

Effect of Program Evaluation and Review Techniques in Manufacturing Industries

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Abstract

The study addressed the effect of program evaluation and review techniques in manufacturing industries. The study obtained relevant data from the staff of Nigeria Breweries Plc through personally administered questionnaire. A sample size of thirty (30) staff was selected with the aid of quota sampling technique. The data were then presented in frequency table while the hypotheses were tested using correlation coefficient with the aid of Statistical Package for Social Science (SPSS version 24). It was discovered that there is a significant relationship between program evaluation and review techniques and organizational efficiency. Therefore, it is however highly recommended that for the adoption of an appropriate project management tool by any organization to save cost and time. Otherwise the project may be too expensive and be delayed unnecessarily because the more time spent on a project the higher the cost incurred.

Keywords: *Program evaluation and Review techniques, Organizational efficiency, Performance*

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Background to the Study

In the manufacturing industry, the aim of project control is to ensure the projects are completed within the time frame, budget and scope in terms of quality. This involves constantly measuring progress; evaluating plans; and taking corrective actions when required. During the last few decades, numerous project control tools and techniques, such as Graphical Evaluation and Review Techniques (GERT), Gantt and Bar Chart, Program Evaluation and Review Technique (PERT), Benefit-Cost ratio and Critical Path Method (CPM), have been developed. Despite the wide use of these methods, some manufacturing projects still suffer time and cost overruns.

The manufacturing industry is often criticized for its poor performance, low safety, and poor work quality, wasteful, inefficient, and low productivity. In 1999 over one billion sterling pounds were spent on projects due to errors and rework (Nicholson 1999). According to Lahndt (1999), project mismanagement, insufficient planning, and poor craftsmanship contribute to poor quality performance. Many studies have urged managers in the sector to understand the relationship between quality management and performance. This calls for a need in the manufacturing industry for quality management strategies and quality improvement programmes to improve work quality and to enhance performance.

Notwithstanding the existence of several project management techniques, there are incessant increase in delay, high cost of operation and cases of substandard manufacturing of products. Thus, there exist need to investigate the cause of these abnormalities, to see if the problem is with the efficacy of the techniques or its applicability and acceptance. This work tries to analyze Six Sigma within manufacturing of products context, comparing it against different manufacturing management techniques like PERT, CPM, GERT and CBA, and evaluate its (six sigma) features that could meet these needs of construction industry from process improvement perspectives.

Statement of the Problem

For companies and factories, completing the project in the expected time is a crucial task. The completion of a project gives an economical perspective to satisfy the request of the customers. In manufacturing industry, many projects are not finished accordingly to the schedule. Thus, an extra amount of the budget and time will be requested to finish the project. Due to these reasons, project managers need to have a better technique to develop a good schedule to ensure project can be run smoothly Furthermore, the project scheduling involves sequencing and allocating time to all project activities. The manager has to decide how long each activity will be taken and to compute how many resources, including workers and materials, will be needed at each stage of the project (Heizer & Render, 2011). Scheduling is normally the bottom atomic partition of the project, which cannot be sectioned. The items of the project are frequently estimated in terms of resource requirements, budget and duration, where they are connected dependently (Ramzan, 2010). The existing tools of project management such as Program Evaluation and Review Technique (PERT), Gantt chart (GC), Critical Path Method (CPM), and Work Breakdown Structure (WBS) are the tools used to monitor the project. With these tools, the project can be run smoothly according to the planning and they help managers

to cut down costs when projects are completed on time. PERT and GC cannot cope the backand-forth altercation of information that usually happens in product development projects (Eppinger, 2001; Shi & Blomquist, 2012). Therefore, many studies about the integration of the project management techniques have been done by researchers. For examples, Azaron (2005) applied GA to develop a model for solving the time-cost trade-off problem in PERT network, where Erlang distributions of activity durations are generalized. From their experiment, the proposed GA method shows its efficiency. The study of GA with GC by Jia (2007) shows that by applying GA to the project duration, the project cost can be reduced. Unfortunately, the previous studies only integrate two of these techniques without comparing to any other methods. In this study, it is proposed that an integration of three methods, which are PERT, GC and Gantt chart, would be further considered. Additional, a comparison between PERT-GC and PERT- GC-GA are carried out to know which of the technique is able to produce a new scheduling with minimum time and cost. It is noticed that the period of the project would be shortened. This is to ensure that the total cost that is expanded on the project is minimized.

