**CHAPTER 10**

**DETERMINING HOW COSTS BEHAVE**

**10-1** The two assumptions are

1. Variations in the level of a single activity (the cost driver) explain the variations in the related total costs.

2. Cost behavior is approximated by a linear cost function within the relevant range. A linear cost function is a cost function where, within the relevant range, the graph of total costs versus the level of a single activity forms a straight line.

**10-2** Three alternative linear cost functions are

1. Variable cost function––a cost function in which total costs change in proportion to the changes in the level of activity in the relevant range.

2. Fixed cost function––a cost function in which total costs do not change with changes in the level of activity in the relevant range.

3. Mixed cost function––a cost function that has both variable and fixed elements. Total costs change but not in proportion to the changes in the level of activity in the relevant range.

**10-3** A linear cost function is a cost function where, within the relevant range, the graph of total costs versus the level of a single activity related to that cost is a straight line. An example of a linear cost function is a cost function for use of a videoconferencing line where the terms are a fixed charge of $10,000 per year plus a $2 per minute charge for line use. A nonlinear cost function is a cost function where, within the relevant range, the graph of total costs versus the level of a single activity related to that cost is not a straight line. Examples include economies of scale in advertising where an agency can double the number of advertisements for less than twice the costs, step-cost functions, and learning-curve-based costs.

**10-4** No. High correlation merely indicates that the two variables move together in the data examined. It is essential also to consider economic plausibility before making inferences about cause and effect. Without any economic plausibility for a relationship, it is less likely that a high level of correlation observed in one set of data will be similarly found in other sets of data.

**10-5** Four approaches to estimating a cost function are

1. Industrial engineering method.

2. Conference method.

3. Account analysis method.

4. Quantitative analysis of current or past cost relationships.

**10-6** The conference method estimates cost functions on the basis of analysis and opinions about costs and their drivers gathered from various departments of a company (purchasing, process engineering, manufacturing, employee relations, etc.). Advantages of the conference method include:

1. The speed with which cost estimates can be developed

2. The pooling of knowledge from experts across functional areas

3. The improved credibility of the cost function to all personnel

**10-7** The account analysis method estimates cost functions by classifying cost accounts in the subsidiary ledger as variable, fixed, or mixed with respect to the identified level of activity. Typically, managers use qualitative, rather than quantitative, analysis when making these cost-classification decisions.

**10-8** The six steps are

1. Choose the dependent variable (the variable to be predicted, which is some type of cost).

2. Identify the independent variable or cost driver.

3. Collect data on the dependent variable and the cost driver.

4. Plot the data.

5. Estimate the cost function.

6. Evaluate the cost driver of the estimated cost function.

Step 3 typically is the most difficult for a cost analyst.

**10-9** Causality in a cost function runs from the cost driver to the dependent variable. Thus, choosing the highest observation and the lowest observation of the cost driver is appropriate in the high-low method.

**10-10** Three criteria important when choosing among alternative cost functions are

1. Economic plausibility.

2. Goodness of fit.

3. Slope of the regression line.

**10-11** A learning curve is a function that measures how labor-hours per unit decline as units of production increase because workers are learning and becoming better at their jobs. Two models used to capture different forms of learning are

1. Cumulative average-time learning model. The cumulative average time per unit declines by a constant percentage each time the cumulative quantity of units produced doubles.

2. Incremental unit-time learning model. The incremental time needed to produce the last unit declines by a constant percentage each time the cumulative quantity of units produced doubles.

**10-12** Frequently encountered problems when collecting cost data on variables included in a cost function are

1. The time period used to measure the dependent variable is not properly matched with the time period used to measure the cost driver(s).

2. Fixed costs are allocated as if they are variable.

3. Data are either not available for all observations or are not uniformly reliable.

4. Extreme values of observations occur.

5. A homogeneous relationship between the individual cost items in the dependent variable cost pool and the cost driver(s) does not exist.

6. The relationship between the cost and the cost driver is not stationary.

7. Inflation has occurred in a dependent variable, a cost driver, or both.

**10-13** Four key assumptions examined in specification analysis are

1. Linearity of relationship between the dependent variable and the independent variable within the relevant range.

2. Constant variance of residuals for all values of the independent variable.

3. Independence of residuals.

4. Normal distribution of residuals.

**10-14** No. A cost driver is any factor whose change causes a change in the total cost of a related cost object. A cause-and-effect relationship underlies selection of a cost driver. Some users of regression analysis include numerous independent variables in a regression model in an attempt to maximize goodness of fit, irrespective of the economic plausibility of the independent variables included. Some of the independent variables included may not be cost drivers.

**10-15** No. Multicollinearity exists when two or more independent variables are highly correlated with each other.

**10-16** (10 min.)  **Estimating a cost function.**

1. Slope coefficient =

**=** 

**= =** $0.35 per machine-hour

Constant = Total cost – (Slope coefficient × Quantity of cost driver)

= $5,400 – ($0.35 × 10,000) = $1,900

= $4,000 – ($0.35 × 6,000) = $1,900

The cost function based on the two observations is

Maintenance costs = $1,900 + $0.35 × Machine-hours

2. The cost function in requirement 1 is an estimate of how costs behave within the relevant range, not at cost levels outside the relevant range. If there are no months with zero machine-hours represented in the maintenance account, data in that account cannot be used to estimate the fixed costs at the zero machine-hours level. Rather, the constant component of the cost function provides the best available starting point for a straight line that approximates how a cost behaves within the relevant range.

**10-17** (15 min.) **Identifying variable-, fixed-, and mixed-cost functions.**

1. See Solution Exhibit 10-17.

2. Contract 1: *y* = $50

Contract 2: *y* = $30 + $0.20*X*

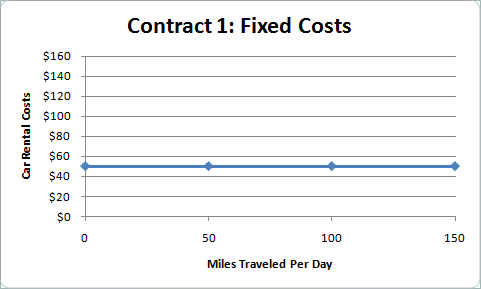
Contract 3: *y* = $1*X*

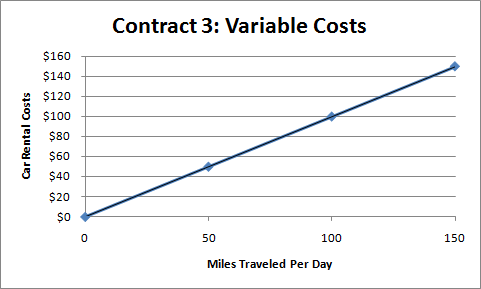
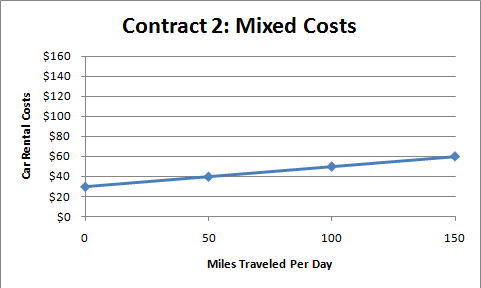
where *X*is the number of miles traveled in the day.

|  |  |  |
| --- | --- | --- |
| 3. | **Contract** | **Cost Function** |
|  | 1  2  3 | Fixed  Mixed  Variable |

Solution Exhibit 10-17

Plots of Car Rental Contracts Offered by Pacific Corp.



**10-18** (20 min.) **Various cost-behavior patterns.**

1. K

2. B

3. G

4. J Note that A is incorrect because, although the cost per pound eventually equals a constant at $9.20, the total dollars of cost increases linearly from that point onward.

5. I The total costs will be the same regardless of the volume level.

6. L

7. F This is a classic step-cost function.

8. K

9. C

**10-19** (30 min.) **Matching graphs with descriptions of cost and revenue behavior.**

1. (1)
2. (6) A step-cost function.
3. (9)
4. (2)
5. (8)
6. (10) It is *data plotted* on a scatter diagram, showing a linear variable cost function with constant variance of residuals. The constant variance of residuals implies that there is a uniform dispersion of the data points about the regression line.
7. (3)
8. (8)

**10-20** (20 min.) **Account analysis, high-low**

**Note: In some print versions of the text, requirement 3 refers to the company as Java Joe’s rather than the correct name of Luwak Coffees.**

1. The electricity cost is variable because, in each month, the cost divided by the number of kilowatt hours equals a constant $0.30. The definition of a variable cost is one that remains constant per unit.

The telephone cost is a mixed cost because the cost neither remains constant in total nor remains constant per unit.

The water cost is fixed because, although water usage varies from month to month, the cost remains constant at $120.

2. The month with the highest number of telephone minutes is June, with 2,880 minutes and $197.60 of cost. The month with the lowest is April, with 1,960 minutes and $179.20. The difference in cost ($197.60 – $179.20), divided by the difference in minutes (2,880 – 1,960) equals $0.02 per minute of variable telephone cost. Inserted into the cost formula for June:

$197.60 = *a* fixed cost + ($0.02 × number of minutes used)

$197.60 = *a* + ($0.02 × 2,880)

$197.60 = *a* + $57.60

*a* = $140 monthly fixed telephone cost

Therefore, Luwak’s cost formula for monthly telephone cost is

*Y* = $140 + ($0.02 × number of minutes used)

3. The electricity rate is $0.30 per kw hour

The telephone cost is $140 + ($0.02 per minute)

The fixed water cost is $120.

Adding them together we get:

Fixed cost of utilities = $140 (telephone) + $120 (water) = $260

Monthly Utilities Cost = $130 + (0.30 per kw hour) + ($0.02 per telephone min.)

