**TO**: Production Manager

**FROM**: Team 4 (Sucharu Gupta, Yunie Le, Ryan Quigley)

**DATE**: December 14, 2015

**SUBJECT**: Cost Estimation and Analysis Models

**Executive Summary**

The cost estimation and cost analysis models provided in this report are highly accurate, and are useful for predicting the average cost of future orders and for analyzing where costs are being realized.

The cost estimation model predicts the average cost per block in a typical job to be $56.64. Using information provided by a potential customer at the time of the order, the sales representative can quickly and easily determine an accurate price to offer the customer.

The factors driving costs are the total number of blocks in a job, the cost of the materials, the number of direct labor hours, the block complexity and the manager on duty. In terms of cost minimization, the optimal order has a large number of blocks and low levels of complexity, material cost, and direct labor. Additionally, Devon should be the production manager on duty during the processing to ensure average cost per block is at its lowest.

Two observations were removed due to data entry errors: 19 and 311. Both exhibited unusually low total costs given how large the total number of blocks was for each order. Removing these points dramatically improved the predictive abilities of the models.

Some variables that were expected to be good predictors of average cost were not found to be significant, and thus were not included in either model. These variables should not be dismissed entirely. More complex, yet less intuitive, models may exist that can incorporate these variables in a meaningful way.

**1. Model Equations**:

*Cost Estimation Model*:

*Average Cost* = 33.49543 – 2.69482⋅ln(*Units*) + 5.55205⋅*Weight* + 1.84245⋅*Complexity*

*Cost Analysis Model*:

*Average Cost* = 24.03600 - 2.85736⋅ln(*Units*) + 1.05708⋅*Material Cost* + 11.14798⋅*Labor* + 1.07926⋅*Complexity* - 3.73533⋅*Devon*

**2. Model Terms**:

*Average Cost*:    average cost per finished block (dollars/block)

*Units*:    total number of blocks in the order

*Weight*:    weight of a finished block (kilograms)

*Complexity*:    combined number of stamping and chiseling operations required per block

*Material Cost*:    cost per block of the input materials (dollars/block). Calculated by adding the weight of a finished block in kilograms and the kilograms of material lost per block during production, then multiplying by the cost per kilogram of input material.

*Labor*:    number of direct labor hours used per block

*Devon*:    indicates whether or not Devon was the production manager on duty. If Devon was the manager on duty, the variable gets the value one; otherwise, the variable is zero.

**3. Prediction of a typical job** **using cost estimation**

Taking the median values of units, weight and complexity to be representative of a typical job, the cost estimation model predicts that the average cost per finished block to be $56.64. Furthermore, we are 95% confident that the average cost per finished block will be between $46.69 and $66.58. Additional predictions for low, medium, and high levels of each variable in the cost estimation model are included in section D. of the appendix.

**4. Model & Prediction Accuracy**

The cost analysis model accounts for about 80.9% of the variability in the original data. Additionally, we expect the model to explain about 80.4% of the variability in predicting new observations. For the cost estimation model, approximately 69.9% of the original data is accounted for by the model, and we expect it to explain about 69.4% of the variability in predicting new observations.

**5. Cost minimization**

Individually examining each term of the cost analysis model provides suggestions for minimizing costs. Perhaps the most interesting factor driving costs is which production manager is on duty. Jobs where Devon is on duty have significantly lower average costs compared to all other managers. Further evaluation of manager performance should be conducted in order to determine why average costs are significantly lower for Devon. If the other managers can replicate his results, average costs will be dramatically reduced for all jobs.

Additionally, high levels of direct labor, complexity, and material cost will lead to increased average cost, whereas jobs with a larger number of total blocks will have lower average cost. The decrease in average cost associated with increased units is more pronounced for lower levels of units. For example, increasing the total number of blocks in an order from 50 to 100 will decreases average cost by $1.98, but increasing the total number of blocks from 450 to 500 will only decrease average cost by $0.30. Because less complex jobs tend to require less direct labor, favoring jobs requiring fewer stamping and chiseling operations will have a significant impact on average cost. Finally, since the material cost is a composite of three variables, it can be minimized in the following ways: 1) all else equal, favor jobs for which the weight of a finished block is lowest 2) cut down on the amount of material lost during processing and 3) minimize the cost of the input material.

**6. Peculiar Observations**:

Careful analysis of the observations in the data set revealed that the information for jobs 19 and 311 was most likely entered incorrectly. Both jobs have average cost less than $10, which is extremely unusual considering how large the number of blocks is for each job: 499 and 674 respectively. All other jobs with more than 400 blocks in the order have an average cost per block of at least $34. After further investigation, we determined this inconsistency is due to the fact that the total cost for each order is alarmingly low: $3,362.97 and $3,706.08 respectively. As a result, we concluded that these values were entered incorrectly, and excluded these jobs when calculating our final models.

**7. Concerns**

We expected the allowable standard deviations in finished size, extra details, rush requests, and percentage of blocks needing rework to have noticeable influences on the average costs of the jobs; however, we were unable to conceive of any models where these variables were statistically significant. By not including these variables, we are not dismissing them entirely. We admit that a more complex model may exist that incorporates these variables in a meaningful way.

The models produced in this report are useful for predicting average cost per unit for future orders and for analyzing where costs are realized. That being said, users should exercise caution when using the models to make predictions for values of the variables outside the range of the original data provided. For example, it is likely that beyond a certain point average cost will increase as the number of blocks increases. This is not accounted for in either model and should be taken into consideration when using the models in such cases.

There are a number of additional observations that may be exerting disproportionate influence on the estimated coefficients of the models. These points were examined thoroughly, but they did not exhibit any blatant inconsistencies, as was the case with 19 and 311. As a result, they were not removed from the model. The points are listed in section E. of the appendix.