Chapter 15

Cost Estimation and Indirect Cost Allocation

Solutions to Problems

15.1 (a) Equipment cost, delivery charges, installation cost, insurance, and training.
(b) Labor, materials, maintenance, power.

15.2 The main difference is what is considered an input variable and an output variable. The bottom-up approach uses price as output and cost estimates as inputs. The design-to-cost approach is just the opposite.

15.3 (a) Direct; (b) Indirect, since it is usually an option to choose a non-toll route; (c) Direct; (d) Indirect; (e) Direct, since it is a part of the direct cost of gas; (f) Direct, but could be considered indirect it is assumed that the owner can drive for a while without paying the monthly loan bill, prior to repossession.

15.4 Property cost: (100 X 150)(2.50) = $37,500
House cost: (50 X 46)(.75)(125) = $215,625
Furnishings: (6)(3,000) = $18,000

Total cost: $271,125

15.5 A: $120(130,000) = $15.60 million

B:

Type	Area	Unit cost	Estimated cost
Classroom	39,000	$125	$4.8750 million
Lab	52,000	185	9.6200 million
Office	39,000	110	4.2900 million
Furnishings-labs	32,500	150	4.8750 million
Furnishings-other	97,500	25	2.4375 million
			$26.0975 million

Average unit cost estimate from A is $15,600,000, which is only about half using the more detailed breakout cost by function of $26,097,500 estimate from B.

15.6 $$\text{Cost} = \frac{1200}{1027.5}(78,000)$$
$$= \$91,095$$

15.7 (Note: This answer uses a mid-year 2004 ENR index value of 7064. The current value must be obtained from the web to get the current estimate at the time the problem is assigned.

Cost = (7064/5471)(2.3 million) = $2.970 million

15.8 From the website, it can be determined that they differ primarily in the basis of the labor component of the standard cost. The CCI uses a total of 200 hours of common labor multiplied by the 20-city average rate for wages and fringe benefits. The BCI uses a total of 66.38 hours of skilled labor, multiplied by the 20-city average rate for wages and fringes for three trade areas –bricklayers, carpenters and structural ironworkers.

The two indexes apply to general construction costs. The CCI can be used where labor costs are a high proportion of total costs. The BCI is more applicable for structures.

15.9 $30{,}000 = \frac{x}{915.1}(20{,}000)$

$x = 1372.7$

15.10 (a) First find the percentage increase (p%) between 1990 and 2000.

6221 = 4732 (F/P,p,10)
$1.31467 = (1+p)^{10}$
p% increase = 2.773 %/year

Predicted index value in 2002 = 6221(F/P,2.773%,2)
= $6221(1+0.02773)^2$
= 6571

(b) Difference = 6571 – 6538
= 33 (too high)

15.11 $1{,}600{,}000 = \frac{1315}{720}(x)$

$x = \$876{,}046$

15.12 Cost in mid-2004 = 325,000 (7064/4732)
= $485,165

15.13 Find the percentage increase (p%) between 1994 and 2002 of the index. The other numbers are not needed.

395.6 = 368.1(F/P,p,8)
$1.0747 = (1+p)^{1/8}$

$(1+p) = 1.009046$
p % increase = 0.905 % per year

15.14 (a) Divide 2002 value by the 1990 base value of 357.6 and multiply by 100.

$$\text{2002 value} = (395.6/357.6)(100) = 110.6$$

(b) For example, in mid-2004, www.che.com/pindex provides the index value of 434.6. The month's index estimate is:

$$\text{2004 estimate} = (434.6/357.6)(100) = 121.5$$

15.15 $395.6 = 357.6(F/P,p\%,12)$
$1.10626 = (1+p\%)^{12}$
$(1+p) = 1.00845$
p% increase = 0.845 % per year

15.16 Index in 2005 $= 1068.3(F/P,2\%,6)$
$= 1068.3(1+0.02)^6$
$= 1203.1$

15.17 (a) Cost $= 60{,}000\,(1+0.02)^3\,(1+0.05)^7$
$= \$89{,}594$

(b) $89{,}594 = 60{,}000(I_{10}/1203)$
$I_{10} = 1796.36$

15.18 The cost index bases the estimate on cost differences over time for a *specified value* of variables, while a CER estimates costs between *different values* of design variables.