4. Estimated utilities cost = $260 + ($0.30 × 4,400 kw hours) + ($0.02 × 3,000 minutes)

= $260 + $1,320 + $60 = $1,640

**10-21** (30 min.) **Account analysis method.**

1. Manufacturing cost classification for 2014:

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **Account** | | **Total**  **Costs**  **(1)** | **% of**  **Total Costs That is** Variable **(2)** | **Variable**  **Costs**  **(3) = (1)** × **(2)** | **Fixed**  **Costs**  **(4) = (1) – (3)** | **Variable**  **Cost per Unit**  **(5) = (3) ÷ 75,000** |
| Direct materials  Direct manufacturing labor  Power  Supervision labor  Materials-handling labor  Maintenance labor  Depreciation  Rent, property taxes, admin | $300,000  225,000  37,500  56,250  60,000  75,000  95,000  100,000 | 100%  100  100  20  50  40  0  0 | $300,000  225,000  37,500  11,250  30,000  30,000  0  0 | $ 0  0  0  45,000  30,000  45,000  95,000  100,000 | $4.00  3.00  0.50  0.15  0.40  0.40  0  0 |
| Total | $948,750 |  | $633,750 | $315,000 | $8.45 |

Total manufacturing cost for 2014 = $948,750

Variable costs in 2015:

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Account** | **Unit Variable Cost per Unit for 2014**  **(6)** | **Percentage Increase**  **(7)** | **Increase in Variable Cost**  **per Unit**  **(8) = (6)** × **(7)** | **Variable Cost per Unit**  **for 2015**  **(9) = (6) + (8)** | **Total Variable Costs for 2015**  **(10) = (9)** × **80,000** |
| Direct materials  Direct manufacturing labor  Power  Supervision labor  Materials-handling labor  Maintenance labor  Depreciation  Rent, property taxes, admin. | $4.00  3.00  0.50  0.15  0.40  0.40  0  0 | 5%  10  0  0  0  0  0  0 | $0.20  0.30  0  0  0  0  0  0 | $4.20  3.30  0.50  0.15  0.40  0.40  0  0 | $336,000  264,000  40,000  12,000  32,000  32,000  0  0 |
| Total | $8.45 |  | $0.50 | $8.95 | $716,000 |

Fixed and total costs in 2015:

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **Account** | **Fixed Costs**  **for 2015**  **(11)** | **Percentage**  **Increase**  **(12)** | **Dollar Increase in Fixed Costs**  **(13) =**  **(11) × (12)** | **Fixed Costs**  **for 2015**  **(14) =**  **(11) + (13)** | **Variable Costs for 2015**  **(15)** | **Total**  **Costs**  **(16) =**  **(14) + (15)** |
| Direct materials  Direct manufacturing labor  Power  Supervision labor  Materials-handling labor  Maintenance labor  Depreciation  Rent, property taxes, admin. | $ 0  0  0  45,000  30,000  45,000  95,000  100,000 | 0%  0  0  0  0  0  5  7 | $ 0  0  0  0  0  0  4,750  7,000 | $ 0  0  0  45,000  30,000  45,000  99,750  107,000 | $336,000  264,000  40,000  12,000  32,000  32,000  0  0 | $ 336,000  264,000  40,000  57,000  62,000  77,000  99,750  107,000 |
| Total | $315,000 |  | $11,750 | $326,750 | $716,000 | $1,042,750 |

Total manufacturing costs for 2015 = $1,042,750

2. Total cost per unit, 2014 =  = $12.65

Total cost per unit, 2015 =  = $13.03

3. Cost classification into variable and fixed costs is based on qualitative rather than quantitative analysis. How good the classifications are depends on the knowledge of individual managers who classify the costs. Gower may want to undertake quantitative analysis of costs, using regression analysis on time-series or cross-sectional data to better estimate the fixed and variable components of costs. Better knowledge of fixed and variable costs will help Gower to better price his products, to know when he is getting a positive contribution margin, and to better manage costs.

**10-22** (15–20 min.) **Estimating a cost function, high-low method.**

1. The key point to note is that the problem provides high-low values of *X* (annual round trips made by a helicopter) and *Y**X* (the operating cost per round trip). We first need to calculate the annual operating cost *Y* (as in column (3) below), and then use those values to estimate the function using the high-low method.

|  |  |  |  |
| --- | --- | --- | --- |
|  | **Cost Driver:**  **Annual Round- Trips (*X*)** | **Operating Cost per Round-Trip** | **Annual Operating**  **Cost (*Y*)** |
|  | **(1)** | **(2)** | **(3) = (1)  (2)** |
| Highest observation of cost driver | 2,000 | $300 | $600,000 |
| Lowest observation of cost driver | 1,000 | $350 | $350,000 |
| Difference | 1,000 |  | $250,000 |
|  |  |  |  |
| Slope coefficient = $250,0001,000 = $250 per round-trip | | | |
| Constant = $600,000 – ($250  2,000) = $100,000 | | | |

The estimated relationship is *Y* = $100,000 + $250 *X*; where *Y* is the annual operating cost of a helicopter and *X* represents the number of round trips it makes annually.

2. The constant *a* (estimated as $100,000) represents the fixed costs of operating a helicopter, irrespective of the number of round trips it makes. This would include items such as insurance, registration, depreciation on the aircraft, and any fixed component of pilot and crew salaries. The coefficient *b* (estimated as $250 per round-trip) represents the variable cost of each round trip—costs that are incurred only when a helicopter actually flies a round trip. The coefficient *b* may include costs such as landing fees, fuel, refreshments, baggage handling, and any regulatory fees paid on a per-flight basis.

3. If each helicopter is, on average, expected to make 1,200 round trips a year, we can use the estimated relationship to calculate the expected annual operating cost per helicopter:

*Y* = $100,000 + $250 *X*

*X* = 1,200

*Y* = $100,000 + $2501,200 = $100,000 + $300,000 = $400,000

With 10 helicopters in its fleet, Reisen’s estimated operating budget is 10$400,000 = $4,000,000.

**10-23** (20 min.) **Estimating a cost function, high-low method.**

1. See Solution Exhibit 10-23. There is a positive relationship between the number of service reports (a cost driver) and the customer-service department costs. This relationship is economically plausible.

2. **Number of Customer-Service**

**Service Reports Department Costs**

Highest observation of cost driver 455 $21,500

Lowest observation of cost driver 115 13,000

Difference 340 $ 8,500

Customer-service department costs = *a* + *b* (number of service reports)

Slope coefficient (*b*) =  **=** $25 per service report

Constant (*a*) = $21,500 – ($25  455) = $10,125

= $13,000 – ($25  115) = $10,125



3. Other possible cost drivers of customer-service department costs are:

a. Number of products replaced with a new product (and the dollar value of the new products charged to the customer-service department).

b. Number of products repaired and the time and cost of repairs.

**Solution Exhibit 10-23**

Plot of Number of Service Reports versus Customer-Service Dept. Costs for Capitol Products



**10-24** (30–40 min.) **Linear cost approximation.**

1. Slope coefficient (*b*) =

**=** ($521,000 – $395,000)/(7,500 – 4,000)

**=** $36.00

Constant (*a*) = $521,000 – ($36.00 × 7,500)

= $251,000

Cost function = $251,000 + ($36.00  professional labor-hours)

The linear cost function is plotted in Solution Exhibit 10-24.

No, the constant component of the cost function does not represent the fixed overhead cost of the Little Rock Reviewers Company. The relevant range of professional labor-hours is from 3,000 to 8,500. The constant component provides the best available starting point for a straight line that approximates how a cost behaves within the 3,000 to 8,500 relevant range.

2. A comparison at various levels of professional labor-hours follows. The linear cost function is based on the formula of $251,000 per month plus $36.00 per professional labor-hour.

Total overhead cost behavior:

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
|  | **Month 1** | **Month 2** | **Month 3** | **Month 4** | **Month 5** | **Month 6** |
| Professional labor-hours  Actual total overhead costs  Linear approximation  Actual minus linear  Approximation | 3,000  $330,000  359,000  $(29,000) | 4,000  $395,000  395,000  $ 0 | 5,000  $425,000  431,000  $ (6,000) | 6,000  $467,000  467,000  $ 0 | 7,500  $521,000  521,000  $ 0 | 8,500  $577,000  557,000  $ 20,000 |

The data are shown in Solution Exhibit 10-24. The linear cost function overstates costs by $6,000 at the 5,000-hour level and understates costs by $20,000 at the 8,500-hour level.

3. **Based on Based on Linear**

**Actual Cost Function**

Contribution before deducting incremental overhead $31,000 $31,000

Incremental overhead 30,000 36,000

Contribution after incremental overhead $ 1,000 $ (5,000)

The total contribution margin actually forgone is $1,000.

### Solution Exhibit 10-24

Linear Cost Function Plot of Professional Labor-Hours

on Total Overhead Costs for Little Rock Reviewers Company

**10-25** (20 min.) **Cost-volume-profit and regression analysis**.

1a. Average cost of manufacturing = 

= = $33 per frame

This cost is higher than the $32.50 per frame that Ryan has quoted.

1b. Goldstein cannot take the average manufacturing cost in 2014 of $33 per frame and multiply it by 35,000 bicycle frames to determine the total cost of manufacturing 35,000 bicycle frames. The reason is that some of the $1,056,000 (or equivalently the $33 cost per frame) are fixed costs and some are variable costs. Without distinguishing fixed from variable costs, Goldstein cannot determine the cost of manufacturing 35,000 frames. For example, if all costs are fixed, the manufacturing costs of 35,000 frames will continue to be $1,056,000. If, however, all costs are variable, the cost of manufacturing 35,000 frames would be $33 × 35,000 = $1,155,000. If some costs are fixed and some are variable, the cost of manufacturing 35,000 frames will be somewhere between $1,056,000 and $1,155,000.

Some students could argue that another reason for not being able to determine the cost of manufacturing 35,000 bicycle frames is that not all costs are output unit-level costs. If some costs are, for example, batch-level costs, more information would be needed on the number of batches in which the 35,000 bicycle frames would be produced, in order to determine the cost of manufacturing 35,000 bicycle frames.

2.  = $435,000 + $19 × 35,000

= $435,000 + $665,000 = $1,100,000

Purchasing bicycle frames from Ryan will cost $32.50 × 35,000 = $1,137,500. Hence, it will cost Goldstein $1,137,500 − $1,100,000 = $37,500 more to purchase the frames from Ryan rather than manufacture them in-house.

