Analytics in Operations Management

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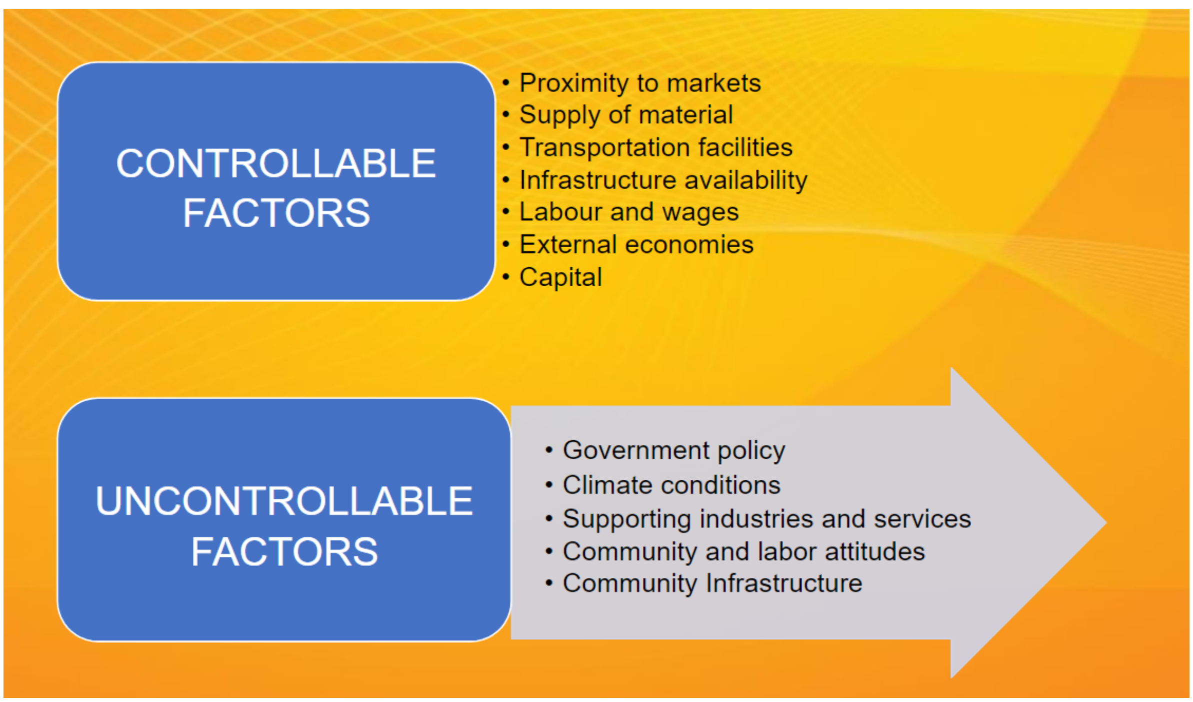
Introduction

Analytics involves the application of quantitative methods and statistical tools to study the patterns in the large amount of data in order to facilitate strategic planning and fact-based decision making. There are various data-driven analytical techniques involved in modern operations management. It help in deriving actionable insights into the crucial areas of operations management such as aggregate planning, demand forecasting, process analysis, sourcing

Integrated Models For Selection Of Facility Location

A critical decision while designing large-scale supply chain systems is about the location of facilities, as these form the backbone of operations. The selection of location is a key-decision as large investment is made in building plants and machinery. It is done using a certain scientific technique. It is not advisable or not possible to change the location very often. Determination of a facility location is a strategic and critical decision and it is affected by a host of factors such as competition levels, costs of production, proximity to markets, etc.

Factors Affecting Facility Location



Models for Selection of Facility Location

To select a facility location, they can use one of the following integrated models, which consider strategic, tactical, and operational factors:

A. Factor rating method (using Equal Weights):

The process of selecting a new facility location involves a series of following steps:

1. Identify the key location factors.
2. Rate each factor according to its relative importance, *i.e.*, higher the ratings is indicative of a prominent factor.
3. Assign each location according to the merits of the location for each factor.
4. Calculate the rating for each location by multiplying factor assigned to each location with basic factors considered.
5. Find the sum of products calculated for each factor and select the best location having the highest total score.

