Subject: Decision Analysis – Task 3

MEMORANDUM

TO: Cynthia Crowninshield

FROM: Jon Horsman (operations consultant)

SUBJECT: Manufacturing Recommendations, Sales Volume Forecast, Control Chart Metrics

**A. Manufacturing Recommendations:**

Our objective is to create a process strategy that will meet Shuzworld's requirements and product specifications within costs & constraints. Since Shuzworld is Repetitive Process with a slight move towards a higher volume, we will be concentrating on the lower cost with a high capability to produce a variety of product such as the new line of Samba Sneakers.

After receiving all three emails. The company has three options for the production of the Samba Sneakers. The following options are: Recondition the existing equipment at the Shanghai, buy new equipment or to Outsource production to a vendor in China.

After reviewing the numbers for the Samba Sneakers, it is recommended that ShuzWorld goes with the purchasing new equipment.

For the Best Results, Shuzworld should do the following based upon the number of units they plan to produce:

0-25 Units should be Outsourced

25-300 Units should be Reconditioned

300 Units and above should be Buying New Equipment.

Shuzworld had given us the fixed cost of $50,000 to recondition the existing equipment and also the variable cost of $1000 for every 1000 pairs of sneakers that are produced. The second option was to purchase new equipment at a fixed cost of $200,000 and the variable cost of $500 for every 1,000 pairs of sneakers produced. Angela Down's email gave us the outsourcing option which was no fixed costs with the vendor's estimated variable cost of $3000 for every 1000 pairs of sneakers produced.

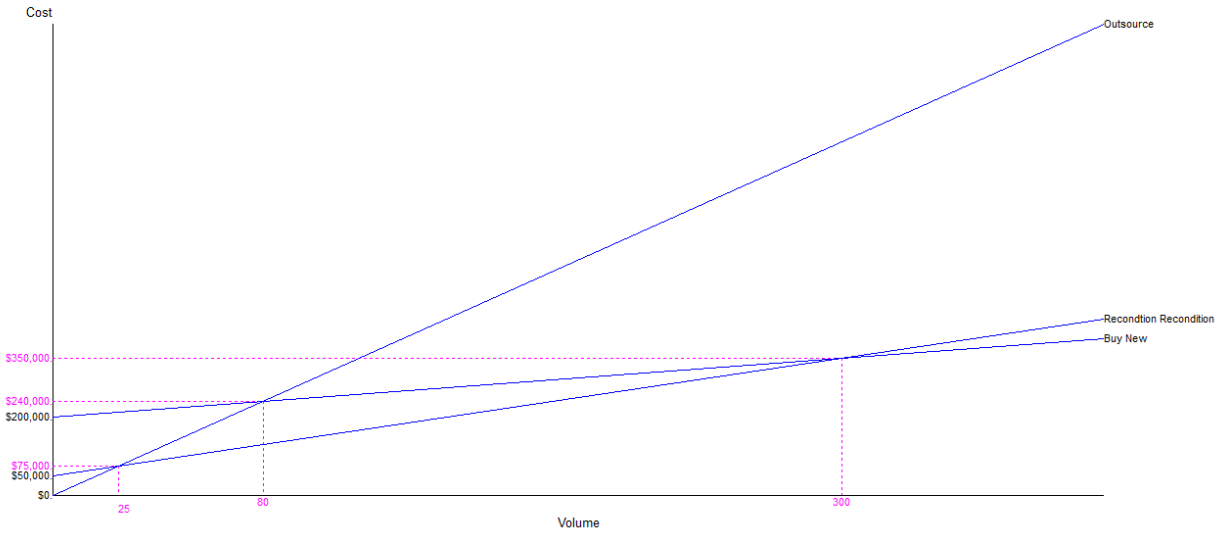
By using the POM Cost-Volume Analysis, it will be able to analyze the above information to give us the best Breakeven/Cost-Volume Analysis results.

**A1. Manufacturing Recommendations Output:**

Below are the results from using the Cost Volume Analysis also known as a Crossover Analysis in the POM system.