15.19 From Table 15-3, the cost-capacity exponent is 0.32.

$$C_2 = 13{,}000(450/250)^{0.32} = 13{,}000(1.207) = \$15{,}690$$

15.20 Correlating exponent is 0.69 for all pump ratings.

(a) Use Equation [15.2] for 200 hp

$$C_2 = 20{,}000(200/100)^{0.69} = 20{,}000(1.613) = \$32{,}260$$

For 75 hp

$$C_2 = 20{,}000(75/100)^{0.69}$$
$$= 20{,}000(0.82) = \$16{,}400$$

A 200-hp pump is estimated to cost about twice as much as a 75-hp one.

(b) Use Equation [15.3] with a cost index ratio of 1.2.

$$C_2 = 20{,}000(200/100)^{0.69}(1.20)$$
$$= 20{,}000(1.613)(1.2) = \$38{,}712$$

15.21 $3{,}000{,}000 = 550{,}000\ (100{,}000/6000)^x$
$5.4545 = (16.6667)^x$
$\log 5.4545 = x \log 16.667$
$0.7367 = 1.2218\ x$
$x = 0.60$

15.22 (a) $450{,}000 = 200{,}000(60{,}000/35{,}000)^x$
$2.25 = 1.7143^x$
$\log 2.25 = 0.3522 = x \log 1.7143 = 0.2341$
$x = 1.504$

(b) Since $x > 1.0$, there is diseconomy of scale and the larger CFM capacity is more expensive than a linear relation would be.

15.23 $250 = 55(600/Q_1)^{0.67}$
$4.5454 = (600/Q_1)^{0.67}$
$Q_1 = 63$ MW

15.24 $1.5 \text{ million} = 0.2 \text{ million } (Q_2/1)^{0.80}$
$Q_2 = 12.4$ MGD

15.25 (a) Estimate made in 2002 using Equation [15.3]
$C_2 = (1 \text{ million})(3)^{0.2}(1.1)$
$= (1 \text{ million})(1.246)(1.1) = \$1.37$ million

Estimate was $630,000 low

(b) Again, use Equation [15.3] to find x.

$2 \text{ million} = (1 \text{ million})(3)^x(1.25)$
$1.6 = (3)^x$

$\log 1.6 = x \log 3$
$0.2041 = x\,(0.4771)$
$x = 0.428$

15.26 Use Equation [15.3] and Table 15-2.
$C_2 = 50{,}000\,(2/1)^{0.24}\,(395.6/389.5)$
$= 50{,}000\,(1.181)(1.0157)$
$= \$59{,}974$

15.27 C_2 in 1995 $= 160{,}000\,(1000/200)^{0.35}$
$= \$281{,}034$

C_2 in 2002 $= 281{,}034\,(1.35)$
$= \$379{,}396$

15.28 *ENR* construction cost index ratio is (6538/4732).
Cost -capacity exponent is 0.60.

Let C_1 = cost of 5,000 sq. m. structure in 1990

C_2 in 1990 $= \$220{,}000 = C_1\,(10{,}000/5{,}000)^{0.60}$
$C_1 = \$145{,}145$

Update C_1 with cost index. To update to 2002

$C_{2002} = C_1\,(6538/4732)$
$= 145{,}145\,(1.382)$
$= \$200{,}540$

15.29 $C_T = 2.97\,(16)$
$= \$47.5$ million

15.30 (a) $h = 1 + 1.52 + 0.31 = 2.83$

$C_T = 2.83\,(1{,}600{,}000)$
$= \$4{,}528{,}000$

(b) $h = 1 + 1.52 = 2.52$
$C_T = [1{,}600{,}000(2.52)](1.31)$
$= \$5{,}281{,}920$

15.31 $h = 1 + 0.2 + 0.5 + 0.25 = 1.95$

Apply Equation [15.5]

C_T in 1994: $1.75\ (1.95) = \$3.41$ million

Update with the cost index to now.

C_T now: $3.41\ (3713/2509) = 3.41(1.48) = \$5.05$ million

15.32 (a) $h = 1 + 0.30 + 0.30 = 1.60$

Let x be the indirect cost factor.

$$
\begin{aligned}
C_T = 450{,}000 &= [250{,}000\ (1.60)]\ (1 + x) \\
(1 + x) &= 450{,}000/[250{,}000\ (1.60)] \\
&= 1.125 \\
x &= 0.125
\end{aligned}
$$

The indirect cost factor used is much lower than 0.40.