Purpose and Objectives of the Study

In order to address the research problem, the following below objectives have been set;

1. To determine the relationship between Program Evaluation and Review Technique and organizational efficiency.
2. To integrate Program Evaluation and Review Technique (PERT), Gantt chart (GC) and Genetic Algorithm (GA) for a better solution.

Research Questions

This research study is poised towards providing answers to the following questions:

1. Is there any relationship between Program Evaluation and Review Technique and organizational efficiency?
2. Is there any integration between Program Evaluation and Review Technique (PERT), Gantt chart (GC) and Genetic Algorithm (GA) for a better solution?

Research Hypothesis

In order to achieve the research objectives and provide answers to the relevant questions, the following research hypothesis was formulated for testing;

- H₁:** There is a significant relationship between Program Evaluation and Review Technique and organizational efficiency.

Significance of the Study

A comprehensive study of the existing techniques in the project management to aid scheduling of a project is provided. At the end of the study, the suggested technique will help project managers to develop an effective schedule to make sure the project completion time is finished on time or earlier than the expected time with enough of raw materials and employees in order to minimize the time and reduce the cost. The study is to understand on how to integrate PERT, GC and GA to ensure a better scheduling diagram is developed. Besides, a basic knowledge of statistics and the MATLAB coding are requested to generate parents and offspring, and to calculate the new duration of the project. The solutions obtained from the existing technique and the proposed approach are compared and explained.

Literature Review

Program Evaluation and Review Technique

Program Evaluation and Review Technique (PERT) was established by Booz, Allen and Hamilton in 1958 for the U.S. Navy (Heizer & Render, 2011). According to Evans (1964) & Howard (2009), PERT is aimed to examine and to denote the tasks that are involved in a given activity. Nevertheless, in this study, PERT is used to show the flow of the project and to know the earlier start time (ES), the earlier finish time (EF) and the time duration of each activity. As an early application of PERT, U.S. government applied it in planning and scheduling the research project for building up the Polaris Ballistic Missile (Elmaghraby, 2007; Mehrotra, 2006). Then, PERT has become the main tool especially for the project funded by U.S. government, as well as in business world. The analysis of PERT is known as stochastic activity network, which has received considerable attention in the literature (Elmaghraby, 2007; Mehrotra, 2006).

A PERT network involves a set of nodes and arrows. Nodes represent the beginning and completion of one or more activities, while arrow shows the connectivity between two nodes. There are two kinds for the PERT network, which are activity on arrow (AOA) and activity on nodes (AON). Many project managers use PERT to schedule, manage and control the large and complex project. By drawing a network graph of AOA or AON, a project manager knows the critical activities in the project, and the activities that might delay the entire project could be identified. Network diagram shows to project manager which activities are non-critical that can be run late without having any delay (Mehrotra, 2006). Hadju (2013) said that originally Program Evaluation and Review Technique (PERT) is an activity-on-arrow technique, which is considered with one start and one finish event that will represent the beginning and the end of an activity in a project. In order to accomplish the project, there are certain activities that must be carried out according to a given pre-defined sequence. PERT is broadly used as a technique for managing large projects. Many researchers have used PERT in their research, see for examples Pontrandolfo (2000), Hahn (2008) and Mouhoub, (2011). Furthermore, PERT is also used as an approach to calculate duration of time, estimated time, mean and variance of the activity duration based on pessimistic, optimistic, and most likely time estimate (Premachandra, 2001). PERT is used in the job that has activities with stochastic times (Ramirez Campos, 2003). Fatemi Ghomi and Rabbani (2003) concluded that PERT is an acyclic, linked and directed network graph, which is a linkage that has one beginning and one terminal node. In project planning and controlling, the PERT network is useful because of the length of all tasks are the positive random variables with the known probability distribution. Cohen and Sadeh (2007) explained that the creation of the PERT network is much more appropriate for certain analytical method and optimization formulation. Shenhar and Dvir (2007) enlightened that PERT is a tool to evaluate and symbolize the tasks included in finishing a given project.