For example, Table 1 illustrates the location factors and factor rating for two potential sites for a hospital:

Location Factors	**Site 1**	**Site 2**
Facility utilisation	6	7
Total patient per month	4	9
Average time per emergency trip	9	7
Land and construction costs	7	3
Employee preferences	5	6
Total	31	32

Please note that Site 2 has the highest rating. Therefore, this site will be selected

B. *Weighted factor rating method*

This method combines the quantitative and qualitative factors by assigning weights based on their relative importance. The assigned weightage score is calculated for each location The site with the highest weighted score is selected.

Location Factors	Weightage	Factor Rating (Out of 10)		Weighted Factor Rating	
		Site 1	Site 2	Site 1	Site 2
Labour availability	0.50	9	7	4.5	3.5
People-to-Product Ratio	0.20	8	6	1.6	1.2
Per Capita Income	0.15	6	4	0.9	0.6
Tax Structure	0.15	5	5	0.75	0.75
Total				7.75	6.05

C. Load distance method

- The load-distance method is a mathematical model used to evaluate locations based on proximity factors.The objective is to select a location that minimizes the total weighted loads moving into and out of the facility. The distance between two points is expressed by assigning the points to grid coordinates on a map. For the load distance method, a rough distance is calculated, which may be: Euclidean distance and Rectilinear distance.

D. Centre of gravity method

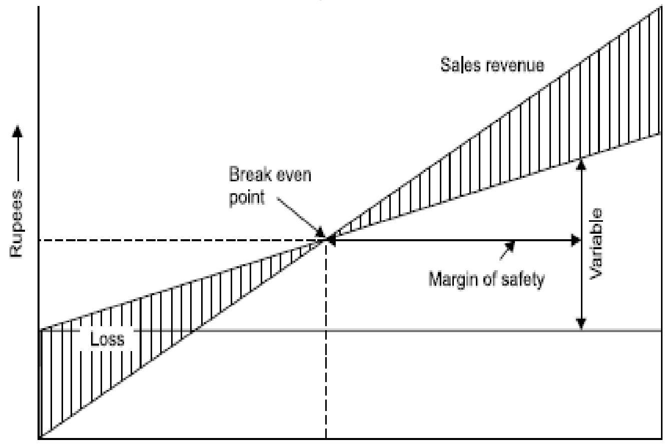
This method is mainly based on cost considerations.It finds the best location for a facility after considering locations of plants and markets, the volume of goods transported and transportation costs. The center of gravity is determined by the following formula: $C_X = \sum D_{ix}.W_i/\sum W_i$ $C_Y = \sum D_{iy}.W_i/\sum W_i$

Where, C_x = x-coordinate of the centre of gravity
C_y = y-coordinate of the centre of gravity
D_{ix} = x-coordinate of location i
D_{iy} = y-coordinate of location i

E. Break-even analysis

The break-even analysis method is used to find the point at which revenues and costs balance called break-even point. It is the volume of output at which neither profit nor loss is made. The Break-even Point is calculated by using the following formula:

BEP = Fixed Cost/Contribution Per Unit
BEP =Fixed Cost/Selling Price- Variable Cost Per Unit



DoE For Manufacturing System Design

Design of Experiments (DoE) is a key tool of Six Sigma which is used for experimentation. It uses the application of statistics to experimentation in order to solve quality problems in key processes. It is a systematic method to determine the relationship between factors affecting a process and the output of that process. DoE helps in reducing the design cost of a product by developing various types of systems and processes for experimentation in order to find out the most efficient and effective process design.

DoE involves a series of steps

1. **Objective formulation:** Objectives are formulated to define purpose for experimentation in this step
2. **Response variable definition:** Various performance measures are analyzed in this step so that the best alternative from the experiments' results can be determined easily.
3. **Identify factors and levels:** Identification of dependent and independent factors that affect the result
4. **Illustrate experimental design type:** The cause and effect relationship is established between the various input variable and the output attained
5. **Execute experiments using design matrix:** In this step, those relationships are analyzed in order to establish a valid conclusion for the final selected process design
6. **Data analysis:** Final conclusion is analyzed using regression to validate the implementation of the result.

