TOTAL COST ESTIMATE METHODS AND EXCEL STATISTICAL ANALYSIS

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ABSTRACT

The purpose of this paper is to compare cost estimates derived from the 'high-low' method against cost estimates derived from conventional regression analysis. These methods were applied to a common set of data (that contained some variation in monthly fixed costs) to determine which method would produce the more accurate results. Excel was used to compare the results. Tables and figures are available from the author.

Keywords: 'High-Low' Method, Regression Analysis, Cost Estimation.

INTRODUCTION

In Cost Accounting, there are various methods for estimating overall costs of an activity. The goal of such analysis is to separate fixed and variable costs and then, given a volume of an activity, estimate the amount of each cost. In most cases, the total costs cannot be precisely calculated given a specific level of activity. Therefore, the best any cost accounting system can hope to accomplish is developing a method that will produce the most accurate estimate possible. One such method is called the 'high-low' cost estimation method. It is called 'high-low' because the estimate is based on the difference in costs between the highest and lowest levels of activity realized throughout the year. A more accurate method is the use of statistical regression analysis. This study seeks to examine the difference in accuracy between 'high-low' and regression analysis as well as explain how statistical analysis can be carried out and performed in Excel. Excel has many built-in features that are underutilized or not utilized at all. Statistical analysis is one of them.

Activities can be defined as anything that can be related to costs incurred. For example, a company that specializes in manufacturing products, may measure activity in terms of machine hours incurred. A restaurant may measure activity in terms of labor hours worked by its employees. Provided that a cost varies with changes in levels of activity a relationship between activity and costs can be assumed to exist. In many cases the impact that activity level changes have on total costs isn't a precise relationship. However, it is vital that businesses understand the relationship between their activity level and total costs incurred because it provides the information needed to set prices charged to customers. If costs are calculated incorrectly, it could result in either overcharging or undercharging the customer. Neither scenario is optimal. Undercharging a customer could lead to a net loss and the demise of a business. Overcharging the customer could lead to lost business (due to non-competitive prices) and a surplus of unsold inventory and ultimately the demise of a business. Therefore, cost estimation is vital to a company's survival.

Total costs are comprised of two key elements: fixed costs and variable costs. Fixed costs are those costs that do not change in direct proportion to changes in activity level. In many businesses, these activities take place regardless if any activity takes place at all. Fixed costs are comprised of costs that cannot be changed. For example, a warehouse company may use units processed as a measure of activity level. The fixed costs in that scenario could include the amount of rent and insurance being paid on the warehouse facility. If zero units are processed, it would not change the amount of fixed costs incurred. Some fixed costs are completely fixed and not subject to change, but there are some fixed costs that may be subject to slight variation per month, such as insurance rates. For example, suppose vehicle insurance expense for a company is $1,000 per month. This cost would remain unchanged throughout the year provided none of the company's vehicles are involved in an accident. If an accident does occur, it would lead to an increase in the monthly insurance rate.

Variable costs do change in direct proportion to changes in activity level. If no activity took place, there would be no variable costs. Variable costs are comprised of costs that can be changed in total. Using the warehouse company example, variable costs could include hourly wages of employees and maintenance hours required to keep lifting equipment in working order. Starting with the first unit processed, variable costs will be incurred and will increase in direct proportion to the number of units (i.e. level of activity) processed.

Cost accounting activities that take place in actual businesses are typically more complex than simply identifying what constitutes variable and fixed costs. There are also other factors involved that cannot be readily identified. For example, if a company delivers products, the cost of gasoline would have an impact on the amount of total costs incurred. The amount of gasoline used would be a variable cost. In most cases the more miles driven by delivery trucks, the higher the cost of gasoline. However, since gasoline prices change on a regular basis, it can have a non-linear impact on total gasoline costs for a month. For example, due to a decrease in gasoline prices, a company may have a lower gasoline cost for that month despite driving more miles. In addition, the lower gasoline cost could lead the company to driving more miles than normal to take advantage of the lower price.

If total costs are calculated monthly, small changes in variable, and even fixed costs could create a situation where two months have the same level of activity but different total costs. Cost accounting relies heavily of cost estimates and expected levels of activity. Even if the expected level of activity for a year is attained, there will always be a difference between actual and expected costs. For a complex business, it would be virtually impossible to predict actual costs exactly. Such accuracy is unrealistic and isn't expected. Sometimes actual costs will be greater than expected costs at a given activity level and in other situations expected costs will be greater than actual costs at a given activity level. The goal is to estimate total costs as accurately as possible and minimize the difference between expected costs and actual costs.

