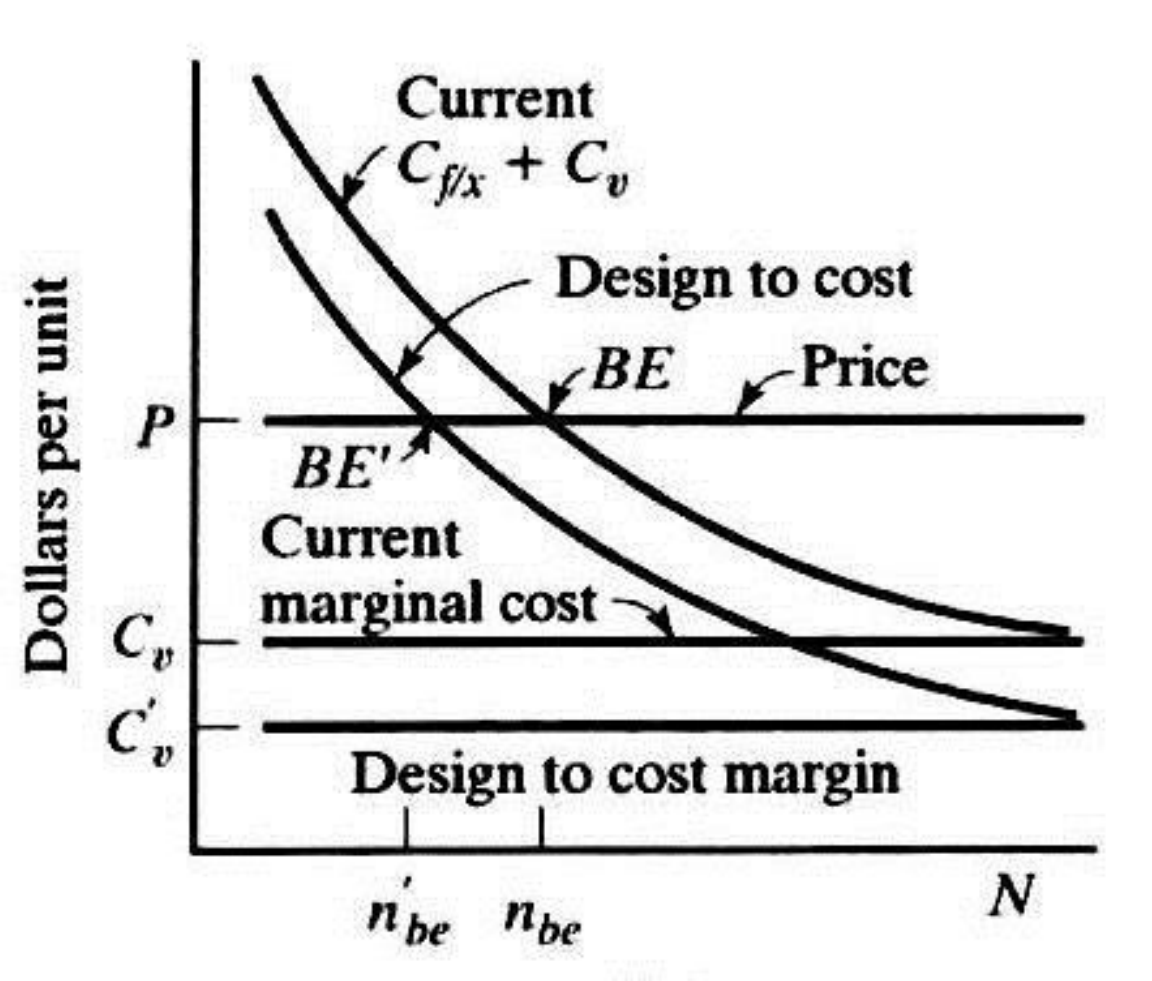
$$M = P_o e^{-k_m t} - P_f e^{-k_f t}$$

Eq 8.17

Opportunity Margin Model



Break Even with Margins



Contracts

- Buying and Selling Involves Contracts
  - –Purchase Orders
  - –Quotations / Estimates
  - –Legal Consequences
- Two Types of Sales Contracts
  - –Firm Fixed Price
  - –Cost-Reimbursable