3. Goldstein would need to consider several factors before being confident that the equation in requirement 2 accurately predicts the cost of manufacturing bicycle frames.

a. Is the relationship between total manufacturing costs and quantity of bicycle frames economically plausible? For example, is the quantity of bicycles made the only cost driver or are there other cost-drivers (for example batch-level costs of setups, production-orders or material handling) that affect manufacturing costs?

b. How good is the goodness of fit? That is, how well does the estimated line fit the data?

c. Is the relationship between the number of bicycle frames produced and total manufacturing costs linear?

d. Does the slope of the regression line indicate that a strong relationship exists between manufacturing costs and the number of bicycle frames produced?

1. Are there any data problems such as, for example, errors in measuring costs, trends in prices of materials, labor or overheads that might affect variable or fixed costs over time, extreme values of observations, or a nonstationary relationship over time between total manufacturing costs and the quantity of bicycles produced?
2. How is inflation expected to affect costs?
3. Will Ryan supply high-quality bicycle frames on time?

**10-26** (25 min.) **Regression analysis, service company.**

1. Solution Exhibit 10-26 plots the relationship between labor-hours and overhead costs and shows the regression line.

*y* = $96,541 + $3.93 *X*

*Economic plausibility.* Labor-hours appears to be an economically plausible driver of overhead costs for a catering company. Overhead costs such as scheduling, hiring and training of workers, and managing the workforce are largely incurred to support labor.

*Goodness of fit.* The vertical differences between actual and predicted costs are extremely small, indicating a very good fit. The good fit indicates a strong relationship between the labor-hour cost driver and overhead costs.

*Slope of regression line.* The regression line has a reasonably steep slope from left to right. Given the small scatter of the observations around the line, the positive slope indicates that, on average, overhead costs increase as labor-hours increase.

2. The regression analysis indicates that, within the relevant range of 5,000 to 15,000 labor-hours, the variable cost per person for a cocktail party equals:

Food and beverages $30.00

Labor (0.5 hrs. × $20 per hour) 10.00

Variable overhead (0.5 hrs × $3.93 per labor-hour) 1.97

Total variable cost per person $41.97

3. To earn a positive contribution margin, the minimum bid for a 200-person cocktail party would be any amount greater than $8,394. This amount is calculated by multiplying the variable cost per person of $41.97 by the 200 people. At a price above the variable costs of $8,394, Stan Baiman will be earning a contribution margin toward coverage of his fixed costs.

Of course, Stan Baiman will consider other factors in developing his bid including (a) an analysis of the competition––vigorous competition will limit Baiman’s ability to obtain a higher price; (b) a determination of whether or not his bid will set a precedent for lower prices––overall, the prices Stan Baiman charges should generate enough contribution to cover fixed costs and earn a reasonable profit; and (c) a judgment of how representative past historical data (used in the regression analysis) is about future costs.

**Solution Exhibit 10-26**

Regression Line of Overhead Costs on Labor-Hours for Stan Baiman’s Catering Company

**10-27 High-low, regression**

1. Mandy will pick the highest point of activity, 4,068 parts (March) at $17,280 of cost, and the lowest point of activity, 2,316 parts (August) at $10,272.

|  |  |  |
| --- | --- | --- |
|  | **Cost driver:**  **Quantity Purchased** | **Cost** |
| Highest observation of cost driver | 4,068 | $17,280 |
| Lowest observation of cost driver | 2,316 | 10,272 |
| Difference | 1,752 | $ 7,008 |

Purchase costs = *a* + *b*Quantity purchased

Slope Coefficient = $7,008/1,752 = $4 per part

Constant (*a*) = $17,280 ─ ($44,068) = $1,008

The equation Mandy gets is:

Purchase costs = $1,008 + ($4Quantity purchased)

2. Using the equation above, the expected purchase costs for each month will be:

|  |  |  |  |
| --- | --- | --- | --- |
| **Month** | **Purchase Quantity**  **Expected** | **Formula** | **Expected**  **cost** |

October 3,360 parts *y* = $1,008 + ($43,360) $14,448

November 3,720 *y* = $1,008 + ($43,720) 15,888

December 3,000 *y* = $1,008 + ($43,000) 13,008

3. Economic Plausibility: Clearly, the cost of purchasing a part is associated with the quantity purchased.

Goodness of Fit: As seen in Solution Exhibit 10-27, the regression line fits the data well. The vertical distance between the regression line and observations is small. An *r*-squared value of greater than 0.98 indicates that more than 98 percent of the change in cost can be explained by the change in quantity.

Significance of the Independent Variable: The relatively steep slope of the regression line suggests that the quantity purchased is correlated with purchasing cost for part #696.

**SOLUTION EXHIBIT 10-27**

According to the regression, Mandy’s original estimate of fixed cost is too low given all the data points. The original slope is too steep but only by 33 cents. So, the variable rate is lower, but the fixed cost is higher for the regression line than for the high-low cost equation.

The regression is the more accurate estimate because it uses all available data (all nine data points), while the high-low method only relies on two data points and may therefore miss some important information contained in the other data.

4. Using the regression equation, the purchase costs for each month will be:

|  |  |  |  |
| --- | --- | --- | --- |
| **Month** | **Purchase**  **Quantity**  **Expected** | **Formula** | **Expected cost** |

October 3,360 parts *y* = $2,135.50 + ($3.673,360) $14,466.70

November 3,720 *y* = $2,135.50 + ($3.673,720) 15,787.90

December 3,000 *y* = $2,135.50 + ($3.673,000) 13,145.50

Although the two equations are different in both fixed element and variable rate, within the relevant range they give similar expected costs. This implies that the high and low points of the data are a reasonable representation of the total set of points within the relevant range.

**10-28** (20 min.) **Learning curve, cumulative average-time learning model.**

The direct manufacturing labor-hours (DMLH) required to produce the first 2, 4, and 8 units, given the assumption of a cumulative average-time learning curve of 85 percent, is as follows:

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **85% Learning Curve** | | | | |
|  |  |  |  | |
| **Cumulative** | **Cumulative** | | **Cumulative** | |
| **Number** | **Average Time** | | **Total Time:** | |
| **of Units (*X*)** | **per Unit (*y*): Labor Hours** | | **Labor-Hours** | |
| **(1)** | **(2)** | | **(3) = (1)** **(2)** | |
| 1 | 4,400 |  | 4,400 | |
| 2 | 3,740 | = (4,400  0.85) | 7,480 | |
| 4 | 3,179 | = (3,740  0.85) | 12,716 | |
| 8 | 2,702 | = (3,179  0.85) | 21,616 | |

Alternatively, to compute the values in column (2) we could use the formula

*y = aXb*

where *a* = 4,400, *X* = 2, 4, or 8, and *b* = – 0.234465, which gives

when *X* = 2, *y* = 4,400× 2– 0.234465 = 7,480

when *X* = 4, *y* = 4,400× 4– 0.234465 = 12,716

when *X* = 8, *y* = 4,400× 8– 0.234465 = 21,616

|  |  |  |  |
| --- | --- | --- | --- |
|  | **Variable Costs of Producing** | | |
|  | **2 Units** | **4 Units** | **8 Units** |
| Direct materials $84,000 × 2; 4; 8  Direct manufacturing labor  $27 × 7,480; 12,716; 21,616  Variable manufacturing overhead  $13 × 7,480; 12,716; 21,616  Total variable costs | $168,000  201,960  97,240  $467,200 | $336,000  343,332  165,308  $844,640 | $672,000  583,632  281,008  $1,536,640 |

**10-29** (20 min.) **Learning curve, incremental unit-time learning model.**

1. The direct manufacturing labor-hours (DMLH) required to produce the first 2, 3, and 4 units, given the assumption of an incremental unit-time learning curve of 85 percent, is as follows:

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **85% Learning Curve** | | | | |
| **Cumulative**  **Number of Units (*X*)** | **Individual Unit Time for *X*th Unit (*y*): Labor Hours** | | **Cumulative Total Time: Labor-Hours** | |
| **(1)** | **(2)** | | **(3)** | |
| 1 | 4,400 |  | 4,400 | |
| 2 | 3,740 | = (4,400  0.85) | 8,140 | |
| 3 | 3,401 |  | 11,541 | |
| 4 | 3,179 | = (3,740  0.85) | 14,720 | |

Values in column (2) are calculated using the formula *y = aXb* where *a* = 4,400, *X* = 2, 3, or 4, and *b* = – 0.234465, which gives

when *X* = 2, *y* = 4,400 × 2– 0.234465 = 3,740

when *X* = 3, *y* = 4,400 × 3– 0.234465 = 3,401

when *X* = 4, *y* = 4,400 × 4– 0.234465 = 3,179

|  |  |  |  |
| --- | --- | --- | --- |
|  | **Variable Costs of Producing** | | |
|  | **2 Units** | **3 Units** | **4 Units** |
| Direct materials $84,000 × 2; 3; 4  Direct manufacturing labor  $27 × 8,140; 11,541; 14,720  Variable manufacturing overhead  $13 × 8,140; 11,541; 14,720  Total variable costs | $168,000  219,780  105,820  $493,600 | $ 252,000  311,607  150,033  $713,640 | $ 336,000  397,440  191,360  $924,800 |

|  |  |  |
| --- | --- | --- |
| 2. | **Variable Costs of Producing** | |
|  | **2 Units** | **4 Units** |
| Incremental unit-time learning model (from requirement 1)  Cumulative average-time learning model (from Exercise 10-29)  Difference | $493,600  467,200  $ 26,400 | $924,800  844,640  $ 80,160 |

Total variable costs for manufacturing 2 and 4 units are lower under the cumulative average-time learning curve relative to the incremental unit-time learning curve. Direct manufacturing labor-hours required to make additional units decline more slowly in the incremental unit-time learning curve relative to the cumulative average-time learning curve when the same 85 percent factor is used for both curves. The reason is that, in the incremental unit-time learning curve, as the number of units double only the last unit produced has a cost of 85 percent of the initial cost. In the cumulative average-time learning model, doubling the number of units causes the average cost of *all* the units produced (not just the last unit) to be 85 percent of the initial cost.