DATA

This study uses numbers provided in an example by RTS Financial (2017).

Cost Behavior in a Trucking Company:

According to RTS Financial (2017) it is imperative that trucking companies know the cost per mile of operating their trucks. If that number is calculated incorrectly, it can easily lead to a company's failure due to the highly competitive nature of the market. RTS Financial (2017) describes the nature of fixed and variable costs in a trucking company (Chuck's Trucks). The following tables are taken directly from RTS' analysis (the only difference is that driver salaries are included as part of fixed costs as opposed to being treated as a separate category):

The first step in cost estimation is identifying all the costs (Tables 1). The next step is estimating those costs and the final step is estimating total costs anticipated at different levels of activity. In this case, the costs are only for the month of August. Total variable costs in that month were $3,665 and total fixed costs were $7,320. The total cost of $10,985 was associated with an activity level of 10,000 miles. These numbers will be used to calculate a cost scenario which covers one year (with August being used as January's numbers).

Table 1 – Costs per Month by Category

Chuck's Trucks Variable Costs for August		
	Monthly Cost	Per-Mile Cost
Fuel	$1,700	$0.17
Tires	$300	$0.03
Regular Maintenance	$450	$0.05
Repairs	$560	$0.06
Lodging/Meals	$380	$0.04
Taxes	$275	$0.03
Total Variable Costs	$3,665	$0.37

Chuck's Trucks Fixed Costs for August		
	Monthly Cost	Per-Mile Cost
Truck Payment	$1,200	$0.12
Collision/Comp Insurance	$600	$0.06
Office Lease	$1,000	$0.10
Health Insurance	$420	$0.04
Permits	$350	$0.04
Driver Salaries	$3,750	$0.38
Total Fixed Costs	$7,320	$0.73

To translate these numbers into a series of monthly costs, the following steps were taken: First, each variable cost category was assigned a range of variation. For example, fuel may vary +20% or -20% from the previous month. The feature for generating a random number between +20% and minus 20% was used in Excel (@randbetween). Each variation range was applied to each category (Table 2).

Table 2 – Monthly Variation Rates per Cost Category

Variable Costs	Variation Range
Fuel	20%
Tires	25%
Regular Maintenance	30%
Repairs	35%
Lodging/Meals	20%
Taxes	5%

Fixed Costs	Variation Range
Truck Payment	N/A
Collision/Comp Insurance	N/A
Office Lease	N/A
Health Insurance	10%
Permits	10%
Driver Salaries	10%

The same step was taken with fixed costs with the only difference being that three fixed cost variables were assigned a +/- 10% rate of variation. Using these rates of variation, monthly fixed costs were randomly generated. Most fixed costs do not change, but in this example, it's reasonable to assume some tiny variation in fixed costs occur (Table 2). The total costs for each month were calculated using the variation rates given above. (Note: January reflects the amounts in the example for August without any changes applied).

Table 3 – Variable Costs per Month

Monthly Cost	Fuel	Tires	Regular Maintenance	Repairs	Lodging/Meals	Taxes	Total Variable Costs
January	$1,700	$300	$450	$560	$380	$275	$3,665
February	$1,638	$271	$481	$716	$349	$269	$3,724
March	$1,872	$375	$410	$747	$311	$273	$3,988
April	$1,542	$275	$538	$901	$330	$278	$3,864
May	$2,101	$349	$467	$800	$260	$266	$4,243
June	$1,759	$237	$555	$744	$348	$281	$3,924
July	$2,304	$273	$441	$921	$270	$260	$4,469
August	$2,106	$263	$486	$587	$303	$282	$4,027
September	$2,409	$334	$363	$1,168	$224	$262	$4,760
October	$2,248	$299	$491	$589	$325	$280	$4,232
November	$2,649	$367	$471	$792	$221	$268	$4,768
December	$1,998	$372	$412	$646	$349	$273	$4,050