(b) $C_T = 250{,}000[1.60](1.40)$
$= \$560{,}000$

15.33 (a) Humboldt plant: Apply Equation [15.7] for each machining type and quarter for 4 different rates. A total of \$225,000 is allocated to each type of machinery. Calculations are performed in \$1,000/1,000 DL hour.

Q1 rate		Q2 rate	
Heavy	Light	Heavy	Light
225/2 = \$112.50/hr	225/0.8 = \$281.25/hr	225/1.5 = \$150/hr	225/1.5 = \$150/hr

(b) Humboldt plant: Blanket rate equation to use is

$$\text{Indirect cost rate} = \frac{\text{total indirect costs for Q1}}{\text{total direct labor hours for Q1}}$$

Blanket rate for Q1 = 450/2.8 = \$160.71/DL hour

Actual charge in Q1 for light using blanket rate: (160.71)(800) = \$128,568

Actual charge in Q1 for light using light rate: (281.25)(800) = $225,000

Blanket rate under-charges light machining by the difference or $96,432

(c) Concourse plant: Use the blanket rate equation above for each quarter.

Q1 rate	Q2 rate
450/1.8 = $250/hr	450/2.8 = $160.71/hr

15.34 Indirect cost rate for 1 = $\frac{50,000}{600}$ = $ 83.33 per hour

Indirect cost rate for 2 = $\frac{100,000}{200}$ = $500.00 per hour

Indirect cost rate for 3 = $\frac{150,000}{800}$ = $187.50 per hour

Indirect cost rate for 4 = $\frac{200,000}{1,200}$ = $166.67 per hour

15.35 (a) From Eq. [15.7]

Basis level = (indirect costs allocated)/(indirect cost rate)

Month	Basis Level	Basis
June	20,000/1.50 = 13,333	DL hours
July	34,000/1.33 = 25,564	DL costs
August	35,000/1.37 = 25,547	DL costs
September	36,000/1.25 = 28,800	Space
October	36,250/1.25 = 29,000	Space

(b) The indirect cost rate has decreased and is constant due to the switching of the allocation basis from one month to the next. If a single allocation basis is used throughout, the monthly rate are significantly different than those indicated. For example, if space is consistently used as the basis, monthly rates are:

June $\frac{20,000}{20,000}$ = $1.00 per ft^2

July $\frac{34,000}{20,000}$ = $1.70 per ft^2

August $\frac{35,000}{29,000}$ = $1.21 per ft^2

September $\frac{36,000}{29,000}$ = $1.24 per ft^2

October $\frac{36,250}{29,000}$ = $1.25 per ft^2

15.36 (a) Space: Use Equation [15.7] for the rate, then allocate the $34,000.

Total space in 3 depts = 38,000 ft^2

Rate = 34,000/38,000 = $0.89 per ft^2

(b) Direct labor hours:

Total hours = 2,080

Rate = 34,000/2,080 = $16.35 per hour

(c) Direct labor cost:

Total costs = $147,390

Rate = 34,000/147,390 = $0.23 per $

15.37 Housing: DLH is basis; rate is $16.35

Actual charge = 16.35(480) = $7,848

Subassemblies: DLH is basis; rate is $16.35

Actual charge = 16.35(1,000) = $16,350

Final assembly: DLC is basis; rate is $0.23

Actual charge = 0.23 (12,460) = $2,866

15.38 (a) Actual charge = (rate)(actual machine hours) where the rate value is from 15.34.

Cost center	Rate	Actual hours	Actual charge	Allocation	Allocation variance
1	$83.33	700	$58,331	$ 50,000	$8,331 under
2	500.00	350	175,000	100,000	75,000 under
3	187.50	650	121,875	150,000	28,125 over
4	166.67	1,400	233,338	200,000	33,338 under
			$588,544	$500,000	

(b) Total variance = allocation – actual charges

= 500,000 – 588,544

= $– 88,544 (under-allocation)

15.39 (a) Indirect cost charge = (allocation rate) (basis level)