Breakeven/Cost-Volume Analysis Results

| | Cost Type | Recondtion Recondition | Buy New | Outsource |
|---|---|---|---|---|
| Cost 1 | Fixed | 50000 | 200000 | 0 |
| Cost 2 | Variable | 1000 | 500 | 3000 |
| | | | | |
| | | | | |
| BREAKEVEN POINTS | Units | Dollars | | |
| Recondtion Recondition vs. Buy | 300 | 350000 | | |
| Recondtion Recondition vs. | 25 | 75000 | | |
| Buy New vs. Outsource | 80 | 240000 | | |




0-25 Units should be Outsourced

25-300 Units should be Reconditioned

300 Units and above should be Buying New Equipment.

**A1a. Manufacturing Recommendations Explanation:**

The purpose of this analysis is to find the lowest cost option. The above graph shows the intersection points. Since we were not given a specific volume, so this means we needed to account for all possible volumes.

The three options above shows the crossover points and when that option is no longer the best option.

By looking at the Outsourcing option, this would be a good decision if the company was only going to produce up to 25 units @ a cost of $75,000. The benefit of the Outsourcing would have been no need for any fixed costs. However, any production that exceeds the 25 units should view another process of production such as reconditioning the equipment.

If Outsourcing had exceeded 80 units/ $240,000 or above, it would be highly recommended to just go with the New Equipment. Even though the New Equipment is more expensive than Reconditioning, the shear extreme cost of Outsourcing of 80 units or more would have been better spent on just getting New Equipment.

Even Reconditioning the equipment will have a point in which it would be advantageous to just Purchase New equipment. Reconditioned equipment while still operational will have a higher Variable cost due to constant replaced and repair of the components in the equipment. The New Equipment will have less wear and therefore will have lower Variable cost. With Shuzworld, the Recondition Variable cost was 1000 and the New cost was only 500. This

means the breakeven/crossover point is at 300 units/$350,000. If the company was going to produce between 25 units/$75,000 and 300 units/$350,000, the company should chose to go with the reconditioning of the equipment. However, Shuzworld plans to increase production in the future so the logical recommendation would be to Buy the New Equipment so that it can benefit from the cost savings when the higher volume begins. The benefit of the Cost Volume Analysis/Crossover Analysis shows Shuzworld the impact of volume can have on selecting the lowest cost course of action needed in regards to production and process decisions.

**B. Sales Volume Forecast**

Gloria Rodriguez has asked us to help improve performance at one of the Four Corners Galleria stores. She had given us the Four Corners store sales for the past nine months. We have recommended that we use the least squares method as well as another forecasting method. The other method for forecasting will be using is the Exponential Smoothing with Trend method because we were given the smoothing constant with an average of 0.3 and a smoothing constant of the trend of 0.4.

They are many ways to achieve a forecast for Shuzworld. Forecasting is an integral component of all business operations. The process of Forecasting could be broken down into seven steps. Determining the use of the forecast and select the items for the forecast. Once the Forecast use and items have been determined, we need to set the time horizon of the forecast such as annual forecast or when to bring on a new product for a certain year. From the Data collected the company should select the appropriate forecasting model to use. The results from that data need to be validated and then implement the results. We have several quantitative

approaches we could use such as the time-series models (Moving average, Weighted Moving averages, Exponential Smoothing and Trend Projection). If we were using something other than time-frame models, we would have used an associative model such as a Linear regression model type of tool.

The Chart below shows the previous Four Corners Shuzworld Sales supplied by Gloria Rodriguez.

| Four Corners Shuzworld Sales | |
|---|---|
| **Quarter** | **Sales** |
| 2Q 2007 | 90,000 |
| 3Q 2007 | 95,000 |
| 4Q 2007 | 98,000 |
| 1Q 2008 | 96,000 |
| 2Q 2008 | 102,000 |
| 3Q 2008 | 99,000 |
| 4Q 2008 | 118,000 |
| 1Q 2009 | 109,000 |
| 2Q 2009 | 124,000 |

Data was entered into the Forecast Module with the Linear Regression/least Squares method using the information supplied by Shuzworld. This Linear Regression/least Squares method requires to identify not only the volume but the time frame as well.

**B1. Sales Volume Forecast Output:**

The First Sales Volume Forecast is the Linear regression/least squares approach. The linear regression fitted with least square method uses the least algorithmic technique to increase a solutions approximation accuracy that corresponds with a particular problem's complexity. The Least squares linear regression is a method for predicting the value of a dependent variable Y, based on the value of an independent variable X. (What is Linear Regression?)