Fixed-Price Contracts

- Used for
  - –Low Tech, Well Developed Products
  - –High Quantities
  - –Short Duration
- Supplier Assumes Risks If Costs Go Up
- Supplier Benefits from Any Savings
- Buyer Benefits from Known Price

Fixed-Price Based on Hourly Cost

- Quoted Hourly Rate (PHC + Profit)
- Multiplied by Actual Time Spent
- Used If Job Scope Is Unpredictable
- Sometimes Bid as “Time and Materials”
- Also:
  - –Quote or Price in Effect
  - –Pass Through Material Cost Increases

Cost Reimbursement

- High Technology
- High Risk
- Low Degree of Definition
- Customer Assumes Most or All of Risk
  - –Negotiated Risk/Benefit Sharing Proportion
- “Cost Plus” a Fee or Profit
  - –Negotiated, Sometimes with Incentives

Other Uses for Estimates

- Make / Buy Decisions
- Breakeven Analysis
- Value Engineering
- Concurrent Engineering
  - DFM and DFA
  - Design to Cost

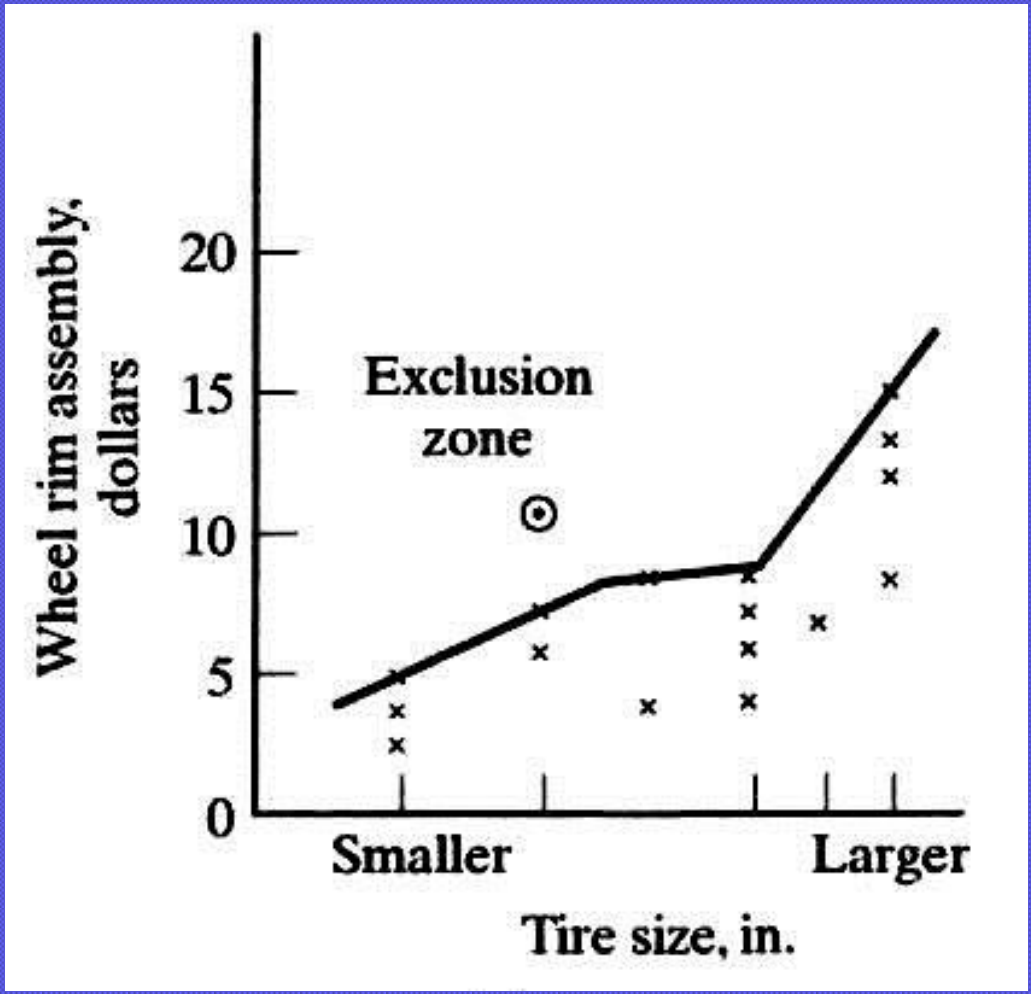
Make vs. Buy

- Be Sure to Compare Equal Situations
  - If Make Cost Includes Design Cost
  - Design Cost Must Be Added to Buy Price
- Include ALL Costs of Buying
  - Transportation
  - In House Costs for Purchasing/Receiving
  - Intangibles (Quality, Schedule, etc)