**10-30** (25 min.) **High-low method.**

1.  **Machine-Hours Maintenance Costs**

Highest observation of cost driver 140,000 $280,000

Lowest observation of cost driver 95,000 190,000

Difference 45,000 $ 90,000

Maintenance costs = *a* + *b*  Machine-hours

Slope coefficient (*b*) =  = $2 per machine-hour

Constant (*a*) = $280,000 – ($2 × 140,000)

= $280,000 – $280,000 = $0

or Constant (*a*) = $190,000 – ($2 × 95,000)

= $190,000 – $190,000 = $0

Maintenance costs = $2 × Machine-hours

2.

**SOLUTION EXHIBIT 10-30**

Plot and High-Low Line of Maintenance Costs as a Function of Machine-Hours

Solution Exhibit 10-30 presents the high-low line.

*Economic plausibility.* The cost function shows a positive economically plausible relationship between machine-hours and maintenance costs. There is a clear-cut engineering relationship of higher machine-hours and maintenance costs.

*Goodness of fit.* The high-low line appears to “fit” the data well. The vertical differences between the actual and predicted costs appear to be quite small.

*Slope of high-low line.* The slope of the line appears to be reasonably steep indicating that, on average, maintenance costs in a quarter vary with machine-hours used.

3. Using the cost function estimated in 1, predicted maintenance costs would be $2 × 100,000 = $200,000.

Howard should budget $200,000 in quarter 13 because the relationship between machine-hours and maintenance costs in Solution Exhibit 10-30 is economically plausible, has an excellent goodness of fit, and indicates that an increase in machine-hours in a quarter causes maintenance costs to increase in the quarter.

**10-31** (30min.) **High-low method and regression analysis.**

1. See Solution Exhibit 10-31.

**SOLUTION EXHIBIT 10-31**

(Regression line solid, high low-line is dotted)

2.

|  |  |  |
| --- | --- | --- |
|  | **Number of**  **Orders per week** | **Weekly**  **Total Costs** |

Highest observation of cost driver (Week 9) 529 $25,275

Lowest observation of cost driver (Week 1) 353 19,005

Difference 176 $ 6,270

Weekly total costs = *a* + *b* (number of orders per week)

Slope coefficient (*b*) **=** $6,270/176=$35.63 per order

Constant (*a*) = $25,275 – ($35.63  529) = $6,429.38

= $19,005 – ($37.41  353) = $6,429.38

Weekly total costs = $6,429.38 + $35.63 × (Number of Orders per week)

See high-low line in Solution Exhibit 10-31.

1. Solution Exhibit 10-31 presents the regression line:

Weekly total costs = $10,048 + $28.91 × (Number of Orders per week)

*Economic Plausibility*. The cost function shows a positive economically plausible relationship between number of orders per week and weekly total costs. Number of orders is a plausible cost driver of total weekly costs.

*Goodness of fit*. The regression line appears to fit the data well. The vertical differences between the actual costs and the regression line appear to be quite small.

*Significance of independent variable*. The regression line has a steep positive slope and increases by $28.91 for each additional order. Because the slope is not flat, there is a strong relationship between number of orders and total weekly costs.

The regression line is the more accurate estimate of the relationship between number of orders and total weekly costs because it uses all available data points while the high-low method relies only on two data points and may therefore miss some information contained in the other data points. In addition, because the low data point falls below the regression line, the high-low method predicts a lower amount of fixed cost and a steeper slope (higher amount of variable cost per order).

4. Profit =

Total weekly revenues + Total seasonal membership fees – Total weekly costs =

(Total number of orders × $35) + (700 × $75) – $229,940 =

(4,478 × $35) + (700 × $75) – $229,940 =

$156,730 + $52,500 – $229,940 = ($20,710).

No, the club did not make a profit.

5. Let the average number of weekly orders be denoted by AWO. We want to find the value of AWO for which Fresh Choice will achieve zero profit. Using the format in requirement 4, we want:

Profit = [AWO × 10 weeks × $35] + (850 × $75) – [$10,048 + ($28.91 × AWO)] × 10 weeks = $0

$350 × AWO + $63,750 – $100,480 – $289.1 × AWO = $0

$60.9 × AWO = $36,730

AWO = $36,730 ÷ $60.9 = 603.12

So, Fresh Choice will have to get at least 604 weekly orders in order to break even next year.

**10-32** (30−40 min.) **High-low method, regression analysis.**

1. Solution Exhibit 10-32 presents the plots of advertising costs on revenues.

**SOLUTION EXHIBIT 10-32**

Plot and Regression Line of Advertising Costs on Revenues

Solution Exhibit 10-32 also shows the regression line of advertising costs on revenues. We evaluate the estimated regression equation using the criteria of economic plausibility, goodness of fit, and slope of the regression line.

*Economic plausibility.* Advertising costs appears to be a plausible cost driver of revenues. Restaurants frequently use newspaper advertising to promote their restaurants and increase their patronage.

*Goodness of fit*. The vertical differences between actual and predicted revenues appears to be reasonably small. This indicates that advertising costs are related to restaurant revenues.

*Slope of regression line.*The slope of the regression line appears to be relatively steep. Given the small scatter of the observations around the line, the steep slope indicates that, on average, restaurant revenues increase with newspaper advertising.

2. The high-low method would estimate the cost function as follows:

**Advertising Costs Revenues**

Highest observation of cost driver $4,500 $83,000

Lowest observation of cost driver 500 56,000

Difference $4,000 $27,000

Revenues = *a* + (*b* × advertising costs)

Slope coefficient (*b*) *= * = 6.75

Constant (*a*) = $83,000 − ($4,500 × 6.75)

= $83,000 − $30,375 = $52,625

or Constant (*a*) = $56,000 − ($500 × 6.75)

= $56,000 − $3,375 = $52,625

Revenues = $52,625+ (6.75 × Advertising costs)

3. The increase in revenues for each $1,000 spent on advertising within the relevant range is

a. Using the regression equation, 6.584 × $1,000 = $6,584

1. Using the high-low equation, 6.75 × $1,000 = $6,750

The high-low equation does fairly well in estimating the relationship between advertising costs and revenues. However, Schaub should use the regression equation because it uses information from all observations. The high-low method, on the other hand, relies only on the observations that have the highest and lowest values of the cost driver and these observations are generally not representative of all the data.

**10-33** (30 min.) **Regression, activity-based costing, choosing cost drivers.**

**Note: In some print versions of the text, the name of the company is referred to in one place as Fitzgerald rather than the correct name of Parker Manufacturing.**

1. Both number of units inspected and inspection labor-hours are plausible cost drivers for inspection costs. The number of units inspected is likely related to test-kit usage, which is a significant component of inspection costs. Inspection labor-hours are a plausible cost driver if labor hours vary per unit inspected because costs would be a function of how much time the inspectors spend on each unit. This is particularly true if the inspectors are paid a wage, and if they use electric or electronic machinery to test the units of product (cost of operating equipment increases with time spent).

2. Solution Exhibit 10-33 presents (a) the plots and regression line for number of units inspected versus inspection costs and (b) the plots and regression line for inspection labor-hours and inspection costs.

**SOLUTION EXHIBIT 10-33A**

Plot and Regression Line for Units Inspected versus Inspection Costs for Parker Manufacturing

**SOLUTION EXHIBIT 10-33B**

Plot and Regression Line for Inspection Labor-Hours and Inspection Costs for Parker Manufacturing

*Goodness of fit*. As you can see from the two graphs, the regression line based on number of units inspected better fits the data (has smaller vertical distances from the points to the line) than the regression line based on inspection labor-hours. The activity of inspection appears to be more closely linearly related to the number of units inspected than inspection labor-hours. Hence number of units inspected is a better cost driver. This is probably because the number of units inspected is closely related to test-kit usage, which is a significant component of inspection costs.

*Significance of independent variable*. It is hard to visually compare the slopes because the graphs are not the same size, but both graphs have steep positive slopes indicating a strong relationship between number of units inspected and inspection costs, and inspection labor-hours and inspection costs. Indeed, if labor-hours per inspection do not vary much, number of units inspected and inspection labor-hours will be closely related. Overall, it is the significant cost of test-kits that is driven by the number of units inspected (not the inspection labor-hours spent on inspection) that makes units inspected the preferred cost driver.

3. At 160 inspection labor hours and 1,500 units inspected:

Inspection costs using units inspected = $98.79 + ($2.02 × 1,500) = $3,128.79

Inspection costs using inspection labor-hours = $3.89 + ($20.06 × 160) = $3,213.49

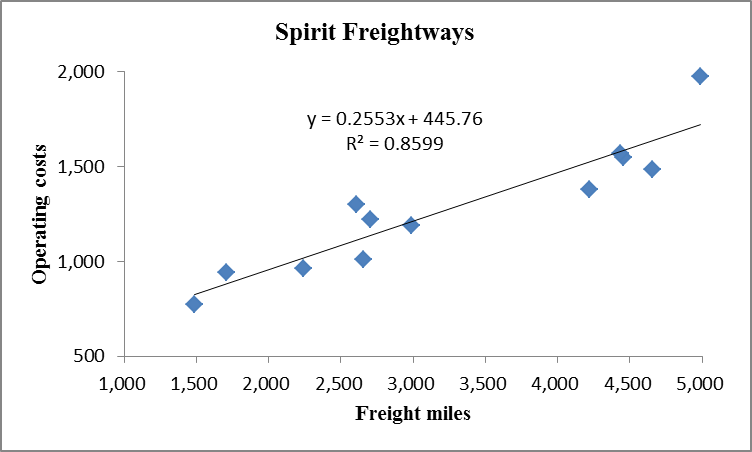
If Sharon uses inspection-labor-hours she will estimate inspection costs to be $3,213.49, $84.70 ($3,213.49 ─ $3,128.79) higher than if she had used number of units inspected. If actual costs equaled, say, $3,160, Sharon would conclude that Parker has performed efficiently in its inspection activity because actual inspection costs would be lower than budgeted amounts. In fact, based on the more accurate cost function, actual costs of $3,160 exceeded the budgeted amount of $3,128.79. Sharon should find ways to improve inspection efficiency rather than mistakenly conclude that the inspection activity has been performing well.