Method: Linear regression/least squares | x value for forecast (0=none): 0 | Instructio There are using the

Forecasting Results

(untitled) Summary

| Measure | Value | Future Period | Forecast |
|---|---|---|---|
| Error Measures | | 10 | 121861.1 |
| Bias (Mean Error) | -.001 | 11 | 125544.4 |
| MAD (Mean Absolute Deviation) | 4183.951 | 12 | 129227.8 |
| MSE (Mean Squared Error) | 23356180 | 13 | 132911.1 |
| Standard Error (denom=n-2=7) | 5479.907 | 14 | 136594.4 |
| MAPE (Mean Absolute Percent Error) | 3.945% | 15 | 140277.8 |
| Regression line | | 16 | 143961.1 |
| Demand(y) = 85027.78 | | 17 | 147644.4 |
| + 3683.333 * Time(x) | | 18 | 151327.8 |
| Statistics | | 19 | 155011.1 |
| Correlation coefficient | .891 | 20 | 158694.4 |
| Coefficient of determination (r^2) | .795 | 21 | 162377.8 |

These results give us not only the 10th period but also the 10th through the 21st period.

Since this is a linear model, we are also able to figure out the Regression Line Formula. Demand(y) = 85027.78 + 3683.333 * Time(x). The results also present the Correlation coefficient (r value) .891 (this determines how well our data lines up on the line – how linear is the data and should be viewed as percentage) and the Coefficient of determination (r^2) which

tells you how well this particular model fits the data .795. For this particular model, it resulted in a MAPE of 3.945%%, MAD of 4183.951 and MSE of 23356180 in the Detail and Error Analysis.

