ENGINEERING TRIPOS PART IIA

Module 3E10: Operations Management for Engineers

Examples Paper IV

Examples class: March 15, 2016 (4pm-6pm, Engineering LT1)

Question 1: How do the philosophies and implementation steps differ between Six Sigma, Lean Thinking, and the Theory of Constraints?

Answer: See the table below.

Program	Six Sigma	Lean thinking	Theory of constraints
Theory	Reduce variation	Remove waste	Manage constraints
Application guidelines	1. Define. 2. Measure. 3. Analyze. 4. Improve. 5. Control.	1. Identify value. 2. Identify value stream. 3. Flow. 4. Pull. 5. Perfection.	1. Identify constraint. 2. Exploit constraint. 3. Subordinate processes. 4. Elevate constraint. 5. Repeat cycle.
Focus	Problem focused	Flow focused	System constraints
Assumptions	A problem exists. Figures and numbers are valued. System output improves if variation in all processes is reduced.	Waste removal will improve business performance. Many small improvements are better than systems analysis.	Emphasis on speed and volume. Uses existing systems. Process interdependence.
Primary effect	Uniform process output	Reduced flow time	Fast throughput
Secondary effects	Less waste. Fast throughput. Less inventory. Fluctuation—performance measures for managers. Improved quality.	Less variation. Uniform output. Less inventory. New accounting system. Flow—performance measure for managers. Improved quality.	Less inventory/waste. Throughput cost accounting. Throughput—performance measurement system. Improved quality.
Criticisms	System interaction not considered. Processes improved independently.	Statistical or system analysis not valued.	Minimal worker input. Data analysis not valued.

Question 2: A manufacturing process has a defect rate of 5 percent, based upon 10 samples of 20 data points each. Calculate the control limits for a p-chart, and explain how it would be used to detect changes in the process performance.

Answer: For attribute data

$$UCL = \bar{p} + 3\sqrt{\frac{\bar{p}(1-\bar{p})}{n}}$$
$$CL = \bar{p}$$
$$LCL = \bar{p} - 3\sqrt{\frac{\bar{p}(1-\bar{p})}{n}}$$

For this question, $\bar{p}$ = 0.05. For a p-chart, *n* is calculated from the number of data points per sample, not the number of samples, which can vary dependent on how long the process had been assessed. That is, n = 20. Using these values, we can calculate UCL and LCL as 0.196 and 0, respectively.

Samples of 20 are taken at intervals and the % defective calculated. This % is plotted on a control chart. While the process remains "in control" subsequent plots should be randomly distributed around the 5% line. Changes to the process will be shown by variation from this, for example, by trends, or several subsequent samples being between warning and control limits. There are various rules used to interpret the significance of such variation, better students might give examples.

<u>Question 3</u>: Given the table of coating weights shown here for samples of size n = 4:

a) Calculate the $\bar{X}$'s and R's for samples 2 to 8.

Answer:

Sample	X1	X2	X3	X4	$\bar{X}$	Range
1	18.5	21.2	19.4	16.5	18.90	4.7
2	17.9	19.0	20.3	21.2	19.6	3.3
3	19.6	19.8	20.4	20.5	20.075	0.9
4	22.2	21.5	20.8	20.3	21.2	1.9
5	19.1	20.6	20.8	21.6	20.525	2.5
6	22.8	22.2	23.2	23.0	22.8	1
7	19.0	20.5	20.3	19.2	19.75	1.5
8	20.7	21.0	20.5	19.1	20.325	1.9

a) Calculate the $\bar{\bar{X}}$ and $\bar{R}$ values based on all eight samples.

Answer: $\bar{\bar{X}}$ = 20.40; $\bar{R}$ = 2.21

b) Determine the appropriate constant (using Table 1 in the Appendix) that would be used with these data to construct $\bar{X}$ and R control chars, and calculate the control limits.