**10-34** (15-20 min.) **Interpreting regression results, matching time periods.**

1.Here is the regression data for monthly operating costs as a function of the total freight miles travelled by Sprit vehicles:

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| SUMMARY OUTPUT | |  |  |  |  |  |
|  |  |  |  |  |  |  |
| *Regression Statistics* | |  |  |  |  |  |
| Multiple R | 0.927299101 |  |  |  |  |  |
| R Square | 0.859883623 |  |  |  |  |  |
| Adjusted R Square | 0.845871986 |  |  |  |  |  |
| Standard Error | 132.0816002 |  |  |  |  |  |
| Observations | 12 |  |  |  |  |  |
|  |  |  |  |  |  |  |
| ANOVA |  |  |  |  |  |  |
|  | *df* | *SS* | *MS* | *F* | *Significance F* |  |
| Regression | 1 | 1070620.18 | 1070620.18 | 61.37 | 0.00 |  |
| Residual | 10 | 174455.49 | 17445.55 |  |  |  |
| Total | 11 | 1245075.67 |  |  |  |  |
|  |  |  |  |  |  |  |
|  | *Coefficients* | *Standard Error* | *t Stat* | *P-value* | *Lower 95%* | *Upper 95%* |
| Intercept | 445.76 | 112.97 | 3.95 | 0.00 | 194.04 | 697.48 |
| X Variable 1 | 0.26 | 0.03 | 7.83 | 0.00 | 0.18 | 0.33 |

2. The chart below presents the data and the estimated regression line for the relationship between monthly operating costs and freight miles traveled by Spirit Freightways.



|  |  |
| --- | --- |
| Economic  plausibility | A positive relationship between freight miles traveled and monthly operating costs is economically plausible since increased levels of economic activity should lead to the consumption of greater amounts of labor, fuel and other operating expenses. |
|  |  |
| Goodness of fit | *r*2 = 86%, Adjusted *r*2 = 85%  Standard error of regression = 132.08  Excellent fit; there is indisputable evidence of a linear relationship between the dependent and independent variables. The distances between the estimated line and the actual data points are small, other than at the highest level of activity recorded during the year. |
|  |  |
| Significance of Independent  Variables | The *t*-value of 7.83 for freight miles traveled output units is significant at the 0.05 and 0.01 levels. |

3. If Brown expects Spirit to generate an average of 3,600 miles each month next year, the best estimate of operating costs is given by:

Monthly operating costs = $445.76 + ($0.26) × (3,600 miles) = $1,381.76.

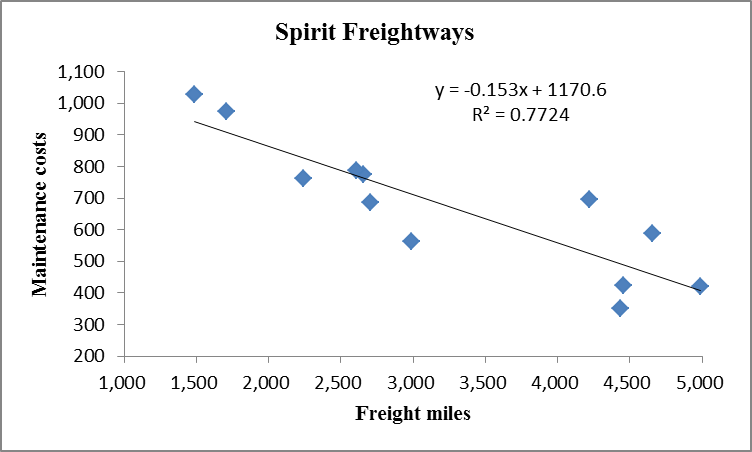
Annual operating costs = ($1,381.76) × 12 = $16,581.12.

4. Three variables, other than freight miles, that Brown might expect to be important cost drivers for Spirit’s operating costs are: input prices (fuel prices and wage rates), mix of agricultural output carried (weight, volume, value), and route mix and conditions (weather, flat versus mountainous terrain, short-haul versus long-haul carriage)**.**

5.Here is the regression data for monthly maintenance costs as a function of the total freight miles travelled by Sprit vehicles:

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| SUMMARY OUTPUT | |  |  |  |  |  |
|  |  |  |  |  |  |  |
| *Regression Statistics* | |  |  |  |  |  |
| Multiple R | 0.87887319 |  |  |  |  |  |
| R Square | 0.77241808 |  |  |  |  |  |
| Adjusted R Square | 0.74965989 |  |  |  |  |  |
| Standard Error | 106.470794 |  |  |  |  |  |
| Observations | 12 |  |  |  |  |  |
|  |  |  |  |  |  |  |
| ANOVA |  |  |  |  |  |  |
|  | *df* | *SS* | *MS* | *F* | *Significance F* |  |
| Regression | 1 | 384747.37 | 384747.37 | 33.94 | 0.00 |  |
| Residual | 10 | 113360.30 | 11336.03 |  |  |  |
| Total | 11 | 498107.67 |  |  |  |  |
|  |  |  |  |  |  |  |
|  | *Coefficients* | *Standard Error* | *t Stat* | *P-value* | *Lower 95%* | *Upper 95%* |
| Intercept | 1170.57 | 91.07 | 12.85 | 0.00 | 967.66 | 1373.48 |
| X Variable 1 | –0.15 | 0.03 | –5.83 | 0.00 | –0.21 | –0.09 |

The data and regression estimate are provided in the chart below:



6. At first glance, the regression result in requirement 5 is surprising and economically implausible. In the regression, the coefficient on freight miles traveled has a negative sign. This implies that the greater the number of freight miles (i.e., the more activity Spirit carries out), the smaller are the maintenance costs; specifically, it suggests that each extra freight mile reduces maintenance costs by $0.14 (recall that all data are in thousands). Clearly, this estimated relationship is not economically credible. However, one would think that freight miles should have some impact on fleet maintenance costs.

The logic behind the estimated regression becomes clearer once one realizes that maintenance costs have a discretionary component to them, especially in terms of timing. Spirit’s peak months of work transporting agricultural products in western Canada occur in late spring and summer (the period from April through August). It is likely that Spirit is simply choosing to defer maintenance to those months when its vehicles are not in use, thereby creating a negative relationship between monthly activity and maintenance costs. The causality also goes the other way—if vehicles are in the shop for maintenance, they are clearly not on the road generating freight miles. A third reason is that vehicles might need to be serviced at greater frequency during the winter months because of the wear and tear that comes from driving on icy terrain and in poor weather conditions.

Possible alternative specifications that would better capture the link between Spirit’s activity levels and the spending on maintenance are to estimate the relationship using annual data over a period of several years, to look at spending on corrective rather than preventive maintenance, or to look at the relation using lags (i.e., freight miles traveled in a period against the spending on maintenance done in a subsequent period in order to service the vehicles).

**10-35** (30–40 min.) **Cost estimation, cumulative average-time learning curve.**

1. Cost to produce the second through the seventh troop deployment boats:

|  |  |
| --- | --- |
| Direct materials, 6  $201,000 | $1,206,000 |
| Direct manufacturing labor (DML), 66,0601  $43 | 2,840,580 |
| Variable manufacturing overhead, 66,060  $24 | 1,585,440 |
| Other manufacturing overhead, 15% of DML costs | 426,087 |
| Total costs | $6,058,107 |

1The direct manufacturing labor-hours to produce the second to seventh boats can be calculated in several ways, given the assumption of a cumulative average-time learning curve of 90 percent:

Use of table format:

|  |  |  |  |
| --- | --- | --- | --- |
|  | **90% Learning Curve** | |  |
| **Cumulative**  **Number of Units (*X*)**  **(1)** | **Cumulative**  **Average Time per Unit (*y*): Labor Hours**  **(2)** | | **Cumulative Total Time: Labor-Hours**  **(3) = (1) (2)** |
| 1 | 15,700 |  | 15,700 |
| 2 | 14,130 | = (15,700  0.90) | 29,830 |
| 3 | 13,285 |  | 43,115 |
| 4 | 12,717 | = (14,130  0.90) | 55,832 |
| 5 | 12,293 |  | 68,125 |
| 6 | 11,957 |  | 80,082 |
| 7 | 11,680 |  | 91,762 |

The direct labor-hours required to produce the second through the seventh boats is 91,762 – 15,700 = 76,062 hours.

Use of formula: *y* = *aXb*

where *a* = 15,700, *X* = 7, and *b* = – 0.152004

*y* = 15,700 × 7– 0.152004 = 11,680 hours

The total direct labor-hours for 7 units is 11,680 × 7 = 81,760 hours

*Note:* Some students will debate the exclusion of the $281,000 tooling cost. The question specifies that the tooling “cost was assigned to the first boat.” Although Blue Seas may well seek to ensure its total revenue covers the $1,533,900 cost of the first boat, the concern in this question is only with the cost of producing six more PT109s.

2. Cost to produce the second through the seventh boats assuming linear function for direct labor-hours and units produced:

|  |  |
| --- | --- |
| Direct materials, 6  $201,000 | $1,206,000 |
| Direct manufacturing labor (DML), 6  15,700 hrs.  $43 | 4,050,600 |
| Variable manufacturing overhead, 6  15,700 hrs.  $24 | 2,260,800 |
| Other manufacturing overhead, 15% of DML costs | 607,950 |
| Total costs | $8,124,990 |

The difference in predicted costs is:

|  |  |  |  |
| --- | --- | --- | --- |
| Predicted cost in requirement 2 | |  | |
| (based on linear cost function) | | $8,124,990 | |
| Predicted cost in requirement 1 | |  | |
| (based on 90% learning curve) | | 6,058,107 | |
| Difference in favor of learning curve cost function | | $2,066,883 | |

Note that the linear cost function assumption leads to a total cost that is almost 35 percent higher than the cost predicted by the learning curve model. Learning curve effects are most prevalent in large manufacturing industries such as airplanes and boats where costs can run into the millions or hundreds of millions of dollars, resulting in very large and monetarily significant differences between the two models. In the case of Blue Seas, if it is in fact easier to produce additional boats as the firm gains experience, the learning curve model is the right one to use. The firm can better forecast its future costs and use that information to submit an appropriate cost bid to the Navy, as well as refine its pricing plans for other potential customers.