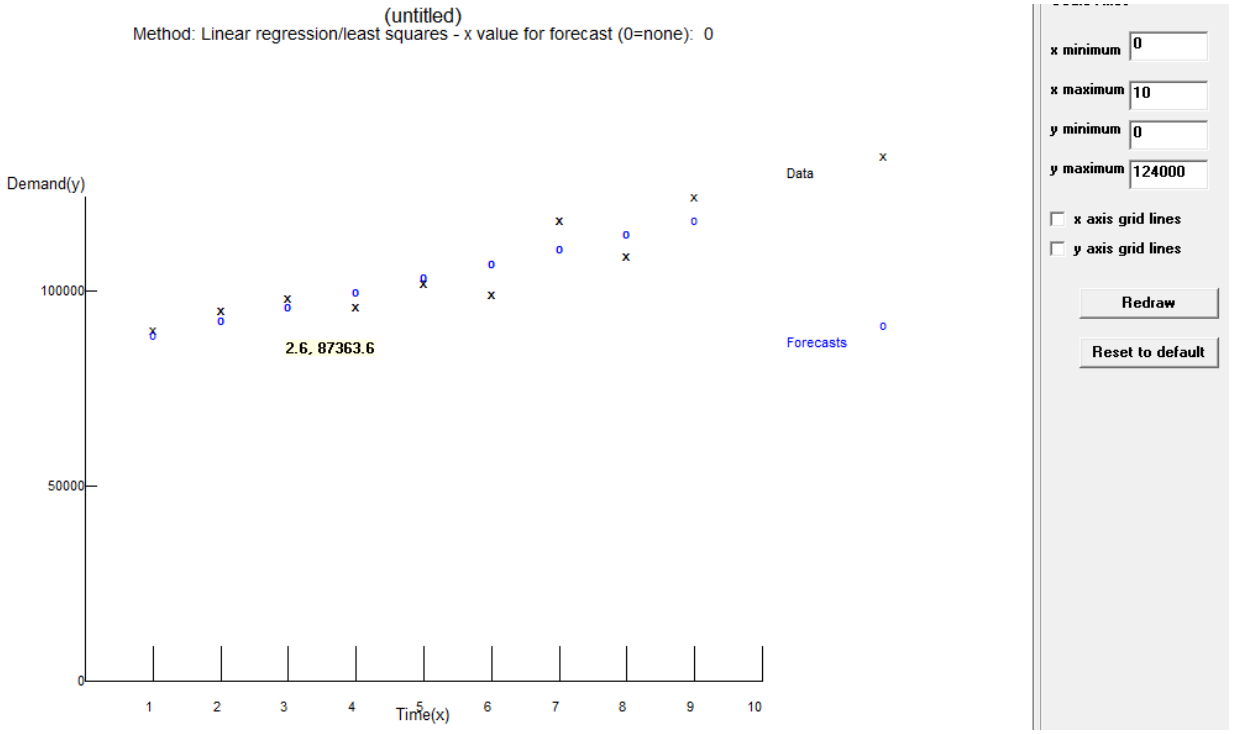
Details and Error Analysis

(untitled) Solution

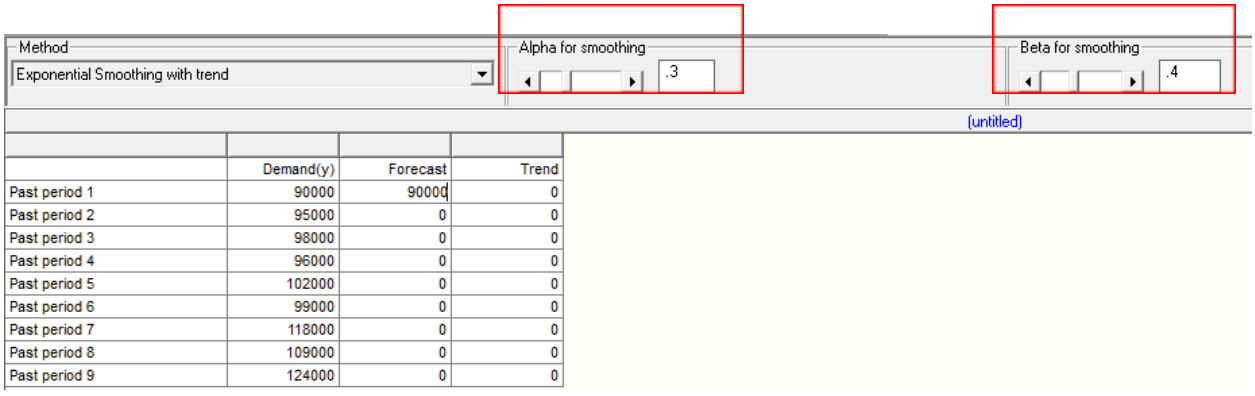
| | Demand(y) | Time(x) | x^2 | x * y | Forecast | Error | \|Error\| | Error^2 | \|Pct Error\| |
|---|---|---|---|---|---|---|---|---|---|
| Past period 1 | 90000 | 1 | 1 | 90000 | 88711.12 | 1288.883 | 1288.883 | 1661219.0 | 1.432% |
| Past period 2 | 95000 | 2 | 4 | 190000 | 92394.45 | 2605.555 | 2605.555 | 6788915 | 2.743% |
| Past period 3 | 98000 | 3 | 9 | 294000 | 96077.78 | 1922.219 | 1922.219 | 3694925 | 1.961% |
| Past period 4 | 96000 | 4 | 16 | 384000 | 99761.11 | -3761.109 | 3761.109 | 14145940 | 3.918% |
| Past period 5 | 102000 | 5 | 25 | 510000 | 103444.4 | -1444.445 | 1444.445 | 2086422.0 | 1.416% |
| Past period 6 | 99000 | 6 | 36 | 594000 | 107127.8 | -8127.781 | 8127.781 | 66060830 | 8.21% |
| Past period 7 | 118000 | 7 | 49 | 826000 | 110811.1 | 7188.891 | 7188.891 | 51680150 | 6.092% |
| Past period 8 | 109000 | 8 | 64 | 872000 | 114494.4 | -5494.445 | 5494.445 | 30188930 | 5.041% |
| Past period 9 | 124000 | 9 | 81 | 1116000 | 118177.8 | 5822.227 | 5822.227 | 33898320 | 4.695% |
| TOTALS | 931000 | 45 | 285 | 4876000 | | -.008 | 37655.55 | 210205600 | 35.508% |
| AVERAGE | 103444.4 | 5 | 31.667 | 541777.8 | | -.001 | 4183.951 | 23356180 | 3.945% |
| Next period forecast | | | | | 121861.1 | (Bias) | (MAD) | (MSE) | (MAPE) |
| Intercept | 85027.78 | | | | | | Std err | 5479.907 | |
| Slope | 3683.333 | | | | | | | | |

The above shows a next period volume forecast of 121861.1

This graph shows the Forecast with the Linear Regression/least squares in correlation to the Historical data.