Answer:

$$UCL = \bar{\bar{x}} + A_2\bar{r} \qquad UCL = D_4\bar{r}$$
$$CL = \bar{\bar{x}} \qquad CL = \bar{r}$$
$$LCL = \bar{\bar{x}} - A_2\bar{r} \qquad LCL = D_3\bar{r}$$

For n= 4:

$A_2 = 0.729$;

$D_3 = 0$;

$D_4 = 2.282$

Using the formulae above and the appropriate constants from Table 1, the control limits for the $\bar{X}$ chart are:

UCL = 20.40 + 0.729*2.21= 21.99;

CL = 20.40;

LCL = 20.40 - 0.729*2.21= 18.80

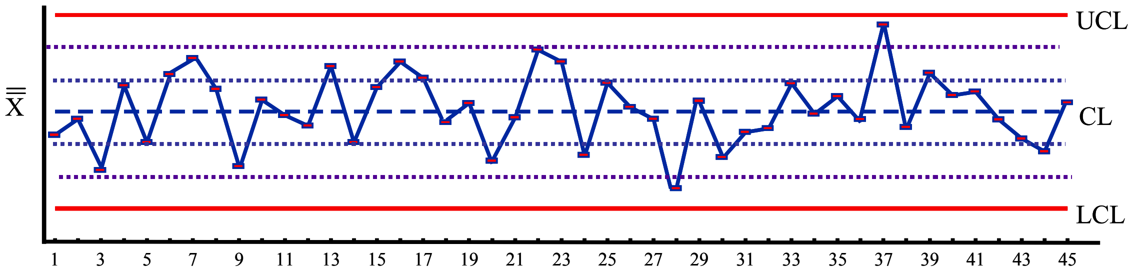
For the R chart:

UCL = 2.282*2.21 = 5.04;

CL = 2.21;

LCL = 0

<u>Question 4</u>: Interpret the following control chart, explaining whether or not the process is in control. Give any recommendations for action.



Answer: This chart displays normal/random variation and is therefore in control. However, this is only the X-bar chart and to know if the process is in control you need to also examine the R chart.

Recommendation: Look at the R chart. If the R chart is in control, then keep running the process as is and monitoring. If the R chart is not in control, then the range/standard deviation has changed (rather than the mean) and should be investigated.

Question 5: Wize Beers UK has 3 beer factories and 5 distribution centres. Their supply capacities, demand data, and the cost of delivery between each location are presented in the table below. Find a policy that matches demand and supply at the minimum cost.

	Aberdeen	Preston	Sheffield	Ipswich	Winchester	**Supply**
Glasgow	*(18)*	*(16)*	*(12)*	*(28)*	*(54)*	**46**
Leeds	*(24)*	*(40)*	*(36)*	*(30)*	*(42)*	**20**
Swindon	*(22)*	*(12)*	*(16)*	*(48)*	*(44)*	**34**
Demand	**27**	**16**	**18**	**10**	**29**	**100**

Answer: See the ppt file.

Question 6:

(i) Which of the following is NOT a key idea of supply chain management?

a) Procurement decisions should be guided by total cost rather than purchase price.
b) Organisations should devolve technological responsibility to the parties in the chain with the greatest expertise.

c) Organisations must collaborate on business process design with customers and suppliers.
d) Organisations should engage in a competitive struggle with their suppliers and customers over the profit to be made in the extended value chain.
e) Organisations need to formulate strategies for managing quality across organisational boundaries.

Answer: d

(ii) Which of the following are NOT common interpretations of supply chain management? (Check all that apply)

a) The management of operations and commerce at customer and supplier interfaces.
b) The management of the flow of goods from earth to the end-consumer.
c) The management of organisations with complex bills-of-materials.
d) The management of organisations with multiple retail outlets.

Answer: c & d

(iii) What is the difference between agile and lean supply chains? Can they co-exist?

Answer: A lean SC reduces waste, and it's focus is in on planning and optimisation with longer lead times. An agile SC on the other hand is about flexibility and shortest lead times. While a lean SC needs predictable demand so that stable processes can be optimised around it, an agile SC needs to deal with unpredictable demand e.g. in innovative products like fashion. These strategies can often co-exist where possible, with hybrid strategies as such as (a) separating surge and base demand and managing forecastable demand using lean, (b) introducing decoupling points along the chain until which lean is implemented, and (c) using lean methods for high volume lines and agile for low volumes. Of course, these hybrid strategies would be applicable only in situations where (a) demand is non-proportionate across the range (b) base demand can be confidently predicted and (c) modular production is possible.

(iv) What is the bullwhip effect?

Answer: Bullwhip effect is the increasing variance in demand from downstream to upstream in a supply chain due to: Rationing/Overstatement of Requirement, Delay/Mismatch of speed of information and products, Batch Sizing. The bullwhip effect can be overcome by sharing sales and demand information with other supply chain members, offering constant prices, removing price promotions that encourage customers to place large orders, and reducing lead time.

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