Predictive Analytics In Sourcing

Predictive analytics is an advanced analytical tool that is used to make future predictions about sourcing activities by analyzing past and current data.

Predictive Process
1. Define project
2. Data collection
3. Data analysis
4. Modeling
5. Deployment
6. Model monitoring

Importance Of Predictive Analytics In Sourcing

-Helps tracking key sourcing activities which further helps in monitoring results
-Helps in gathering, cleaning and categorizing all enterprise data
-Helps in detecting fraud using spend analytics
-Helps in improving demand forecast accuracy and fact-based negotiations
-Helps in building strategic supplier management and category sourcing
-Aids in research and development in order to find new sources for procurement
-Helps in mitigating suppliers' risk strategically as decisions are not made on assumptions and anticipation

Aggregate Production Planning & Control

Aggregate production planning is concerned with the determination of production, inventory, and personnel levels to fulfill varying demand over a planning perspective that ranges from a period of six months to one year.

Objectives of Aggregate planning

-Minimize cost and maximize profits
-Minimize inventory investment Minimize changes in workforce levels
-Minimize changes in production rates
-Maximize utilization of plant and equipment Maximize customer service

Tools For Aggregate Production Planning & Control

1. Qualitative Tools : These tools usually start with built-in assumptions
    + Non-quantitative haggling
    + Adjustment of last year's plan
    + Graphical methods

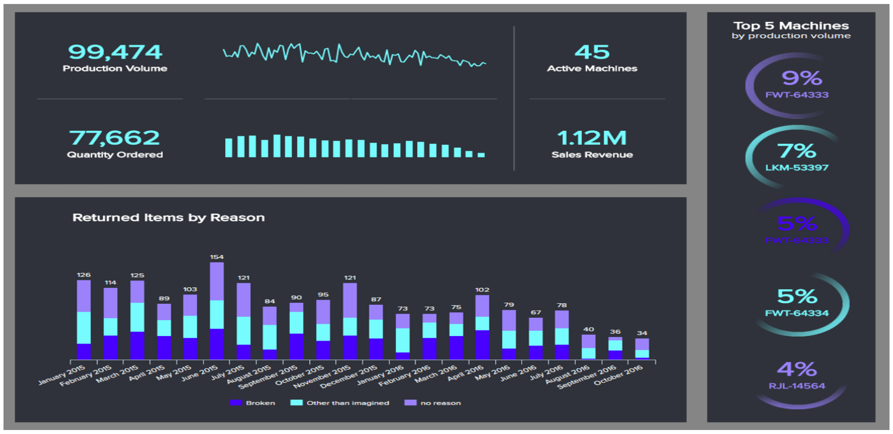
2. Quantitative tools : These are mathematical tools
    + Linear Decision Rule (LDR)
    + Sectioning search
    + Goal programming
    + Range programming
    + Linear programming
    + Search decision rule (SDR)
    + DE decision model Dynamic programming

Automated dashboards with KPIs

These are business intelligence (BI) and data reporting tools that monitor frequently changing business processes and track key performance indicators (KPIs). They are used by businesses to track, evaluate and optimize the quantity, quality and cost of production processes. Some examples of automated dashboards with KPIs are:

- Production dashboard
- Production quality dashboard
- Manufacturing cost management dashboard

Production dashboard



The production dashboard can be used to track the following KPIs:

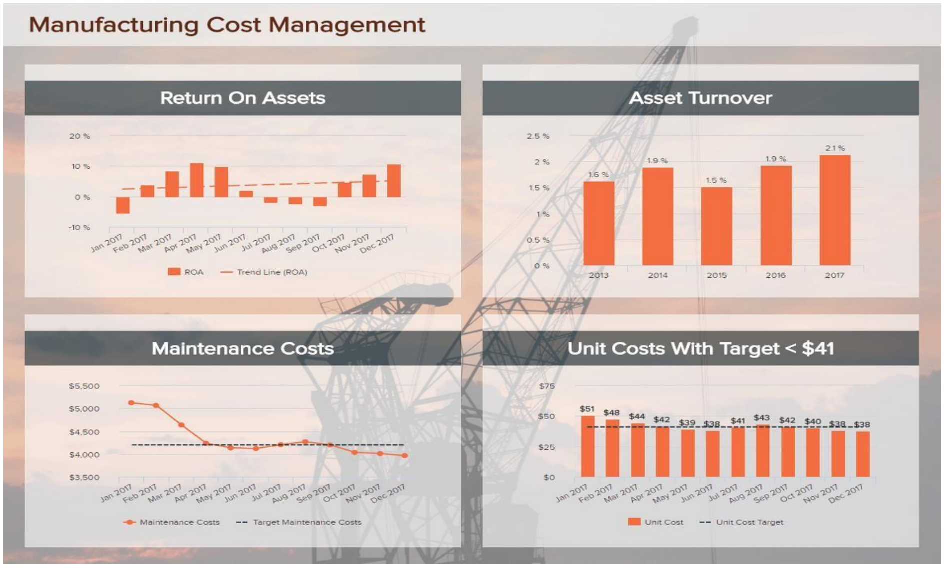
- Production volume : Quantities that factories are able to produce in a period
- Production downtime : Analyses and controls production downtime
- Production costs : Breaks down production costs into various types of costs to indicate which costs contribute maximum to the unit

Production quality dashboard

The production quality dashboard can be used to track the following KPIs:

- Defect density : The production quality dashboard identifies the number of defective products divided by the total number of products produced
- Rate of return : This evaluates the percentage of products that are sent back to factories
- Right first time :The production dashboard enables you to evaluate the right first time KPI, which indicates how often you can produce a product without any defect over the production line

Manufacturing cost management dashboard

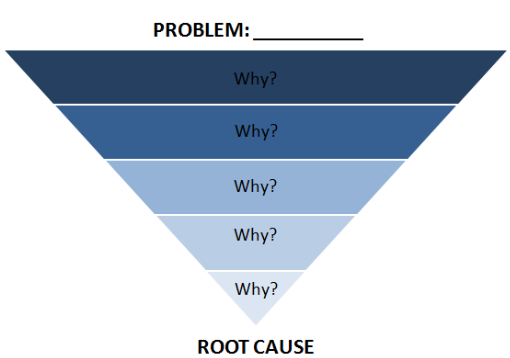


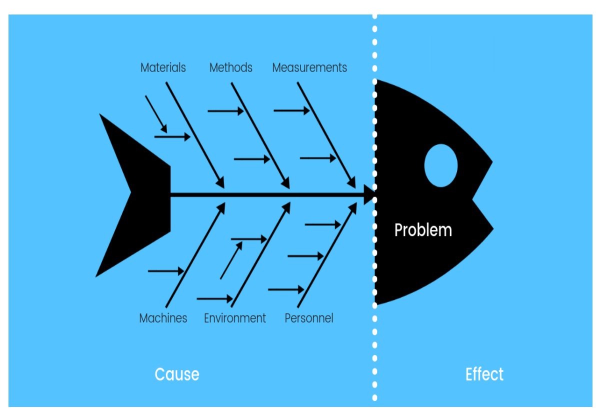
This dashboard can be used to track the following KPIs :

- Asset turnover : It provides the value of the business revenue relatively to the value of assets.
  Asset turnover = Revenue/Total assets
- Unit costs : This manufacturing KPI calculates the total costs involved in the production of an item, which includes fixed and variable costs
- Return on Asset (ROA) : This manufacturing metric demonstrates how profitable a company is relative to its overall assets
- Maintenance costs : This manufacturing KPI tells which equipment needs more maintenance, where resources should be focused, and what preventive steps can optimize maintenance in the future.

ROOT CAUSE ANALYSIS FOR DEVIATION

Root cause analysis (RCA) is the process that determines reasons or factors that cause deviations from quality in the manufactured product. Common examples of RCA in manufacturing include Fishbone diagram and the 5 Whys.