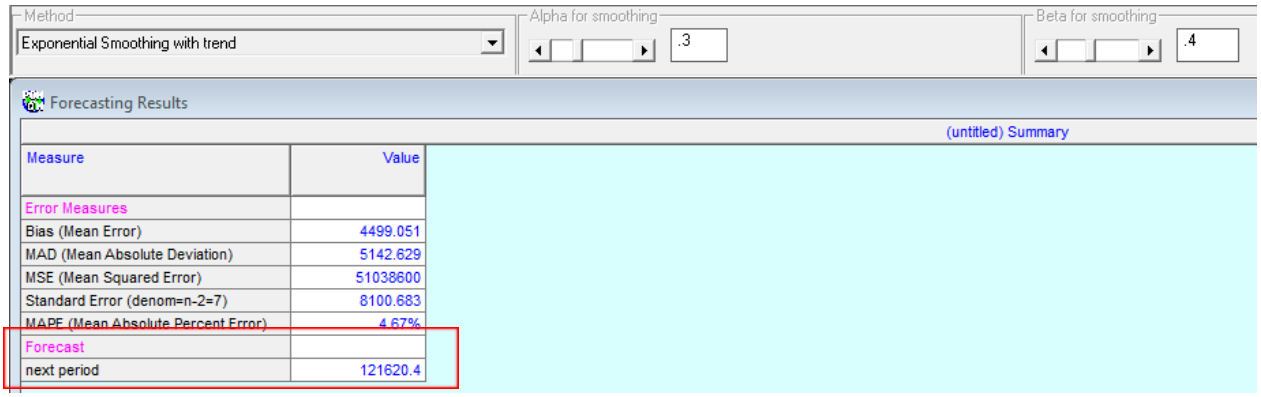



The Second Sales Volume Forecast is the Exponential Smoothing with Trend approach. The reason for selecting the Exponential Smoothing with the Trend approach was because of the given information about the smoothing constant for the average of 0.3 and a smoothing constant for the trend of 0.4. Since I was given my Alpha for smoothing of .3 and the Beta for smoothing .4, We were able to come up with the following results.




| | Demand(y) | Forecast | Trend |
|---|---|---|---|
| Past period 1 | 90000 | 90000 | 0 |
| Past period 2 | 95000 | 0 | 0 |
| Past period 3 | 98000 | 0 | 0 |
| Past period 4 | 96000 | 0 | 0 |
| Past period 5 | 102000 | 0 | 0 |
| Past period 6 | 99000 | 0 | 0 |
| Past period 7 | 118000 | 0 | 0 |
| Past period 8 | 109000 | 0 | 0 |
| Past period 9 | 124000 | 0 | 0 |

We entered the following same information to determine the Forecast using the Expontial Smoothing with Trend analysis tool. This shows that the next period forecast of 121620.4.




| Measure | Value |
|---|---|
| Error Measures | |
| Bias (Mean Error) | 4499.051 |
| MAD (Mean Absolute Deviation) | 5142.629 |
| MSE (Mean Squared Error) | 51038600 |
| Standard Error (denom=n-2=7) | 8100.683 |
| MAPE (Mean Absolute Percent Error) | 4.67% |
| Forecast | |
| next period | 121620.4 |

These are the Forecast Results: Again, this shows the Next period forecast of 121620.4 along with the MAD of 5142.629, MSE of 51038600 and MAPE of 4.67%