**10-36** (20–30 min.) **Cost estimation, incremental unit-time learning model.**

1. Cost to produce the second through the seventh boats:

|  |  |
| --- | --- |
| Direct materials, 6  $201,000 | $1,206,000 |
| Direct manufacturing labor (DML), 76,0621  $43 | 3,270,666 |
| Variable manufacturing overhead, 76,062  $24 | 1,825,4888 |
| Other manufacturing overhead, 15% of DML costs | 490,600 |
| Total costs | $6,792,754 |

1The direct labor hours to produce the second through the seventh boats can be calculated using a table format, given the assumption of an incremental unit-time learning curve of 90 percent:

|  |  |  |  |
| --- | --- | --- | --- |
| **90% Learning Curve** | | | |
| **Cumulative Number of Units (*X*)** | **Individual Unit Time for *X*th Unit (*y*)\*: Labor Hours** | | **Cumulative Total Time: Labor-Hours** |
| **(1)** | **(2)** | | **(3)** |
| 1 | 15,700 |  | 15,700 |
| 2 | 14,130 | = (15,700 0.90) | 29,830 |
| 3 | 13,285 |  | 43,115 |
| 4 | 12,717 | = (13,285 0.90) | 55,832 |
| 5 | 12,293 |  | 68,125 |
| 6 | 11,957 |  | 80,082 |
| 7 | 11,680 |  | 91,762 |

\*Calculated as *y* = *aXb* where *a* = 15,700, *b* = – 0.152004, and *X* = 1, 2, 3,. . .7.

The direct manufacturing labor-hours to produce the second through the seventh boat is 91,762 – 15,700 = 76,062 hours.

2. Difference in total costs to manufacture the second through the seventh boat under the incremental unit-time learning model and the cumulative average-time learning model is $6,792,754 (calculated in requirement 1 of this problem) – $6,058,107 (from requirement 1 of Problem 10-36) = $734,647, i.e., the total costs are higher for the incremental unit-time model.

The incremental unit-time learning curve has a slower rate of decline in the time required to produce successive units than does the cumulative average-time learning curve (see Problem 10-36, requirement 1). Assuming the same 90 percent factor is used for both curves:

|  |  |  |
| --- | --- | --- |
|  | **Estimated Cumulative Direct Manufacturing Labor-Hours** | |
| **Cumulative**  **Number of Units** | **Cumulative Average-**  **Time Learning Model** | **Incremental Unit-Time Learning Model** |
| 1  2  4  7 | 15,700  28,260  50,868  81,760 | 15,700  29,830  55,832  91,762 |

The reason is that, in the incremental unit-time learning model, as the number of units double, only the last unit produced has a cost of 90 percent of the initial cost. In the cumulative average-time learning model, doubling the number of units causes the average cost of *all* the units produced (not just the last unit) to be 90 percent of the initial cost.

Blue Seas should examine its own internal records on past jobs and seek information from engineers, plant managers, and workers when deciding which learning curve better describes the behavior of direct manufacturing labor-hours on the production of the PT109 boats.

* 1. (30 min.) **Regression; choosing among models.**

1. See Solution Exhibit 10-37A below.

**SOLUTION EXHIBIT 10-37A**

(a) Regression Output for Medical Supplies Costs and Number of Procedures

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| SUMMARY OUTPUT | |  |  |  |  |  |
|  |  |  |  |  |  |  |
| *Regression Statistics* | |  |  |  |  |  |
| Multiple R | 0.599152481 |  |  |  |  |  |
| R Square | 0.358983696 |  |  |  |  |  |
| Adjusted R Square | 0.294882065 |  |  |  |  |  |
| Standard Error | 52998.71699 |  |  |  |  |  |
| Observations | 12 |  |  |  |  |  |
|  |  |  |  |  |  |  |
| ANOVA |  |  |  |  |  |  |
|  | *df* | *SS* | *MS* | *F* | *Significance F* |  |
| Regression | 1 | 15730276644 | 1.57E+10 | 5.60 | 0.04 |  |
| Residual | 10 | 28088640022 | 2.81E+09 |  |  |  |
| Total | 11 | 43818916667 |  |  |  |  |
|  |  |  |  |  |  |  |
|  | *Coefficients* | *Standard Error* | *t Stat* | *P-value* | *Lower 95%* | *Upper 95%* |
| Intercept | 36939.77 | 56404.86 | 0.65 | 0.53 | -88738.09 | 162617.63 |
| X Variable 1 | 361.91 | 152.93 | 2.37 | 0.04 | 21.16 | 702.66 |

(b) Regression Output for Medical Supplies Costs and Number of Patient-Hours

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| SUMMARY OUTPUT | |  |  |  |  |  |
|  |  |  |  |  |  |  |
| *Regression Statistics* | |  |  |  |  |  |
| Multiple R | 0.91669199 |  |  |  |  |  |
| R Square | 0.84032421 |  |  |  |  |  |
| Adjusted R Square | 0.82435663 |  |  |  |  |  |
| Standard Error | 26451.5032 |  |  |  |  |  |
| Observations | 12 |  |  |  |  |  |
|  |  |  |  |  |  |  |
| ANOVA |  |  |  |  |  |  |
|  | *df* | *SS* | *MS* | *F* | *Significance F* |  |
| Regression | 1 | 36822096457 | 3.68E+10 | 52.63 | 0.00 |  |
| Residual | 10 | 6996820210 | 7E+08 |  |  |  |
| Total | 11 | 43818916667 |  |  |  |  |
|  |  |  |  |  |  |  |
|  | *Coefficients* | *Standard Error* | *t Stat* | *P-value* | *Lower 95%* | *Upper 95%* |
| Intercept | 3654.86 | 23569.51 | 0.16 | 0.88 | –48861.29 | 56171.00 |
| X Variable 1 | 56.76 | 7.82 | 7.25 | 0.00 | 39.33 | 74.19 |

2. See Solution Exhibit 10-37B below.

**SOLUTION EXHIBIT 10-37B**

Plots and Regression Lines for (a) Medical Supplies Costs and Number of Procedures and (b) Medical Supplies Costs and Number of Patient-Hours

(a)

(b)

3.

|  |  |  |
| --- | --- | --- |
|  | **Number of Setups** | **Number of Setup Hours** |
| Economic  plausibility | A positive relationship  between medical supplies costs  and the number of procedures  is economically plausible. | A positive relationship between medical supplies costs and the number of patient-hours is also economically plausible, especially because the time taken to serve patients is not uniform. Patient-hours is more likely to capture the true level of activity in the hospital because it accounts for the mix of procedures performed. |
| Goodness of fit | *r*2 = 36%  Standard error of regression = $52,999  Reasonable goodness of fit. | *r*2 = 84%  Standard error of regression = $26,452  Excellent goodness of fit. |
| Significance of independent  variables | The *t*-value of 2.37 is significant at the 0.05 level. It is not significant at the 0.01 level. | The *t*-value of 7.25 is highly significant at the 0.05 and 0.01 levels. |
| Specification  analysis of estimation assumptions | Based on a plot of the data, the linearity assumption holds, but there is some possibility that the constant variance assumption does not hold. The Durbin-Watson statistic of 2.48 suggests the residuals are independent. The normality of residuals assumption appears to hold. However, inferences drawn from only 12 observations are not reliable. | Based on a plot of the data, the assumptions of linearity, constant variance, independence of residuals (Durbin-Watson = 1.91), and normality of residuals hold. However, inferences drawn from only 12 observations are not reliable. |

4. The regression model using number of patient-hours should be used to estimate medical supplies costs because the number of patient-hours is a more economically plausible cost driver of medical supplies costs (compared to the number of procedures performed). The time taken to prepare medical facilities and to actually deal with patient issues (surgery, post-procedure care, etc.) is different for different procedures. The more complex the procedure, the more time is taken with the patient to analyze and manage the problem, and the greater the supplies costs incurred. As such, patient-hours might serve as a better driver of medical supplies costs. The regression of number of patient-hours and medical supplies costs also has a better fit, a substantially significant independent variable, and better satisfies the assumptions of the estimation technique used.

**10-38** (30 min.) **Multiple regression (continuation of 10-37).**

1. Solution Exhibit 10-38 presents the regression output for medical supplies costs using both number of procedures and number of patient-hours as independent variables (cost drivers).

**SOLUTION EXHIBIT 10-38**

Regression Output for Multiple Regression for Medical Supplies Costs Using Both Number of Procedures and Number of Patient-Hours as Independent Variables (Cost Drivers)

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| SUMMARY OUTPUT | |  |  |  |  |  |
|  |  |  |  |  |  |  |
| *Regression Statistics* | |  |  |  |  |  |
| Multiple R | 0.91806327 |  |  |  |  |  |
| R Square | 0.84284017 |  |  |  |  |  |
| Adjusted R Square | 0.80791577 |  |  |  |  |  |
| Standard Error | 27661.7936 |  |  |  |  |  |
| Observations | 12 |  |  |  |  |  |
|  |  |  |  |  |  |  |
| ANOVA |  |  |  |  |  |  |
|  | *df* | *SS* | *MS* | *F* | *Significance F* |  |
| Regression | 2 | 36932343254 | 1.85E+10 | 24.13 | 0.00 |  |
| Residual | 9 | 6886573413 | 7.65E+08 |  |  |  |
| Total | 11 | 43818916667 |  |  |  |  |
|  |  |  |  |  |  |  |
|  | *Coefficients* | *Standard Error* | *t Stat* | *P-value* | *Lower 95%* | *Upper 95%* |
| Intercept | –3103.76 | 30406.54 | -0.10 | 0.92 | –71888.13 | 65680.61 |
| X Variable 1 | 38.24 | 100.76 | 0.38 | 0.71 | –189.68 | 266.17 |
| X Variable 2 | 54.37 | 10.33 | 5.26 | 0.00 | 31.00 | 77.73 |

2.

|  |  |
| --- | --- |
| Economic  plausibility | A positive relationship between medical supplies costs and each of the independent variables (number of procedures and number of patient-hours) is economically plausible. |
| Goodness of fit | *r*2 = 84%, Adjusted *r*2 = 81%  Standard error of regression =$27,662  Excellent goodness of fit. |
| Significance of independent variables | The *t*-value of 0.38 for number of procedures is not significant at the 0.05 level. The *t*-value of 5.26 for number of patient-hours is significant at the 0.05 and 0.01 levels. |
| Specification analysis of estimation assumptions | Assuming linearity, constant variance, and normality of residuals, the Durbin-Watson statistic of 1.96 suggests the residuals are independent. However, we must be cautious when drawing inferences from only 12 observations. |

3. Multicollinearity is an issue that can arise with multiple regression but not simple regression analysis. Multicollinearity means that the independent variables are highly correlated.