Department 1: 2.50(5,000) = $ 12,500

Department 2: 0.95(25,000) = 23,750

Department 3: 1.25(44,100) = 55,125

Department 4: 5.75(84,000) = 483,000

Department 5: 3.45(54,700) = 188,715

Department 6: 0.75(19,000) = 14,250

Total actual charges = $777,340

(b) Variance = allocation – actual charges
= 800,000 – 777,340
= \$ +22,660 (over-allocation)

15.40 DLC average rate = (1.25 + 5.75 + 3.45) /3 = \$3.483 per DLC \$

Department 1:	3.483(20,000) =	\$ 69,660
Department 2:	3.483(35,000) =	121,905
Department 3:	3.483(44,100) =	153,600
Department 4:	3.483(84,000) =	292,572
Department 5:	3.483(54,700) =	190,520
Department 6:	3.483(69,000) =	240,327
Total actual charges		\$1,068,584

Allocation variance = allocation – actual charges
= 800,000 – 1,068,584
= \$ -268,584 (under-allocation)

15.41 (a) Alternatives are Make and Buy. Determine the total monthly costs, TC.

TC_{make} = –DLC – materials cost – indirect costs for Housing
– indirect costs from Testing and Engineering
= –31,680 – 41,000 – 20,000 – 3500
= \$–96,180 per month

TC_{buy} = \$–87,500 per month

Buy the components.

(b) Three alternatives are Make/old, Buy, and Make/new, meaning with new equipment.

$TC_{make/old}$ = \$–96,180 per month

TC_{buy} = \$–87,500 per month

$TC_{make/new}$ = –AW of equipment – DLC – materials cost
– total indirect costs for Housing and redistribution
from Testing and Engineering

The new indirect costs and direct labor hours for all departments are:

Department	Indirect cost	Direct labor hours
Housing	$20,000	200
Subassemblies	45,000	1,000
Final assembly	10,000	600
Testing	13,000	---
Engineering	16,000	---
	Total	1,800

Redistribution rate for Testing and Engineering indirect costs is based on direct labor hours:

$$\text{Redistribution rate} = \frac{\text{Testing + Engineering indirect costs}}{\text{Total direct labor hours}}$$

$$= \frac{13{,}000 + 16{,}000}{1{,}800} = \$16.11 \text{ per hour}$$

The Housing indirect cost = 200(16.11) + 20,000 = $23,222

AW of new equipment = 375,000(A/P,1%,60) + 5000
= $13,340 per month

$TC_{make/new}$ = –13,340 – 20,000 – 41,000 – 23,222
= $–97,562

Select the buy alternative.

15.42 (a) Charge = (rate)(DLH) = 4.762 (DLH)

Plant A: 4.762 (200,000) = $952,400
Plant B: $476,200
Plant C: $8,571,600

(b) Total capacity = 125,000 + 62,500 + 1,125,000 = 1,312,500

$$\text{Rate} = \frac{\$10 \text{ million}}{1.3125 \text{ million units}} = \$7.619 \text{ per unit}$$

Plant A: 7.619 (125,000) = $952,375
Plant B: $476,188
Plant C: $8,571,375

These are the same as the DLH basis.

(c)

Plant	Actual/Capacity
A	100,000/125,000 = 0.80
B	60,000/62,500 = 0.96
C	900,000/1,125,000 = 0.80

Plant A: 7.619(125,000)/0.80 = $1,190,470
Plant B: 7.619(62,500)/0.96 = $496,029
Plant C: 7.619(1,125,000)/0.80 = $10,714,219

Total allocated is $12,400,718

The first methods always allocate the exact amount of the indirect cost budget. They are based on plant parameters, not performance. The numbers in part (c) will be more (ratio > 1) or less (ratio < 1) than the allocations in (a) and (b).

15.43 As the DL hours component decreases, the denominator in Eq. [15.7], basis level, will decrease. Thus, the rate for a department using automation to replace direct labor hours will increase in the computation

$$\text{Rate} = \frac{\text{indirect costs}}{\text{basis level}}$$

The increased use of indirect labor for automation requires that these costs be tracked directly when possible and the remainder allocated with bases other than DLH.

15.44 The ABC method is useful in control of the cost of production, rather than just estimating where the costs are incurred. From this viewpoint, ABC is considered more of a control tool of management as compared to an accounting technique.