As stated by Hanh (2008), PERT is a technique that the activities times are taken to be stochastic manner. Hence, to facilitate a project's management, it is needed to produce the task time distributions for the tasks in the project. Hendrickson and Au (2008) mentioned that PERT is used with the famous Gantt chart which is used to signify in time, and the various tasks. Project management experts use PERT broadly in estimating the project completion

time. It is important to know the approximation of project finishing time due to the cost of planning and the resource provision decision are joined crucially on the approximation. Since 1950s, when PERT was formulated, researchers have tried to create a difficult theoretical base and now, it is accepted that the estimations given by PERT are useful (Banerjee & Paul, 2008). PERT is used to simplify the planning and scheduling of the project. It concerns with the time needed to complete each task, the minimum time to complete the whole project and to schedule a project while not knowing precisely the particulars and periods of all the activities. Project planning and controlling are use PERT as the method that is based on a network representation of the tasks for the structure of the project (Howard, 2009). As stated by Montoya-Torres (2010), PERT and CPM are allowed to be shown by network illustrations where the arcs denote the tasks, nodes denote the actions, and the network structure denote the relationship between the jobs. Trietsch and Baker (2012) said that PERT is focused on generating and monitoring the project schedule in a stochastic manner. In this study, PERT is used to find ES and EF. It is because the data of the projects is in sequence. ES and EF are easy to use to determine the duration of the project. Many researchers have used PERT in their previous study because scheduling can be represented easily by using PERT.

Critical Path Method

In 1950s, Critical Path Method has been broadly used as the industry rule for construction project scheduling (Lu, 2008). According to Heizer & Render (2011), Critical Path Method is used for the prediction that task times are known with inevitability and only one-time factor for each task is needed. According to Kim & Jr. (2005), CPM has been broadly used in the construction company. It is used to produce a useful data for the project manager in order to plan and control the project more aggressively and competently. Nevertheless, it is proven that CPM is helpful only when the project dead-line is not fixed and the resources are not controlled by either availability or time. Thus, CPM can be highly employed by combination of knowledge-based system, as suggested by Cheng (1996), where an approximately optimum rescheduling of trains was made under time and resource constraints. During the rescheduling process, the universal information regards to final completion times of trains used was considered as a reaction function to mechanism the delay and resolution the resource conflict in relation to the current processing trains. There are four methods used to solve the problem of the resource conflict in scheduling which are Prior Arrival Method (Cheng, 2004), Local Optimum Method (Cheng, 2004, Cheng, 2006), the longest path method (Abe & Araya, 2006; Cheng, 2006) and the combined method (Cheng, 2006). Prior Arrival Method is a method that gives more priority to the arrival train compared to the departure trains for solving the resource conflict between two trains. However, Abe and Araya (2006) suggested the use of the longest path method, where all of the time and resource constraints are changed into consecutive relations in a network. But then, Cheng,2004) proposed another method named Local Optimum Method, which is a disjunctive graph model for getting more accurate simulation under resource constraints. This method is used to reduce the total delay of both arrival and departure trains by choosing one of the disjunctive arcs from a disjunctive arc pair.

As the result, of the combined method in that Prior Arrival Method's total sum of total start delay and total final delay is the longest than those from Local Optimum Method and the combined method. Yet, comparison between the combined method and Local Optimum

Method, for an initial 30 minutes' delay, which can be considered as small delay, the total start and final delays is almost the same. The computing time for both of the techniques is also the same because the slack time can be calculated if the scale of delay is large. However, for an initial delay that is more than 30 minutes, it can be assumed as a large delay, so the total final delay is reduced rapidly as the initial delay increases. Still, the total start delay is increasing slightly between 30 minutes to 57 minutes of an initial delay, and then the total start delay is reduced gradually. Nevertheless, the sum of the total start and final delays for the combined method is always less than those obtained from Local Optimal Method. It can be concluded that the combined method is more efficient than Local Optimum Method. In contrast, the computing time of the combined method is larger than Local Optimum Method.