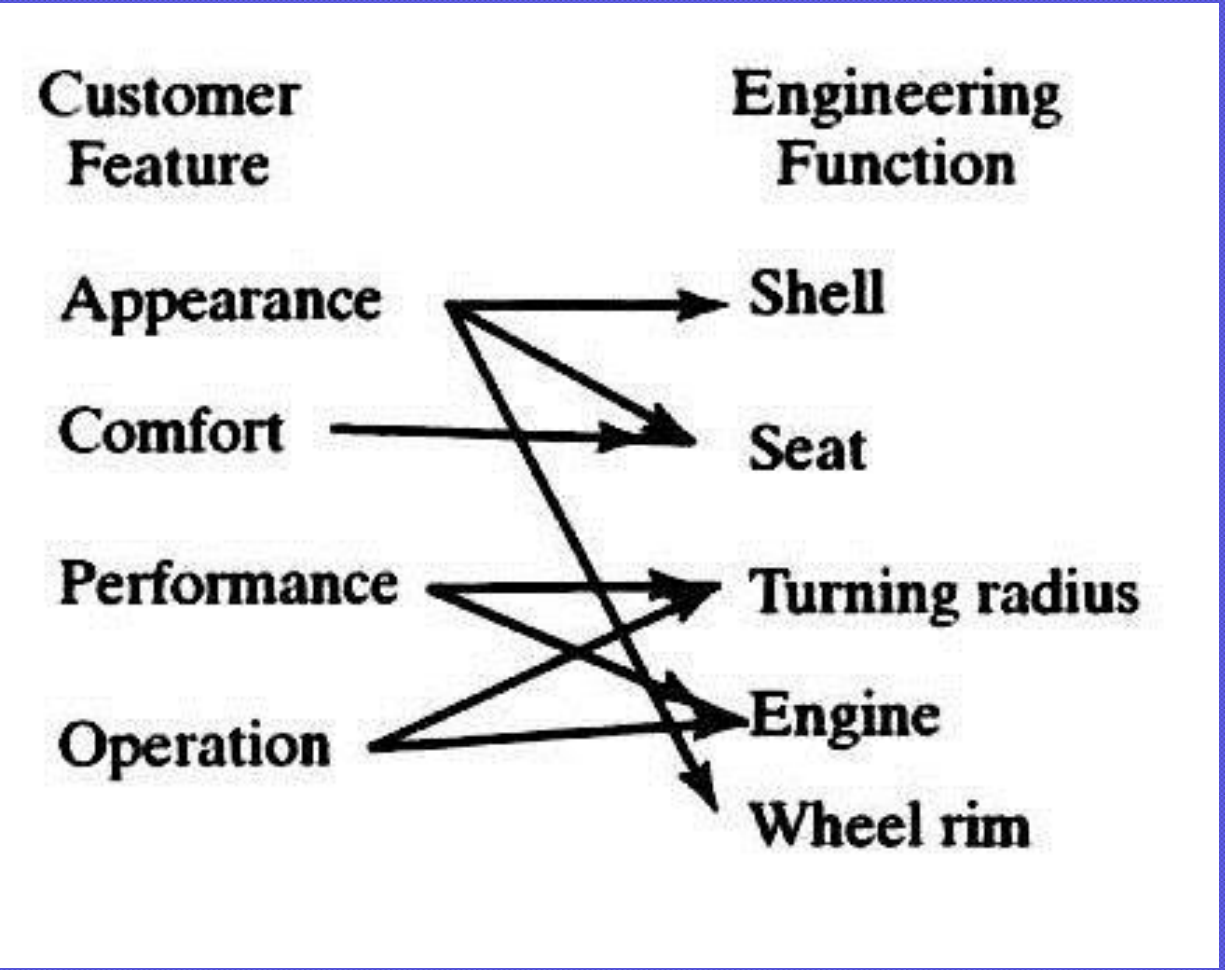
Concurrent Engineering

- Saves Money and Time
- Reduces Changes and Time to Market
- Recognizes Cost as a Design Reqm't
- Savings
  - –30% Less Development Time
  - –65% Fewer Engineering Changes
  - –20% Less Time to Market