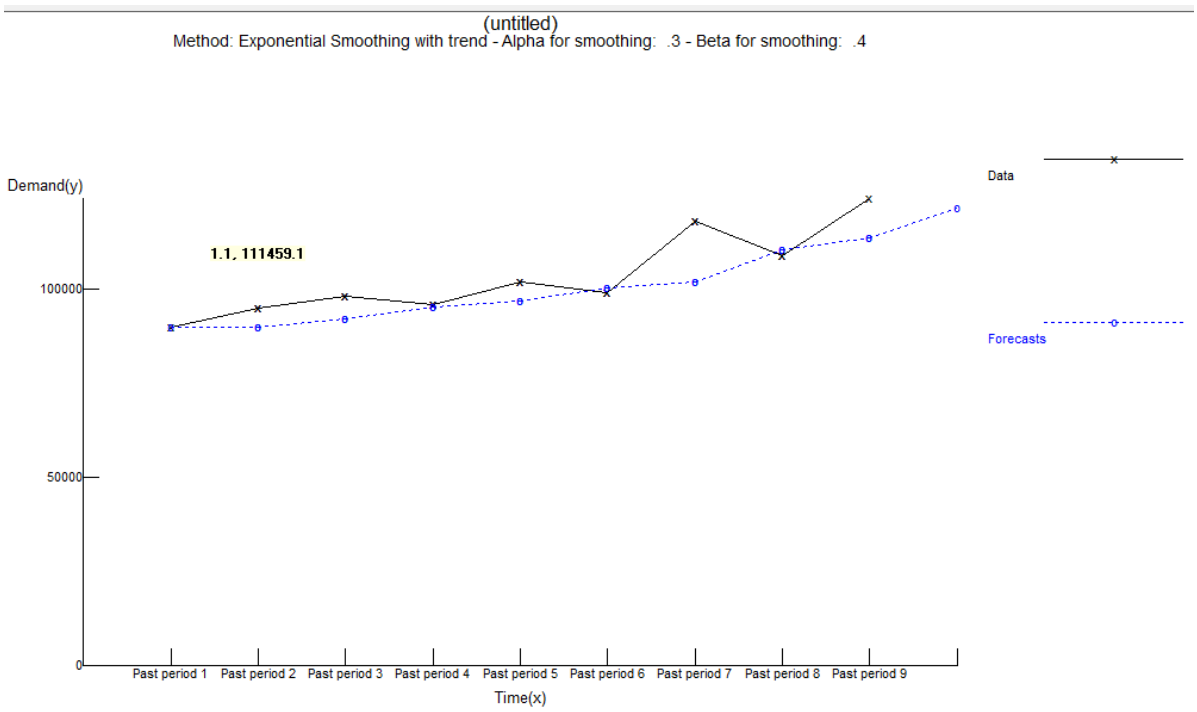
Details and Error Analysis

(untitled)

| | Demand(y) | Smoothed Frcst, Ft | Smoothed Trend, Tt | Frcst Inc Trend,FITt | Error | \|Error\| | Error^2 | \|Pct Error\| |
|---|---|---|---|---|---|---|---|---|
| Past period 1 | 90000 | 90000 | 0 | 90000 | 0 | 0 | 0 | 0% |
| Past period 2 | 95000 | 90000 | 0 | 90000 | 5000 | 5000 | 25000000 | 5.263% |
| Past period 3 | 98000 | 91500 | 600 | 92100 | 5900 | 5900 | 34810000 | 6.02% |
| Past period 4 | 96000 | 93870 | 1308 | 95178 | 822 | 822 | 675684 | .856% |
| Past period 5 | 102000 | 95424.6 | 1406.641 | 96831.24 | 5168.758 | 5168.758 | 26716060 | 5.067% |
| Past period 6 | 99000 | 98381.87 | 2026.891 | 100408.8 | -1408.758 | 1408.758 | 1984599.0 | 1.423% |
| Past period 7 | 118000 | 99986.13 | 1857.841 | 101844.0 | 16156.02 | 16156.02 | 261017100 | 13.692% |
| Past period 8 | 109000 | 106690.8 | 3796.564 | 110487.3 | -1487.344 | 1487.344 | 2212192.0 | 1.365% |
| Past period 9 | 124000 | 110041.1 | 3618.082 | 113659.2 | 10340.78 | 10340.78 | 106931800 | 8.339% |
| TOTALS | 931000 | | | | 40491.46 | 46283.66 | 459347400 | 42.026% |
| AVERAGE | 103444.4 | | | | 4499.051 | 5142.629 | 51038600 | 4.67% |
| Next period forecast | | 116761.5 | 4858.974 | 121620.4 | (Bias) | (MAD) | (MSE) | (MAPE) |
| | | | | | | Std err | 8100.683 | |

For this particular model, it resulted in a MAPE of 4.67%%, MAD of 5142.629 and MSE of 51038600 in the Detail and Error Analysis.