Table 4 – Fixed Costs per Month

Monthly Cost	Truck Payment	Collision/Comp Insurance	Office Lease	Health Insurance	Permits	Driver Salaries	Total Fixed Costs
January	$1,200	$600	$1,000	$420	$350	$3,750	$7,320
February	$1,200	$600	$1,000	$419	$338	$3,713	$7,270
March	$1,200	$600	$1,000	$424	$348	$3,438	$7,010
April	$1,200	$600	$1,000	$432	$371	$3,786	$7,389
May	$1,200	$600	$1,000	$412	$355	$3,493	$7,060
June	$1,200	$600	$1,000	$429	$356	$3,588	$7,173
July	$1,200	$600	$1,000	$418	$341	$3,657	$7,216
August	$1,200	$600	$1,000	$400	$337	$4,039	$7,576
September	$1,200	$600	$1,000	$405	$326	$3,816	$7,347
October	$1,200	$600	$1,000	$418	$341	$3,938	$7,497
November	$1,200	$600	$1,000	$413	$373	$3,918	$7,504
December	$1,200	$600	$1,000	$411	$340	$3,966	$7,517

As can be seen in Tables 3 and 4, by applying various random fluctuations to the costs, each month resulted in unique total variable and fixed costs. Most of the costs incurred by Chucks Trucks are variable costs. This example poses a natural obstacle to the high-low method in terms of providing accuracy. The high-low method determines a variable rate to apply to activity levels. However, in this example, the average variable costs per month are $4,143 with a standard deviation of $366 while fixed costs average $7,323 with a standard deviation of $184. The high-low method determines a set fixed cost per month, but in this example fixed costs vary slightly per month.

The next step was to adjust the amount of variable costs per month (which includes different levels of cost variation per category) into an amount that would reflect total mileage. To calculate total mileage per month, random mileage

was calculated for each month by applying a different range (i.e. ceiling and floor). This resulted in a pattern of miles driven that followed an activity pattern in which the months with the highest miles would be at the beginning and end of each year. Those mileage amounts are in the table below:

Table 5 - Randomly Generated Mileage Amounts Per Month

Month	Floor	Activity in Miles	Ceiling
January		10,000	
February	10,000	14,059	15,500
March	9,750	12,980	14,500
April	10,000	11,417	13,000
May	9,250	9,903	11,500
June	8,250	9,563	10,000
July	7,500	9,214	10,500
August	8,000	8,402	10,250
September	9,000	10,198	10,750
October	9,500	10,381	14,500
November	9,750	11,451	15,500
December	10,000	12,207	16,000

The amounts in Tables 4 & 5 were then applied to the monthly costs calculated using randomly generated numbers. These monthly costs were then converted into a final total cost per month by dividing the variable costs per month by 10,000 miles. This converted total variable costs into a rate per 10,000 miles. These rates were then multiplied by total mileage per month to arrive at a variable cost which was directly related to mileage activity. This adjusted variable cost was then added to the fixed costs for that month to arrive at a total cost for the month (Table 6).

Table 6 – Adjusted Actual Cost per Month Adjusted for Mileage Activity

	Variable Cost	Fixed Cost	Total Cost	10,000 Miles	Activity in Miles	Total Adj Cost
January	$3,665	$7,320	$10,985	$0.37	10,000	$10,985
February	$3,724	$7,270	$10,994	$0.37	14,059	$12,506
March	$3,988	$7,010	$10,998	$0.40	12,980	$12,186
April	$3,864	$7,389	$11,253	$0.39	11,417	$11,801
May	$4,243	$7,060	$11,303	$0.42	9,903	$11,262
June	$3,924	$7,173	$11,097	$0.39	9,563	$10,926
July	$4,469	$7,216	$11,685	$0.45	9,214	$11,334
August	$4,027	$7,576	$11,603	$0.40	8,402	$10,959
September	$4,760	$7,347	$12,107	$0.48	10,198	$12,201
October	$4,232	$7,497	$11,729	$0.42	10,381	$11,890
November	$4,768	$7,504	$12,272	$0.48	11,451	$12,964
December	$4,050	$7,517	$11,567	$0.41	12,207	$12,461

RESULTS

Now that a set of data was developed containing sufficient random cost behavior, the first step is to calculate a variable rate and fixed cost using the high-low method:

$$\text{High-Low Method} = \frac{\text{Cost at Highest Activity Level - Cost at Lowest Activity Level}}{\text{Highest Activity Level - Lowest Activity Level}} \quad \frac{\$12,506 - \$10,959}{14,059 - 8,402} = \$0.27$$

The month with the highest activity is February. The month with the lowest activity is August. Using the $.27 variable rate, the variable costs for February (14,059 x $.27) are $3,845 and the variable costs for August (8,402 x $.27) are $2,298. Using these amounts, fixed cost is $8,661. For February: $12,506 total cost - $3,845 variable costs = $8,661 fixed cost. For August: $10,959 total cost - $2,298 variable costs = $8,661 fixed cost.