Gantt Chart

Gantt chart (GC) has been used as a graphical tool to represent the activities schedule (Luz & Masoodian, 2011). GC is the operational procedure of such graphical schedule because GC is able to chart all of main occasions for all works on the master schedule (Wilson, 2003). Nowadays, GC is known as the most used method to plan and control the project. According to survey with the 750 project managers, GC was the fourth most used techniques out of 70 techniques that are connected with project management (Besner & Hobbs, 2008). Kelly (2001) concluded that GC is easy to understand and generally consumed for on-site announcement in the employee level. Truscott and Cho (2007; Wilson, 2003) used GC to schedule batch production through multiple work centers. The GC has been used broadly for scheduling and it builds up a planning board generator as a management decision support system (Wennik & Salvesbergh, 2006; Wilson, 2003). GC practices a time-phased needy demand method to construction planning. Gantt's planning is operated in a "top-down" method by connecting end-item necessities to their essential components with time-phased production. In this way, it allows all mechanisms to be available when they are desired for the following production activities. These due dates are further used to design day-to-day production by deciding the amounts to be completed and then pursuing production against the day-to-day goals (Wilson, 2003). Wilson (2003) also stated that the determination of GC was not the local optimization but as a portion of a larger scheme to accomplish the planning and mechanism in the factory. It is used to coordinate activities of the project or production and then the orders would flow efficiently through the factory while custody machines and staff are busy. Managers can see the progress of activities as it progresses between work centres and the time planned for each activity. GC provides means that is fast and simple to understand for recitation project activities. GC shows a readily programme and it is straightforwardly presented in a variety of layouts that is valuable for managers.

It is favorable for displaying schedule that is either created manually or through some exploratory of optimizing algorithms (Wilson, 2003). Moreover, Geraldi & Lechter (2012) said that GC is remained as an important method to both in planning and controlling project schedule. The popular project management software such as Microsoft Office Project and Primavera has used GC as the dominant platform to plan and control projects integrating all other functions of the software. By using the developed GC, project managers can easily ensure that all activities are planned, order of performance is documented, time estimation of

activity is recorded and importantly overall of project time is developed. GC is likely a permit for project managers for observing the progress of the task in the respective project. It is also to avoid any delay and in case of any problem, it can easily be spotted quickly (Heizer & Render, 2011). GC shows the relationship of each activity in the project, if any overlap activity happens, it can be seen in the chart. The estimated and realistic times for a project to be finished are also shown in the chart. Thus, the precedence relationships among tasks are identified and the critical bottleneck in the project is known so that the usage of material, workers and money can be managed easily (Heizer & Render, 2011).

The Network Diagram

In a project, an activity is a task that must be performed and an event is a milestone marking the completion of one or more activities. Before an activity can begin, all of its predecessor activities must be completed. Project network models represent activities and milestones by arcs and nodes.

Empirical Framework

Integration Techniques, Genetic Algorithm integrated with Gantt chart

The integration technique combines two or more methods for solving the scheduling problems. By integrating the methods used in scheduling with GA, different results of the schedule such as the length of the period are reduced and smaller cost is provided.