Also is the graph showing the Forecast with the exponential smoothing in correlation to the Historical data.




**B2. Results Difference**

When comparing the two different models, I pay particular attention to the MAPE (Mean Absolute Percent Error), MAD (Mean Absolute Deviation) and MSE (Mean Squared Error) between the two models. Another area particular attention should be made is in the area of Volume. For Shuzworld, the Least Squares was 121861.1 vs Exponential Smoothing with Trend of 121620.4. The higher volume forecast is always more favorable as long as the forecast has the lowest forecast margin of error.

The best way to determine which model displays the most accurate forecast is by using error analysis. By reviewing the various models, the model with the lowest forecast error will appear.

In the case of Shuzworld forecasting:

MAD – Least squares was 4183.951 vs Exponential Smoothing with Trend of 5142.629

MSE – Least squares was 23356180 vs Exponential Smoothing with Trend of 51038600

MAPE – Least squares was 3.945% vs Exponential Smoothing with Trend of 4.67%

As a result, the model with the lowest percentage of error for the MAPE would be the most accurate forecast model to use. This would mean that the linear regression or least squares method would be the forecast tool of choice.

**C. Control Chart Metrics**

Control chart metrics can improve the quality in the Shuzworld production line. Control Chart Metrics are a Statistical tool. This tool is used in quality control for understanding process variables. It can be used in determining a process capabilities as well as monitoring the effects of the variables on performance and hitting actual targets. In the case of Shuzworld, a Statistical Process Control (SPC) System helps identify when data variations are present. It should be known that variability is inherent in every process. These variations could be from natural or

common causes and even special or assignable causes. By using Statistics, it can help determine if these variations are natural causes or something that needs attention in the case of special and assignable causes.

Control charts indicate upper and lower control limits, and often include a central (average) line, to help detect trend of plotted values. (Control Chart)

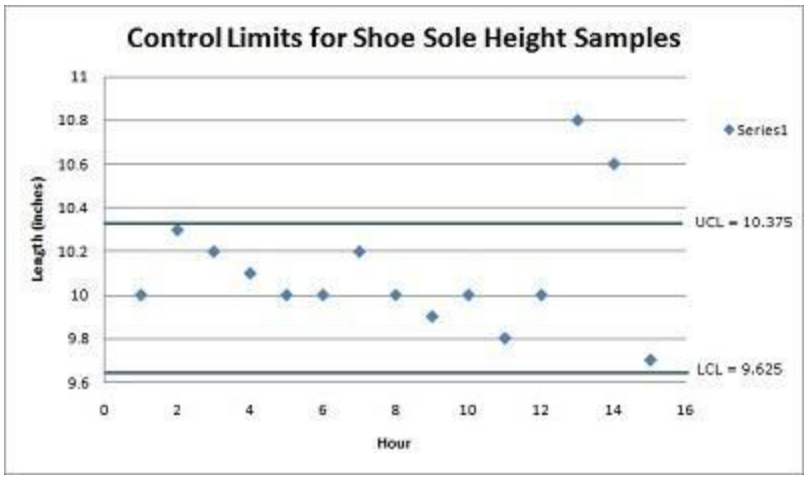
With all data points, they either fall within the control limits or fall out of control limits. The data that falls within "in control" limits but has variations in the values could be caused by natural or common causes. These types of are to be expected and are acceptable within the limits.

Unlike In Control limits, Out of Control limits could be caused by Assignable Variations which could be traced back to the type of change in the system. These changes could include: Equipment out of calibration, something stuck in the machine or any other type of infraction that is effecting the accuracy of production. These Statistical metrics can quickly identify if everything is working correctly.

The objective for Shuzworld is to discover when these assignable causes are present and do something about it. A key part to identifying when assignable causes are present is by Sampling. This process of Sampling is to take the samples and analyze them. Shuzworld has done an excellent job of getting samples by the hourly random selection of 16 soles which was done over a 15 hour period. By doing this process, the company was able to get the mean or average and even create a distribution analysis. This distribution analysis would look like a Bell Curve. So by taking these samples, we can see over time if the product is "in control".