15.45 (a)

$$\text{Rate} = \frac{\$1 \text{ million}}{16{,}500 \text{ guests}}$$

$$= \$60.61 \text{ per guest}$$

Charge = (# guests) (rate)

Site	A	B	C	D
Guests	3,500	4,000	8,000	1,000
Charge	$212,135	242,440	484,880	60,610

(b) Guest-nights = (guests) (length of stay)

Total guest-nights = 35,250

Rate = $1 million / 35,250 = $28.37 per guest-night

Site	A	B	C	D
Guest-night	10,500	10,000	10,000	4,750
Charge	$297,885	283,700	283,700	134,757

(c) The actual indirect cost charge to sites C and D are significantly different using the two methods. Another basis could be guest-dollars, that is, total amount of money a guest (or group) spends, if this could be tracked.

(d) There is no difference at all in the actual indirect cost amounts charged since the actual distribution of the $1 million to each hotel is not used in any of the computations in (a) or (b). However, the allocation variances of over- and under-allocation will change appreciably. Using part (b) actual charges, allocation variances change as follows.

Site	A	B	C	D
Actual charge, part (b), $	297,885	283,700	283,700	134,757
10% of budget method:				
Allocated, $	200,000	300,000	400,000	100,000
Variance, $	–97,885	+16,300	+116,300	–34,757
30%/20% of budget method:				
Allocated, $	200,000	300,000	300,000	200,000
Variance, $	–97,885	+16,300	+16,300	+65,243

Variance = allocated amount – actual charge
(Note: + is over-allocation; – is under-allocation)

15.46 Rates are determined first.

$$\text{DLH rate} = \frac{\$400{,}000}{51{,}300} = \$7.80 \text{ per hour}$$

$$\text{Old cycle time rate} = \frac{\$400{,}000}{97.3} = \$4{,}111 \text{ per second}$$

$$\text{New cycle time rate} = \frac{\$400{,}000}{45.7} = \$8{,}752.74 \text{ per second}$$

Actual charges = (rate)(basis level)

Line	10	11	12
DLH basis	$156,000	99,060	145,080
Old cycle time	53,443	229,394	117,164
New cycle time	34,136	148,797	217,068

The actual charge patterns are significantly different for all 3 bases.

15.47 (a) Workforce basis rate = $200,200/1,400
= $143 per employee

CA: 143(900) = $128,700 AZ: 143(500) = $ 71,500

(b) Accident basis rate = $200,200/560
= $357.50 per accident

CA: 357.50(425) = $151,938 AZ: 357.50(135) = $ 48,262

This basis lowers the Arizona charge since it has fewer accidents per employee relative to California site.

CA: 425/900 = 0.472 AZ: 135/500 = 0.270

(c) ABC: 80% of $200,200 is $160,160

Generation-area accident basis:

Rate: $160,160/530 = $302.19 per accident

CA: 302.19(405) = $122,387
AZ: 302.19(125) = $ 37,774

Classic: 20% of $200,200 is $40,040

Employee rate = $40,040/900 = $44.49 per employee

CA: 44.49(600) = $26,693
AZ: 44.49(300) = $13,346

Total actual charges:

CA: 122,387 + 26,693 = $149,080
AZ: 37,774 + 13,346 = $ 51,120

Comparison for (a), (b) and (c):

Basis	Employees	Accidents	80% - 20% Split
CA	$128,700	$151,938	$149,080
AZ	$ 71,500	$ 48,262	$ 51,120

The difference is not great for the accident basis compared to the split-basis approach.

FE Review Solutions

15.48 $C_2 = 400,000(6950/6059)$

$= \$458,822$

Answer is (c)

15.49 $89,750 = 75,000(I_2 /1027)$

$I_2 = 1229$

Answer is (a)

15.50 $C_2 = 2100\ (200/50)^{0.76}$
$= \$6023$

Answer is (b)

15.51 $Cost_{now} = 15,000\ (1164/1092)\ (2)^{0.65}$
$= \$25,089$

Answer is (b)

Case Study #1 Solution

1. An increase in the chemical cost moves the optimum dosage to the left, or decreases the optimum dosage in Figure 15-3. For example, at a cost of \$0.25 per kilogram, the optimum dosage is about 4.7 mg/L (by trial and error using spreadsheet and total cost equation of $C_T = -0.0024F^3 + 0.0749F^2 - 0.548F + 3.791$).