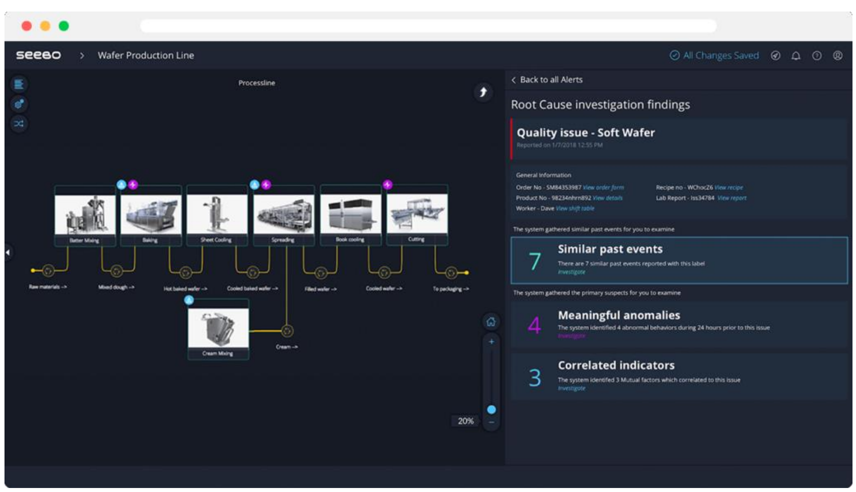


Shortcomings of Traditional Root Cause Analysis

- Some production lines may be too complicated even for experts
- Experts may be biased towards certain ideas
- Experts may inaccurately define problems
- Expert knowledge is not easily transferred across manufacturing sites
- Expert knowledge is difficult to save, store, and transfer for future use

The Power of Automated Root Cause Analysis

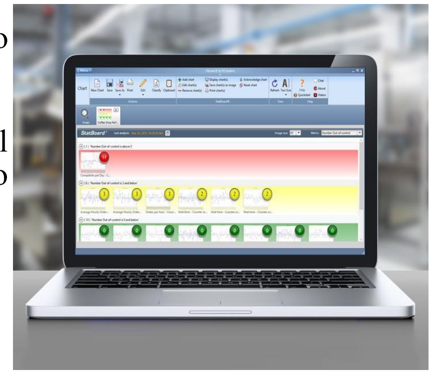
Automated RCA uses machine learning and Big Data analytics for RCA. To perform RCA using machine learning, we need to be able to detect that something is out of the ordinary, or in other words, that an anomaly is present.Examples of anomalies include component failure, corrupt sensor values, corrupt sensor values, changes made to the control logic and Change in environmental conditions. Its algorithms make predictions based on the current behavioral pattern of an anomaly.



Benefits of automated RCA in manufacturing

- Early identification of safety concerns
- Detection of complex disruptions in the process
- Prediction of quality deviations and automatic adjustment of processes to prevent wastage
- Efficient consumption of electricity through anomaly detection
- Reduced emissions due to accurate monitoring of production

Dashboard For SQC, SPC, TQM and TPM To Capture Deviations



- The Standard Quality Control (SQC) dashboards are used to monitor the quality performance of key processes

- When any monitored process deviates from the normal behavior, the control chart background triggers an alarm to alert users.

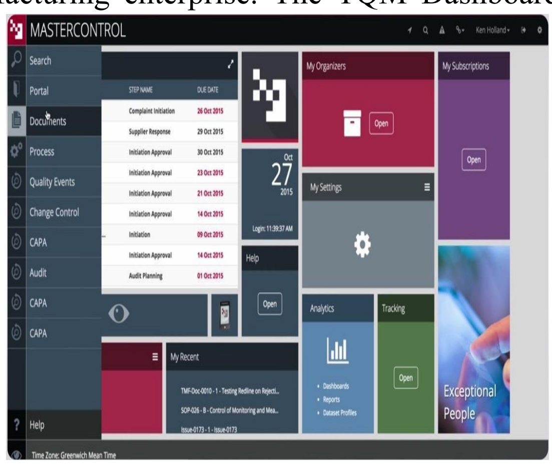
Standard Process Control Dashboard

The Standard Process Control (SPC) dashboards are used to collect data that can provide useful information about process performance and product quality and consistency.It enables users to monitor processes and identify deviations
Feature of SPC dashboard:

- Flexibility
- Comprehensiveness
- Speed
- Simplicity

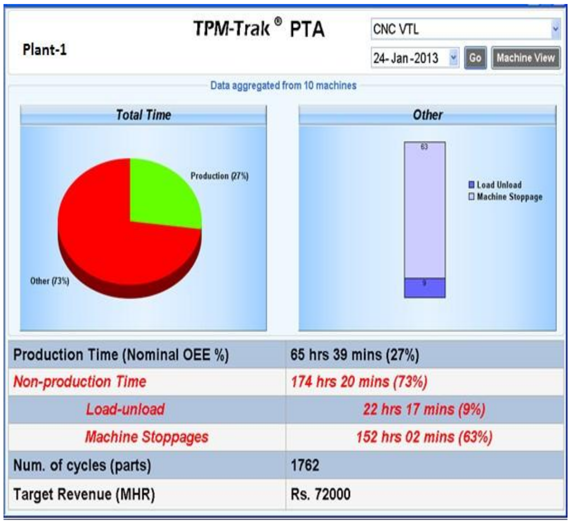
Total Quality Management (TQM) Dashboard

The Total Quality Management (TQM) dashboards are used to monitor quality events in real-time as they occur in a manufacturing enterprise. The TQM Dashboard displays real-time information about process events.



Total Productivity Management (TPM) Dashboard

The Total Productivity Management (TPM) dashboard enables operators to proactively maintain equipment and decrease production downtime. It relies on the Overall Equipment Effectiveness (OEE) system to measure productivity. The OEE system uses three measures to track productivity: Quality Performance Availability.



Analysis of Processes for Optimisation

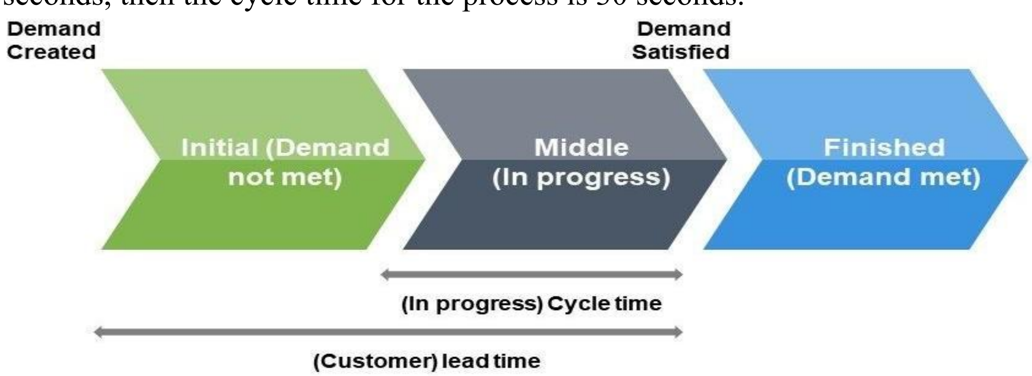
In order to analyze the selected process, there are various performance measures available which can be used to identify the issues prevailing in the existing process.

Following are a few relevant performance measures which can be opted-

Cycle time , Throughput time, and Bottleneck.

Cycle Time

Cycle time is defined as the elapsed time between two successive output from a continuously operating process For instance, in a bakery, if a loaf of bread comes out of oven every 30 seconds, then the cycle time for the process is 30 seconds.



__Throughput Time__

Throughput time is also known as lead time. It is the total time invested from the initial stage of the process to the final stage of the process. For instance, in a customized automobile organization, the order was launched on Tuesday morning at 8.00 a.m. and the product was manufactured by Wednesday evening at 4.00 p.m., in this case, the throughput time is 32 hours.

__Measuring Process Performance__

$$\text{Cycle time} = \text{Average time between completion of units}$$

$$\text{Throughput rate} = \frac{1}{\text{Cycle time}}$$

__Bottleneck__

Bottleneck is defined as a process with limited capacity that in a chain of processes tends to reduce the capacity of the whole chain. It is considered as a limiting factor that affects the overall cycle time of the production system. The main aim of process optimization is to maximize the efficiency or throughput time and minimize the cost of production.

Buffering, Blocking, Bottleneck and Starving

- __Buffer:__ a storage area between stages where the output of a stage is placed prior to being used in a downstream stage
- __Blocking:__ occurs when the activities in a stage must stop because there is no place to deposit the item
- __Starving:__ occurs when the activities in a stage must stop because there is no work
- __Bottleneck:__ stage that limits the capacity of the process