The correlation feature in Excel’s Data Analysis reveals a coefficient of correlation of 0.61 between number of procedures and number of patient-hours. This is close to the threshold of 0.70 that is usually taken as a sign of multicollinearity problems. As evidence, note the substantial drop in the *t*-value for patient-hours from 7.25 to 5.26, despite a fairly small change in the estimated coefficient (from $56.76 to $54.37).

4. The simple regression model using the number of patient-hours as the independent variable achieves a comparable *r*2 to the multiple regression model. However, the multiple regression model includes an insignificant independent variable, number of procedures. Adding this variable does not improve Apollo Hospital’s ability to better estimate medical supplies costs, and it also introduces multicollinearity issues. Julie should use the simple regression model with number of patient-hours as the independent variable to estimate medical supplies costs.

**10-39** (30 min.) **Cost estimation.**

1. Here is the summary output for the monthly regression of Direct Labor Hours on Output Units for Hankuk Electronics:

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| SUMMARY OUTPUT | |  |  |  |  |  |
|  |  |  |  |  |  |  |
| *Regression Statistics* | |  |  |  |  |  |
| Multiple R | 0.2333602 |  |  |  |  |  |
| R Square | 0.054457 |  |  |  |  |  |
| Adjusted R Square | –0.0400973 |  |  |  |  |  |
| Standard Error | 206.18345 |  |  |  |  |  |
| Observations | 12 |  |  |  |  |  |
|  |  |  |  |  |  |  |
| ANOVA |  |  |  |  |  |  |
|  | *df* | *SS* | *MS* | *F* | *Significance F* |  |
| Regression | 1 | 24483.86 | 24483.86 | 0.575933 | 0.465422344 |  |
| Residual | 10 | 425116.1 | 42511.61 |  |  |  |
| Total | 11 | 449600 |  |  |  |  |
|  |  |  |  |  |  |  |
|  | *Coefficients* | *Standard Error* | *t Stat* | *P-value* | *Lower 95%* | *Upper 95%* |
| Intercept | 345.24 | 589.07 | 0.59 | 0.57 | –967.29 | 1657.77 |
| X Variable 1 | 0.71 | 0.93 | 0.76 | 0.47 | –1.37 | 2.79 |

2. The plot and regression line for monthly direct labor hours on monthly output for Hankuk Electronics are given below:

|  |  |
| --- | --- |
| Economic  plausibility | A positive relationship between direct labor hours and monthly output is economically plausible because increased levels of production should lead to the consumption of greater amounts of direct labor. |
|  |  |
| Goodness of fit | *r*2 = 5.45%, Adjusted *r*2 = - 4%  Standard error of regression = 206.18  Terrible fit; in fact, there is no evidence of a linear relationship between the dependent and independent variables. At least one data point represents a significant outlier. |
|  |  |
| Significance of independent  variables | The *t*-value of 0.76 for output units is not significant at the 0.05 level. |
|  |  |

3. Given Inbee’s expectation that Hankuk will produce 650 units in January 2014, her best estimate given the linear regression above is that Hankuk will use:

345.24 + (0.71 × 650 units) = 806.74 direct labor hours.

At an estimated variable cost of $17.50 per direct labor-hour, this implies that Inbee should budget

806.74 × $17.50 = $14,118

for direct labor costs for January 2014.

Note that 650 units is in the range of output values that were used to find the regression equation and therefore falls in the range of predictability for this model. However, there is substantial uncertainty around the cost estimate of $14,118. In particular, this predicted value relies on the regression point estimate of 0.71 for the marginal impact of output on labor hours. But, the 95 percent confidence interval for the slope of the regression ranges all the way from –1.37 to 2.79, and the predicted cost would vary accordingly. One cannot reject the null hypothesis that output levels have no impact on labor consumption, leaving the budgeted cost estimate a highly speculative one!**10-40** (30 min.) **Cost estimation, learning curves (continuation of 10-39).**

1. Here is the summary output for the monthly regression of the natural log of Cumulative Average Direct Labor-Hours per Unit on the natural logarithm of Cumulative Output:

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| SUMMARY OUTPUT | |  |  |  |  |  |
|  |  |  |  |  |  |  |
| *Regression Statistics* | |  |  |  |  |  |
| Multiple R | 0.9989528 |  |  |  |  |  |
| R Square | 0.9979068 |  |  |  |  |  |
| Adjusted R Square | 0.9976975 |  |  |  |  |  |
| Standard Error | 0.0074326 |  |  |  |  |  |
| Observations | 12 |  |  |  |  |  |
|  |  |  |  |  |  |  |
| ANOVA |  |  |  |  |  |  |
|  | *df* | *SS* | *MS* | *F* | *Significance F* |  |
| Regression | 1 | 0.263368 | 0.263368 | 4767.34 | 9.89803E-15 |  |
| Residual | 10 | 0.000552 | 5.52E-05 |  |  |  |
| Total | 11 | 0.26392 |  |  |  |  |
|  |  |  |  |  |  |  |
|  | *Coefficients* | *Standard Error* | *t Stat* | *P-value* | *Lower 95%* | *Upper 95%* |
| Intercept | 2.09 | 0.02 | 85.44 | 0.00 | 2.03 | 2.14 |
| X Variable 1 | –0.21 | 0.00 | –69.05 | 0.00 | –0.21 | –0.20 |

2. The plot of the data and the regression line estimated above are provided next.

|  |  |
| --- | --- |
| Economic  plausibility | A negative relationship between cumulative average direct-labor hours per unit and cumulative output (in natural logarithms) is economically plausible and reflects the presence of learning effects. Specifically, as the firm gains experience from production, it becomes more efficient and is able to use fewer direct labor hours to make each unit of product. |
|  |  |
| Goodness of fit | *r*2 = 99.8%, Adjusted *r*2 = 99.8%  Standard error of regression = 0.007  Unparalleled goodness of fit. Virtually perfect linear fit in logarithms. |
|  |  |
| Significance of independent  variables | The *t*-value of –69.05 for the logarithm of cumulative output is significant at all conventional levels. The *t*-value for the intercept (85.44) is highly significant as well. |
|  |  |
|  |  |

3. The original learning curve specification, *y = axb* is mathematically identical to the following log-linear specification:

Ln *y =* Ln *a* + *b* × Ln *x*

The regression equation we have estimated,

Ln (Cumulative avg DLH per unit) = *a* + (*b* × Ln (Cumulative Output))

is precisely the above specification, and in particular, the slope coefficient directly yields the “*b*” from the learning curve equation. We know, therefore, that for Hankuk electronics, *b* = –0.208. As explained in Exhibit 10-10, this value is related to the learning curve percentage as follows:

*b* = Ln(learning-curve % in decimal form)/Ln 2, or

–0.208 = Ln(learning-curve % in decimal form)/0.693, or

Ln(learning-curve % in decimal form) = –0.208 × 0.693 = –0.144.

As the exponent of –0.144 is 0.8659, this implies that Hankuk is experiencing an 86.6 percent cumulative average-time learning curve.

4. With an additional 650 units in January 2014, Hankuk’s cumulative output will go from 7,527 at the end of December 2013 to 8,177 (7,527 + 650). As Ln (8,177) = 9.0091, the cumulative average direct-labor hours in logarithmic terms are given by:

2.0876 – 0.2079 × 9.0091 = 0.2146.

The cumulative direct-labor hours per unit therefore equals Exp(0.2146) = 1.2394. This implies a total direct labor hours of 1.2394 × 8,177 = 10,134 by the end of January. As Hankuk has used a total of 9,480 direct labor hours at the end of December 2013, the incremental hours needed in January therefore are 654 (10,134 – 9,480). At $17.50 per labor hour, this suggest that Inbee should budget

654 × $17.50 = $11,445

for direct labor costs for January 2014.

Although 9.0091 is outside the range of cumulative output values (measured in logarithms) used to find the regression equation, unless there has been a structural break in the experience curve Hankuk is facing, it is highly likely that its January costs will be in the neighborhood of $11,445. The reason is that the estimated regression line is close to perfect and has a standard error close to zero. There is virtually no uncertainty around the coefficient estimates. The slope coefficient, for example, has a point estimate of –0.2079, and a narrow 95 percent confidence interval between –0.2146 and –0.2012. Using either of those estimates would make barely any difference to the predicted cost for the month of January 2014.

**10-41**  (25 min.) **Interpreting regression results, matching time periods.**

1. Here is the summary output for the monthly regression of Sales Revenue on Online Advertising Expense:

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| SUMMARY OUTPUT | |  |  |  |  |  |
|  |  |  |  |  |  |  |
| *Regression Statistics* | |  |  |  |  |  |
| Multiple R | 0.15 |  |  |  |  |  |
| R Square | 0.02 |  |  |  |  |  |
| Adjusted R Square | –0.07 |  |  |  |  |  |
| Standard Error | 11837.30 |  |  |  |  |  |
| Observations | 12.00 |  |  |  |  |  |
|  |  |  |  |  |  |  |
| ANOVA |  |  |  |  |  |  |
|  | *df* | *SS* | *MS* | *F* | *Significance F* |  |
| Regression | 1 | 33972689.79 | 33972690 | 0.242451 | 0.633072 |  |
| Residual | 10 | 1401216525 | 1.4E+08 |  |  |  |
| Total | 11 | 1435189215 |  |  |  |  |
|  |  |  |  |  |  |  |
|  | *Coefficients* | *Standard Error* | *t Stat* | *P-value* | *Lower 95%* | *Upper 95%* |
| Intercept | 51999.64 | 7988.68 | 6.51 | 0.00 | 34199.74 | 69799.54 |
| X Variable 1 | –0.98 | 1.99 | –0.49 | 0.63 | –5.41 | 3.45 |

2. SOLUTION EXHIBIT 10-41A presents the data plot for the initial analysis. The formula of Sales Revenue = $52,000 – (0.98 × Online advertising expense) indicates that there is a fixed amount of revenue each month of $52,000, which is reduced by 0.98 times that month’s online advertising expense. This relationship is not economically plausible, as advertising would not reduce revenue. The data points do not appear linear, and the *r*-square of 0.02 indicates a very weak goodness of fit (in fact, almost no fit at all).