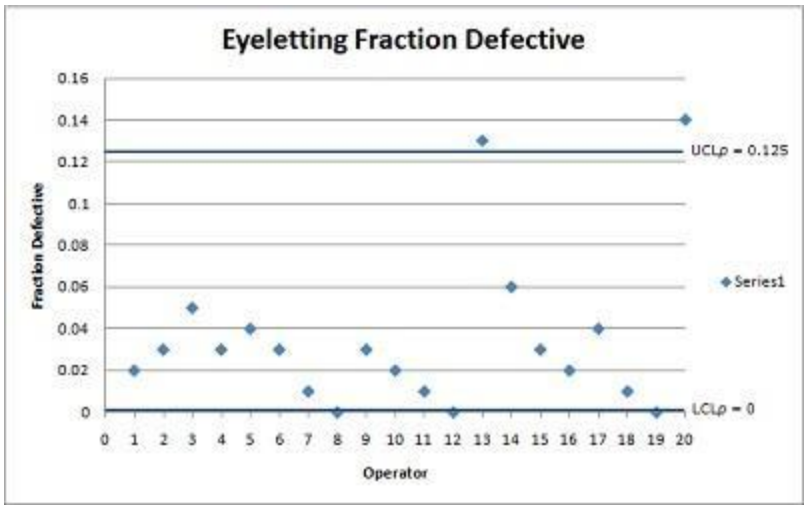
Control Charts constructed from historical data can help in distinguishing between the natural variations and variations cause by assignable causes. These Control Charts can show the average/mean with Upper Control Limits (UCL) and Lower Control Limits (LCL).

In the case of Shuzworld, the following are the Control Limits for the Sole Height deviation limit of .5 inches with control limit of 99.73%




Shuzworld had set their control limits at 10.375 for the UCL and at 9.625 for the LCL. After reviewing this Chart, it appears that the 13 & 14 hours are Out of Control. This Assignable variation means that something had changed in the factory production line and needs to be addressed. The timing of this assignable variation could be the result of a shift change, tired employees and even machinery repair or maintenance. Since this was closer to the 16$^{th}$ hour, it could also mean that the machines are requiring more servicing than previously considered.

Shuzworld had also provided the Eyeletting Fraction Defective Chart. The chart below shows the control limits for the 20 operators for the eyeletting machines. With a control limit of 99.73%, we reviewed 100 of the pieces created by each worker.




It is important to know that there are two types of data which could be derived from the process control. The two types are variables which has real measurable data and attributes which is classified as either good or bad. Attributes commonly have discrete random variables and are commonly referred to defect-related characteristics.

There are also four types of control charts.

The numerical variables such as mean weight, continuous dimension, weight, strength, and length. X-Charts or X Bar charts commonly use the mean and have a central tendency of the process. For an example, it would measure to see if the average weight is in control. While the R-Charts controls the dispersion of the process or the range of control. The R-Chart is usually the measurement of the width of the Bell Curve. It measures the range over time and

monitors the process variability. The R-Chart is independent from the process mean and does not detect the change in the mean but picks up on the changes in dispersion.

The last two types of control charts are Attributes Charts. The Attribute Charts can be a p–chart which measures the percent defective or a c-chart which counts the number of defects.

Since Shuzworld has given us the p-chart for the Eyeletting Fraction Defective chart, we are able to determine the measurement in terms of defects. The above chart shows that two of the 20 workers have fallen out of control (Worker 13 and 20). Since all of the other workers have of .06 fraction defective rate or lower, this means that there is a serious problem that exists for those two workers. This problem should be investigated. It might also benefit Shuzworld to review and consider lowering the UCLp(Upper Control Limit Percent) since the majority of the data points are at 0.06 and lower. By addressing of the two workers issues, it would greatly increase the overall quality of the shoes which would create more value to the customers. When the customers see the value and quality in the shoes, it will translate into higher sales and larger profits for Shuzworld.

## D. Sources

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*What is Linear Regression?* (n.d.). Retrieved from STAT TREK:

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