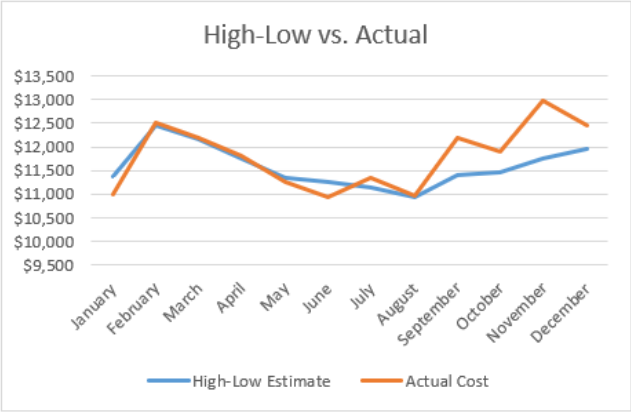
The fixed cost amount produced by the high-low method is $8,661. This is significantly different than $7,323 actual average fixed cost amount per month. If the high-low method is applied to each month, it produces the following results (Table 7):

Table 7 – High-Low Method Results

Month	Randomly Generated Activity in Miles	x High-Low Method Variable Rate .27	High-Low Method Fixed Rate $8,661	Estimated Total Cost	Actual Total Cost	Difference
January	10,000	$2,700	$8,661	$11,361	$10,985	$376
February	14,059	$3,796	$8,661	$12,457	$12,506	$49
March	12,980	$3,505	$8,661	$12,166	$12,186	$21
April	11,417	$3,083	$8,661	$11,744	$11,801	$57
May	9,903	$2,674	$8,661	$11,335	$11,262	$73
June	9,563	$2,582	$8,661	$11,243	$10,926	$317
July	9,214	$2,488	$8,661	$11,149	$11,334	$185
August	8,402	$2,269	$8,661	$10,930	$10,959	$30
September	10,198	$2,753	$8,661	$11,414	$12,201	$787
October	10,381	$2,803	$8,661	$11,464	$11,890	$426
November	11,451	$3,092	$8,661	$11,753	$12,964	$1,211
December	12,207	$3,296	$8,661	$11,957	$12,461	$504

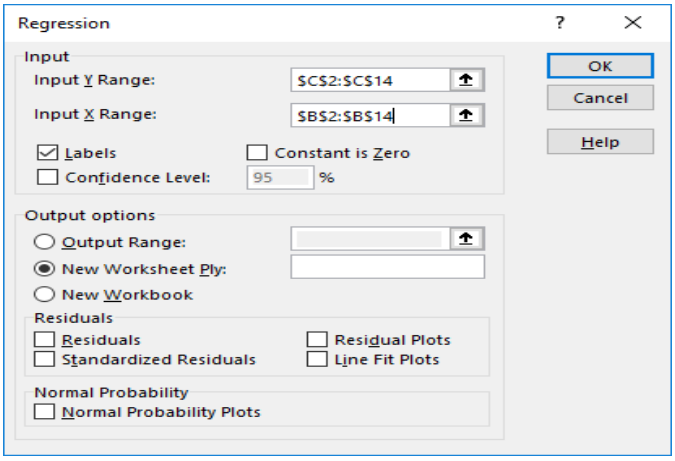
The total amount estimated by the high-low method was $2,503 less than the actual total amount. On average, the high-low method produced an amount that was $209 less than actual. The standard deviation was $456. This is represented in Exhibit 1.

Exhibit 1 – Line Graph of High-Low vs. Actual



The next step is using Regression analysis in Excel. This function can be found under Data -> Data Analysis.

Exhibit 2 – Choosing Independent and Dependent Variables for Regression Analysis



The independent variable in this analysis is Activity per Miles (y range). The dependent variable is Total Cost (x range). Exhibit 2 shows how these variables are specified.