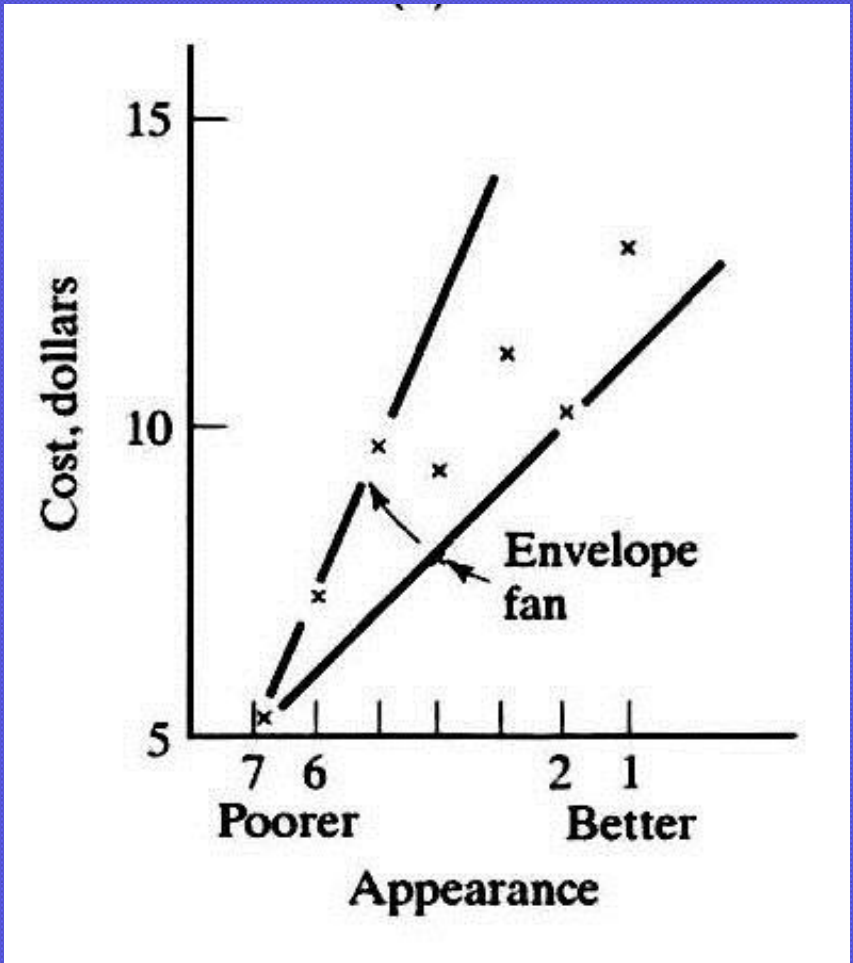
Benchmarking – Exclusion Chart



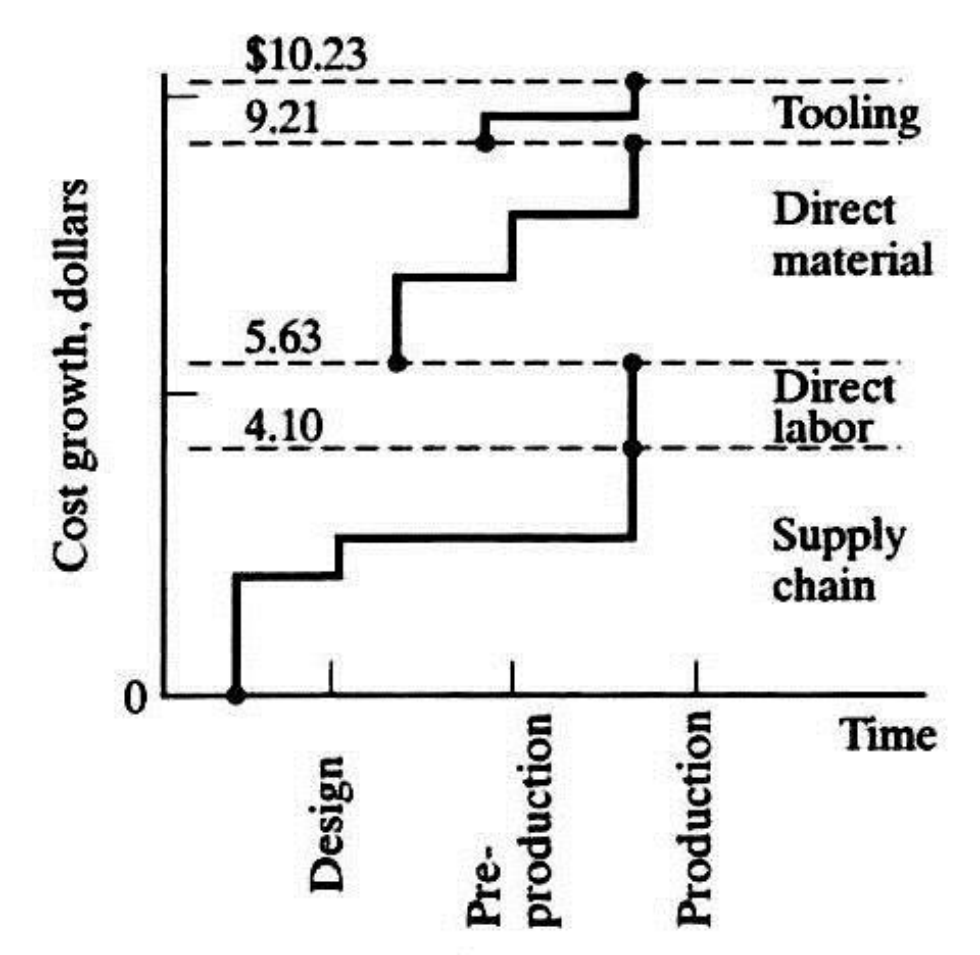
Benchmarking – Feature Map



Benchmarking – Envelope Fan



Benchmarking – Design to Cost



Future Directions

Web browser based, collaborative system providing real time access to cost data across the enterprise with application service provider

Supplier-design collaboration

Commodity team collaboration

Contract manufacturing assessment

Integration with data from enterprise information systems such as resource planning, manufacturing execution systems, supply chain, and product data management

Make versus buy analysis

Cost saving/increase tracking

Future Directions

Part estimating along with a manufacturing process tied to the BOM and specification

People coalitions across the enterprise have role-specific access to real time data

Forecasting of labor rates, material costs domestically, internationally

Configurable user access

Product cost visibility and forecasting from initial concept through end of life, life cycle costing

Future Directions

Blended cost from multiple suppliers

Supplier access for quoting

CAD integrations from RFP to final design release
Service costs of warranty, repairs
BOM cost roll-up and cost tracking, transfer
Product portfolio optimization by standardization on components and sub-assemblies
Process times, labor rates under preliminary or detail levels
Overhead extensions for productive hour cost or activity based costing principles
Specification management
Capital-equipment total cost of ownership

Summary

- Determined Product Costs
  - –Applied Learning and PHC
- Studied Tools for Establishing Prices
  - –Bottom Up and Top Down
- Looked at Purchasing Contracts
- Peeked into the Future of Estimating