Jia (2007) showed the usage of GA that the crossover operator is applied once, and the mutation operator is applied twice to improve the selections of factory and job sequence. A better scheduling that reduces the period of the project can be developed when GA is integrated with GC. In this integrated approach, objectives such as minimization of the total length of the schedule, reducing cost and more in the reasonable computational time can be considered. Jia (2003) suggested this integrated technique, which modifies GA to solve problems in a distributed manufacturing environment. In their technique, the small-sized or medium-sized of the scheduling problem was resolved in more efficient and effective way. In description of the distributed manufacturing system, different machines with the available times for each factory to process the jobs are considered (Jia, 2007). There are four main sections and five sub-sections. At first, the selected factories and the job operations are chosen. It is complicated to encode the chromosome for the scheduling problem when jobs are being dispatched to many factories. It happens because the chromosome has to comprise more information such as selected factory for every job and their operation sequence. In the proposed integration GA technique, three digits are used as a gene to represent a factory and the operation of a job. For a selected factory, the job that is being processed is denoted by the first digit and the next two digits denote the operation of a job random combination of operation genes are used for all of the jobs. It is called chromosome in GA terminology. A preliminary chromosome population will be initially produced at random. Then, crossover and mutation are used for recombination of genes for the offspring. For crossover operation, the procedure is given below:

- (a) Choose the chromosome randomly for the gene of the parents.
- (b) Exchange the genes of the parents to produce two offspring chromosomes.

- (c) Authorize the offspring chromosomes by adding or deleting the genes of the parents. All of the operations which take over the genetic traits from their parents shall be covered.

Methodology

Research Design

The survey research method was used in the course of the study because the whole population cannot be effectively covered. Hence, a sample was selected of which the findings will be generalized for the whole population.

Data Sources and Collection Method

The data for this study originated from the primary source alone. The primary data was gathered through personally administered questionnaire aimed at obtaining first hand original responses on issues relating to the objectives of the study.

The Study Population

The population target for this study was employees of Nigeria Breweries Plc, with an estimated population of three hundred (300). From this population a sample size would be carefully selected.

Sample Size and Sampling Techniques

From the population a sample size thirty (30) staff were selected using convenience sampling technique to select ten (10) each from three different departments. This is because the sampling frame was inaccessible.

Research Instrument Specification

The research instrument that will be use in obtaining data for the study is questionnaire. The questionnaire will be close ended which will be in two part. Section A will contain the bio-data while section B will contain questions that are pertinent to the study.

Data Presentation and Method of Analysis

The study data were presented in a frequency table showing the variables, the frequency and the corresponding percentage while the hypothesis were tested with the aid of correlation using the statistical package for social science (SPSS version 20)

Data Presentation and Analysis

Presentation and Interpretation of Data

A total number of thirty (30) questionnaires were distributed among respondent and 29 were returned. The analysis is based on these responses.

Test of Hypothesis

The hypotheses were tested using Pearson Correlation. The analysis enables us identify relationship between dependent variable and independent variable.

Hypothesis One

H₁: There is a significant relationship between Program Evaluation and Review Technique and organizational efficiency.

Table 1: Correlations

		Program Evaluation and Review Technique	Organizational efficiency
Program Evaluation and Review Technique	Pearson Correlation	1	.119**
	Sig. (2-tailed)		.002
	N	29	29
organizational efficiency	Pearson Correlation	.119*	1
	Sig. (2-tailed)	.002	
	N	29	29

** . Correlation is significant at the 0.01 level (2-tailed).

Since the P- Correlation co-efficient is positive at 5% significant level indicating the level of significant relationship between Program Evaluation and Review Technique and organizational efficiency, and then the alternative hypothesis is accepted that there is a significant relationship between Program Evaluation and Review Technique and organizational efficiency.

Conclusion

From the hypothesis tested, Conclusions were drawn that:

There is a significant relationship between Program Evaluation and Review Technique and organizational efficiency. this implies that when management utilizes program evaluation and review techniques properly, it increases organizational performance level through organizational efficiency.

Recommendations

- i. Keeping the project within schedule and as well keeping the customer satisfied are the key qualities of a successful project.
- ii. Successful project management involves the use of a good project management tool. The correct project management tool can help a project manager spot the early warning trends that could spell the downfall of a project. It also allows the project manager to monitor a project, keeping abreast with trends and possible problems whether it is deviating from the schedule and planned completion time in order to keep it on track.
- iii. It is however highly recommended for the adoption of an appropriate project management tool by any organization to save cost and time. Otherwise the project may be too expensive and be delayed unnecessarily because the more time spent on a project the higher the cost incurred.

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