2. An increase in backwash water cost raises the backwash water cost line and moves the optimum dosage to the right in Figure 15-3. For example, doubling the cost of water from \$0.0608/m^3 to \$0.1216/m^3 moves the optimum dosage to 7.2 mg/L (by trial and error).

3. The chemical cost at 10 mg/L is \$1.83/1000 m^3 of water produced

4. The backwash water cost at 14 mg/L is \$0.71/1000 m^3 of water produced by using 14 mg/L in Eq. [15.10].

5. For $C_C = 0.21$ in Eq. [15.11], C_T in Eq. [15.12] is:
   $C_T = -0.0024F^3 + 0.0749F^2 - 0.588F + 3.791$.
   At 6 mg/L, total cost is: $C_T = \$2.44$.

6. The minimum dosage would be 8 mg/L at a chemical cost of \$0.06/kg. Determined by trial and error using $C_T = -0.0024F^3 + 0.0749F^2 - 0.738F + 3.791$.

Case Study #2 Solution

1. DLH basis

Standard: rate = $\dfrac{\$1.67 \text{ million}}{187{,}500 \text{ hrs}}$ = \$8.91/DLH

Premium: rate = $\dfrac{\$3.33 \text{ million}}{125{,}000 \text{ hrs}}$ = \$26.64/DLH

Model	IDC rate	DL hours	IDC allocation	Direct material	Direct Labor	Total cost	Price, ~1.10 x cost
Std	\$8.91	0.25	\$2.23/un	2.50/m	\$5/un	\$9.73	10.75
Prm	26.64	0.50	13.32	3.75	10	27.07	29.75

2.

Cost pool	Cost driver	Volume of driver	Total cost/year	Cost per activity
Quality	inspections	20,000	$800,000	$40/inspection
Purchasing	orders	40,000	1,200,000	30/order
Scheduling	orders	1,000	800,000	800/order
Prod. Set-ups	set-ups	5,000	1,000,000	200/set-up
Machine Ops.	hours	10,000	1,200,000	120/hour

ABC allocation

	Standard		Premium	
Driver	Activity	IDC allocation	Activity	IDC allocation
Quality	8,000@$40	$320,000	12,000@$40	$480,000
Purchasing	30,000@30	900,000	10,000@30	300,000
Scheduling	400@800	320,000	600@800	480,000
Prod. Set-ups	1,500@200	300,000	3,500@200	700,000
Machine Ops.	7,000@120	840,000	3,000@120	360,000
Total		$2,680,000		$2,320,000
Sales volume		750,000		250,000
IDC/unit		$3.57		$9.28

Model	Direct material	Direct labor	IDC allocation	Total cost
Standard	2.50	5.00	3.57	$11.07
Premium	3.75	10.00	9.28	$23.03

3. Traditional

Model	Profit/unit	Volume	Profit
Standard	10.75 – 9.73 = $1.02	750,000	$765,000
Premium	29.75 – 27.07 = $2.68	250,000	670,000
Profit			$1,435,000

ABC

Standard	10.75 – 11.07 = $–0.32	750,000	$ –240,000
Premium	29.75 – 23.03 = $6.72	250,000	1,680.000
Profit			$1,440,000

4. Price at Cost + 10%

Model	Cost	Price	Profit/unit	Volume	Profit
Standard	$11.07	$12.18	$1.11	750,000	$832,500
Premium	23.03	25.33	2.30	250,000	575,000
Profit					$1,407,000

Profit goes down ~$33,000

5. a) They were right on IDC allocation under ABC, but they were wrong on traditional where the cost is ~ 1/3 and IDC is ~1/6.

	Allocation	
Model	Traditional	ABC
Standard	$2.23/unit	$3.57/unit
Premium	13.32	9.28

b) Cost versus Profit comment – Wrong if old prices are retained.
Under ABC standard model loses $0.32/unit. Price for standard should go up.
Price for standard should go up. Premium makes good profit at current price under ABC ($7.72/unit).

c) Premium require more activities and operations
Wrong : Premium is lower in cost drivers of purchase orders and machine operations hours, but is higher on set ups and inspections. However, number of set-ups is low (5000 total) and (quality) inspections have a low cost at $40/inspection.
Overall – Not a correct impression when costs are examined.