Table 8 – Excel Regression Output

SUMMARY OUTPUT								
Regression Statistics								
Multiple R	0.759801169							
R Square	0.577297817							
Adjusted R Square	0.535027598							
Standard Error	471.0203842							
Observations	12							
ANOVA								
	df	*SS*	*MS*	*F*	*Significance F*			
Regression	1	3030015.352	3030015.352	13.65731808	0.004138556			
Residual	10	2218602.024	221860.2024					
Total	11	5248617.375						
	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*	*Lower 95.0%*	*Upper 95.0%*
Intercept	8348.77616	940.9198778	8.872993713	4.70125E-06	6252.276024	10445.2763	6252.276024	10445.2763
Activity in Miles	0.318158009	0.086091475	3.695580885	0.004138556	0.126334249	0.509981769	0.126334249	0.509981769

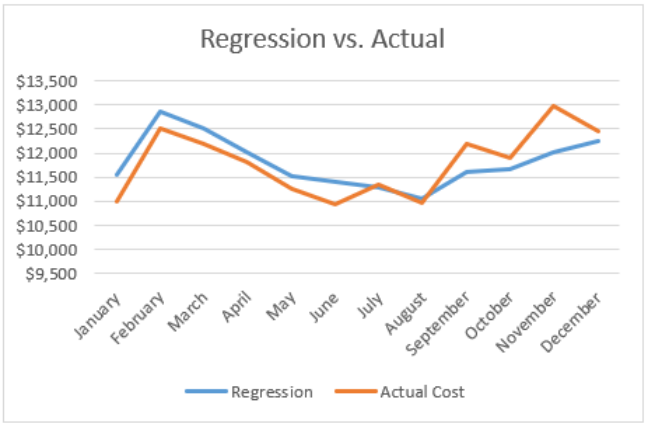
Per Table 8, the output didn't produce a very high Multiple R (Correlation Coefficient) and the low R Square indicates that activity doesn't explain the proportional changes to total costs very well. Regression analysis produces the following equation to predict expenses based on miles: = .32 Miles + $8,349 = Total Cost

Table 9 – Regression Analysis Results

Month	Activity in Miles	Miles x Regression Equation	Actual Cost	Difference
January	10,000	$11,549	$10,985	$564
February	14,059	$12,848	$12,506	$342
March	12,980	$12,503	$12,186	$316
April	11,417	$12,002	$11,801	$202
May	9,903	$11,518	$11,262	$256
June	9,563	$11,409	$10,926	$484
July	9,214	$11,297	$11,334	$36
August	8,402	$11,038	$10,959	$78
September	10,198	$11,612	$12,201	$589
October	10,381	$11,671	$11,890	$219
November	11,451	$12,013	$12,964	$951
December	12,207	$12,255	$12,461	$206

The total amount estimated by regression analysis was $242 more than the actual total amount. On average, regression analysis produced an amount that was $20 more than actual. The standard deviation was $449. This is represented in Exhibit 3.

Exhibit 3 – Line Graph of Regression vs. Actual



CONCLUSIONS

Both methods produced results that were close to actual. Unfortunately, neither method was able to accurately capture the total amount of fixed costs. Average fixed cost was $7,323. The high-low method resulted in a fixed cost of $8,661. Regression analysis produced a fixed cost of $8,349. Therefore, regression was $312 closer in terms of fixed cost.

Overall, the total difference between the total amount predicted by regression analysis was only $242 more than the total actual costs. Monthly, it predicted costs that were on average, only $20 more than actual. The difference between the total costs predicted by high-low was $2,503 less than actual. On average, high-low produced monthly cost predictions that were $209 less than actual. The monthly standard deviation between high-low and regression predictions and actual costs were $456 and $449 respectively. Exhibit 5 shows that regression produced higher estimates than actual at the beginning of the year and lower estimates than actual at the end of the year. High-low produced results very close to actual at the beginning of the year, but its results diverged quite a bit at the end of the year. Overall, regression was the better method as it produced a much closer overall result ($242 total difference).

The 'high-low' method is popular due to its ease of use. However, in some situations where there is considerable cost variation, it may not be the best method to use. Regression makes up for some deficiencies created by the 'high-low' method but not all of them. In some cases, it may be best to use estimates based on individual monthly costs rather than develop generalized estimates for the entire year.

REFERENCE

RTS Financial (2017, July 31). *How to Calculate Cost per Mile for Your Trucking Company.* Retrieved from https://www.rtsfinancial.com/guides/trucking-calculations-formulas