**SOLUTION** **EXHIBIT 10-41 A**

Plot and Regression Line for Sales Revenue and Online Advertising Expense

3. Here is the summary output for the regression of monthly Sales Revenue on the prior month’s Online Advertising Expense:

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| SUMMARY OUTPUT | |  |  |  |  |  |
|  |  |  |  |  |  |  |
| *Regression Statistics* | |  |  |  |  |  |
| Multiple R | 0.808588 |  |  |  |  |  |
| R Square | 0.653815 |  |  |  |  |  |
| Adjusted R Square | 0.61535 |  |  |  |  |  |
| Standard Error | 7393.922 |  |  |  |  |  |
| Observations | 11 |  |  |  |  |  |
|  |  |  |  |  |  |  |
| ANOVA |  |  |  |  |  |  |
|  | *df* | *SS* | *MS* | *F* | *Significance F* |  |
| Regression | 1 | 9.29E+08 | 929262059 | 16.99763 | 0.002587 |  |
| Residual | 9 | 4.92E+08 | 54670085 |  |  |  |
| Total | 10 | 1.42E+09 |  |  |  |  |
|  |  |  |  |  |  |  |
|  | *Coefficients* | *Standard Error* | *t Stat* | *P-value* | *Lower 95%* | *Upper 95%* |
| Intercept | 28361.37 | 5428.687 | 5.2243522 | 0.000546 | 16080.83 | 40641.91 |
| X Variable 1 | 5.381665 | 1.305336 | 4.1228186 | 0.002587 | 2.428789 | 8.33454 |

3. SOLUTION EXHIBIT 10-41 B presents the data plot for the revised analysis. The formula of Sales Revenue = $28,361 + (5.38 × Online Advertising Expense) indicates that there is a fixed amount of revenue each month of $28,361, which increases by 5.38 times the prior month’s advertising expense in the online channel. This relationship is economically plausible. One would expect a positive correlation between advertising expense and (future) sales revenue. The slope coefficient of 5.38 has a *t* stat of 4.12 indicating that it is statistically significant at the 5 percent level. In the revised analysis, there is improved linearity in the data points, and the *r*-square of 0.65 indicates a much stronger goodness of fit.

**SOLUTION** **EXHIBIT 10-41B**

Plot and Regression Line for Sales Revenue and Previous Month Online Advertising

4. Nandita must be very careful about making conclusions regarding cause and effect. Even a strong goodness of fit does not prove a cause and effect relationship. The independent and dependent variables could both be caused by a third factor, or the correlation could be simply coincidental. However, there is enough of a correlation in the revised analysis for Nandita to make a meaningful presentation to the store’s owner.

**10-42** (40–50 min.) **Purchasing Department cost drivers, activity-based costing, simple regression analysis.**

The problem reports the exact *t*-values from the computer runs of the data. Because the coefficients and standard errors given in the problem are rounded to three decimal places, dividing the coefficient by the standard error may yield slightly different *t*-values.

1. Plots of the data used in Regressions 1 to 3 are in Solution Exhibit 10-42A.See Solution Exhibit 10-42B for a comparison of the three regression models.

2. Both Regressions 2 and 3 are well-specified regression models. The slope coefficients on their respective independent variables are significantly different from zero. These results support the Couture Fabrics’ presentation in which the number of purchase orders and the number of suppliers were reported to be drivers of purchasing department costs.

In designing an activity-based cost system, Designer Wear should use number of purchase orders and number of suppliers as cost drivers of purchasing department costs. As the chapter appendix describes, Designer Wear can either (a) estimate a multiple regression equation for purchasing department costs with number of purchase orders and number of suppliers as cost drivers, or (b) divide purchasing department costs into two separate cost pools, one for costs related to purchase orders and another for costs related to suppliers, and estimate a separate relationship for each cost pool.

3. Guidelines presented in the chapter could be used to gain additional evidence on cost drivers of purchasing department costs.

1. Use physical relationships or engineering relationships to establish cause-and-effect links. Lee could observe the purchasing department operations to gain insight into how costs are driven.

2. Use knowledge of operations. Lee could interview operating personnel in the purchasing department to obtain their insight on cost drivers.

Solution Exhibit 10-42A

Regression Lines of Various Cost Drivers for Purchasing Dept. Costs for Designer Wear

**Solution Exhibit 10-42B**

Comparison of Alternative Cost Functions for Purchasing Department

Costs Estimated with Simple Regression for Designer Wear

| **Criterion** | **Regression 1**  **PDC = *a* + (*b* × MP$)** | **Regression 2**  **PDC = *a* + (*b* × # of POs)** | **Regression 3**  **PDC = *a* + (*b* × # of Ss)** |
| --- | --- | --- | --- |
| 1. Economic plausibility | Result presented at seminar by Couture Fabrics found little support for MP$ as a driver. Purchasing personnel at the Miami store believe MP$ is not a significant cost driver. | Economically plausible. The higher the number of purchase orders, the more tasks undertaken. | Economically plausible. Increasing the number of suppliers increases the costs of certifying vendors and managing the Designer Wear-supplier relationship. |
| 2. Goodness of fit | *r*2 = 0.08. Poor goodness of fit. | *r*2 = 0.42. Reasonable goodness of fit. | *r*2 = 0.40. Reasonable goodness of fit. |
| 3. Significance of independent variables | *t*-value on MP$ of 0.83 is insignificant. | *t*-value on # of POs of 2.40 is significant. | *t*-value on # of Ss of 2.32 is significant. |
| 4. Specification analysis  A. Linearity within the relevant range | Appears questionable but no strong evidence against linearity. | Appears reasonable. | Appears reasonable. |
| B. Constant variance of residuals | Appears questionable, but no strong evidence against constant variance. | Appears reasonable. | Appears reasonable. |
| C. Independence of residuals | Durbin-Watson  Statistic = 2.42.  Assumption of independence is not rejected. | Durbin-Watson  Statistic = 1.99.  Assumption of independence is not rejected. | Durbin-Watson  Statistic = 2.00.  Assumption of independence is not rejected. |
| D. Normality of residuals | Database too small to make reliable inferences. | Database too small to make reliable inferences. | Database too small to make reliable inferences. |

**10-43** (30–40 min.) **Purchasing Department cost drivers, multiple regression analysis (continuation of 10-42).**

The problem reports the exact *t*-values from the computer runs of the data. Because the coefficients and standard errors given in the problem are rounded to three decimal places, dividing the coefficient by the standard error may yield slightly different *t*-values.

1. Regression 4 is a well-specified regression model:

*Economic plausibility:* Both independent variables are plausible and are supported by the findings of the Couture Fabrics study.

*Goodness of fit:* The *r2* of 0.63 indicates an excellent goodness of fit.

*Significance of independent variables:* The *t-*value on # of POs is 2.09 while the *t*-value on # of Ss is 2.02. These *t*-values are either significant or border on significance.

*Specification analysis:* Results are available to examine the independence of residuals assumption. The Durbin-Watson statistic of 1.91 indicates that the assumption of independence is not rejected.

Regression 4 is consistent with the findings in Problem 10-42 that both the number of purchase orders and the number of suppliers are drivers of purchasing department costs. Regressions 2, 3, and 4 all satisfy the four criteria outlined in the text. Regression 4 has the best goodness of fit (0.63 for Regression 4 compared to 0.42 and 0.40 for Regressions 2 and 3, respectively). Most importantly, it is economically plausible that both the number of purchase orders and the number of suppliers drive purchasing department costs. We would recommend that Lee use Regression 4 over Regressions 2 and 3.

2. Regression 5 adds an additional independent variable (MP$) to the two independent variables in Regression 4. This additional variable (MP$) has a *t-*value of –0.11, implying its slope coefficient is insignificantly different from zero. The *r2* in Regression 5 (0.63) is the same as that in Regression 4 (0.63), implying the addition of this third independent variable adds close to zero explanatory power. In summary, Regression 5 adds very little to Regression 4. We would recommend that Lee use Regression 4 over Regression 5.

3. Budgeted purchasing department costs for the Baltimore store next year are

$481,186 + ($121.37 × 4,200) + ($2,941 × 120) = $1,343,860

4. Multicollinearity is a frequently encountered problem in cost accounting; it does not arise in simple regression because there is only one independent variable in a simple regression. One consequence of multicollinearity is an increase in the standard errors of the coefficients of the individual variables. This frequently shows up in reduced *t-*values for the independent variables in the multiple regression relative to their *t*-values in the simple regression:

|  |  |  |
| --- | --- | --- |
| **Variables** | ***t*-value in**  **Multiple Regression** | ***t-*value from**  **Simple Regressions**  **in Problem 10-42** |
| *Regression 4:*  # of POs  # of Ss | 2.09  2.02 | 2.40  2.32 |
| *Regression 5:*  # of POs  # of Ss  MP$ | 1.92  1.82  -0.11 | 2.40  2.32  0.83 |

The decline in the *t*-values in the multiple regressions is consistent with some (but not very high) collinearity among the independent variables. Pairwise correlations between the independent variables are:

**Correlation**

# of POs and # of Ss 0.30

# of POs and MP$ 0.27

# of Ss and MP$ 0.28

There is no evidence of difficulties due to multicollinearity in Regressions 4 and 5.

5. Decisions in which the regression results in Problems 10-42 and 10-43 could be useful are as follows:

*Cost management decisions:* Designer Wear could restructure relationships with the suppliers so that fewer separate purchase orders are made. Alternatively, it may aggressively reduce the number of existing suppliers.

*Purchasing policy decisions:* Designer Wear could set up an internal charge system for individual retail departments within each store. Separate charges to each department could be made for each purchase order and each new supplier added to the existing ones. These internal charges would signal to each department ways in which their own decisions affect the total costs of Designer Wear.

*Accounting system design decisions:* Designer Wear may want to discontinue allocating purchasing department costs on the basis of the dollar value of merchandise purchased. Allocation bases better capturing cause-and-effect relations at Designer Wear are the number of purchase orders and the number of suppliers.