UTILIZATION OF NETWORK ANALYSIS FOR EFFICIENT PROJECT MANAGEMENT

Dr. Peter Ositadinma Ndubuisi
Department of Entrepreneurship Studies,
Chukwuemeka Odumegwu Ojukwu University,
Igbariam, Anambra State, Nigeria.
Email: petendubuisi@gmail.com

Dr. Friday Ogbu Edeh
Department of Business Administration
Alex Ekwueme Federal University, Ndufu-Alike, Ebonyi State, Nigeria
Email: edeh.ogbu@gmail.com

ABSTRACT
Poor project scheduling and management has resulted to delays in completion times and at heavy costs to many business organizations in Nigeria. The study aims at establishing the relevance and extent of utilization of analysis of project network in operations scheduling and management. In a field study of two firms in Enugu metropolis, data were sourced using likert structured questionnaire in alignment with the objectives. Data were analysed using Cumulative percentages and bar charts. Hypotheses were tested with the use of Pearson Correlation Coefficient (F-statistic). Findings reveal that most commercial organizations in routine operations apply Critical Path Method (CPM) in estimating time for project activities. Analysis of network results in minimizing project duration and completion costs, though delays are sometimes inevitable. It is recommended that organizations attach greater commitment to meticulous execution of critical activities to prevent overall project delays.

Keywords: Utilization, Network Analysis, Efficiency, Project Management

Introduction
One of the major challenges of modern organizations is the concept of time management as much as the exigencies to perform business operations effectively, while minimizing unsought consequences like costs. Time is the most delicate and most perishable of all assets known to man, yet the most neglected. According to Hornby (2000:1254), time is moment measured in micro seconds, seconds, minutes, hours, days, weeks, months, years, etc. The need for adequate management and apportionment of time has led to many documented efforts by management scholars, the most prominent being the time and motion studies (TAMS) of Frederick W. Taylor in the early 20th century. Consequently, the application of the results of this study (TAMS) has aided organizations significantly in achieving greater output and minimizing costs, especially idle labour.

(Klastorin, 2003:114) observes that greater emphasis are progressively being channeled on not just output and cost minimization, but in ensuring that datelines and contract timelines are kept and that strict planning schedules guide businesses in project operations, especially with globalization, research and development as well as technological growth.

Statement of the Problem

Modern business organizations are experiencing poor project management and scheduling, resulting in delays in execution and completion times. As a result, many modern projects are completed at very high costs, resulting to inefficiencies in project operations. Business organizations appear not to take full advantage of the benefits from a comprehensive analysis of project networks in achieving effective project execution. There is the need to analyze the extent to which a comprehensive application of this technique can assist firms achieve efficiency.

Objectives of the Study

The major focus of the study is to evaluate the extent of application of analysis of project network in project management by business organizations. The specific objectives of the study are to:

i)   Identify the extent to which the application of analysis of project network will result in minimizing project completion time.

ii)   Establish the extent to which analysis of project network will result in minimizing project completion cost.

Research Questions

A number of research questions have been raised to guide the study. They include:

1)   What is the degree at which the application of analysis of project network will result in minimizing project completion time?

2)   To what extent does analysis of project network result in minimizing project completion cost?

Hypotheses

H_0:   The application of analysis of project network will not significantly result in minimizing project completion time.

H_0:   The application of analysis of project network will not significantly result in minimizing project completion cost.

Scope and De-limitation of the Study

The study assesses the extent of utilization and relevance of analysis of project network in project scheduling in businesses in Nigeria. It x-rays the extent of the application, utilization, and impact of available network techniques on business activities. Programme Evaluation and Review Technique (PERT) and Critical Path Method (CPM) were examined in the operation of two medium sized business concerns in Enugu metropolis. The studied firms are Kings Engineering Limited (A Civil Engineering and Construction Firm), and Glitters Ventures Limited (A fashion design, tailoring and commercial enterprise).

LITERATURE REVIEW
Network Analysis and Project
According to Klastorin (2003), network analysis is a comprehensive and systematic schedule for planning, execution and controlling large projects like construction, engineering, maintenance, research and development, etc. It aims at effective monitoring and directing of the various activities in the progression of a project, as to complete the entire project within a minimum/specified time and cost.

Network analysis is of much avail in the allocation of resources, e.g. labour and equipment on tasks and jobs so as to minimize total cost. It is in fact, an organized application of systematic reasoning in planning and scheduling relationships among various spontaneous or systematic tasks leading to the accomplishment of a project.

Newell (2003) noted that a project is a temporary endeavour undertaken to create a unique product (goods or services). In other words, it is temporary - has a scheduled beginning and a scheduled end, it is also unique in some way - aims at producing something relatively new. A project is usually non-repetitive/non-routine, e.g. building the first Boeing jumbo jet. On the other hand, even when it is repetitive in nature, it must maintain its features of temporariness and relative uniqueness. Some ideal real life projects could be construction, e.g. stadium, inventing/manufacturing a new product, e.g. drug, designing a new car, aerospace and defense, software development, research projects, engineering and plant maintenance, etc.

Relevant Components in the Network
Typically, Munns and Bjeirmi (1996) observe that all projects must exhibit the following components:
i.   A number of separate activities or tasks which will consume resources (time, money, equipment) for accomplishment (from start to finish).
ii.   Precedence relationships – logical order of accomplishment of series of activities.
iii.   Events – Milestones or stages of actual accomplishments of each activity.
In consideration of all the above situations, the aim is to integrate/link all these activities in logical and coherent fashion to effect the completion of the project.

Network Techniques
Two different techniques are applicable in network analysis;
i.   Programme Evaluation and Review Techniques (PERT)
ii.   Critical Path Method (CPM)

Programme Evaluation and Review Techniques (PERT)
PERT was developed in 1958 by the special project office of the U.S. Navy to aid in the planning and control of its Polaris Missile programme at the time of the cold war between the U.S.A and Russia. It is most suitable to non-repetitive and novel operations especially when early completion time and not cost is of essence.

In fact, PERT is a method that minimizes production delays, interruptions and conflicts; coordinate and synchronizes various project activities; expedites the completion time of projects.

In consideration of uncertainties associated with non-routine projects to which PERT is suitable, there is an adopted formular that gives the expected time for PERT activities from the basis of past experience or guess work as follows:

$$te = \frac{a + 4m + b}{6}$$

Where: te   =   Expected time for PERT activity
a   =   Most optimistic time
m   =   Most likely time
b   =   Most pessimistic time

In the estimation of expected time for PERT activity, Koontz, et al (1983) noted that when several estimates are made, they are usually averaged, with special weight given to the most likely estimate and a single estimate then used. So, the most optimistic time refers to an estimate of time required if everything goes exceptionally well. Most likely time represents an estimate of what the project engineer really believes is necessary to accomplish the job. The most pessimistic time, an estimate predicted on the assumption that any logically conceived bad luck other than major disaster is possible. These estimates are often included because it is very difficult in many engineering and development projects to make accurate time estimates.

Application by the U.S.A Navy
The Polaris missile programme was a project to build a strategic weapons system to launch submarine intercontinental ballistic missile, at the time of the U.S.A and Russia cold war. Punmia, B.C. and K. Kardelwal (2005) observe that the military doctrine at that time (late 50's) emphasized mutually assured destruction (MAD). It implies that if the other side struck first, then sufficient nuclear weapons would remain to obliterate their homeland. That made peace preservation possible. Then, it was widely believed that the U.S.A land based missiles and nuclear bombers were vulnerable to a first strike, hence the strategic emphasis on completing the Polaris project as early as possible, irrespective of whatever it would cost. Then, the project was a novelty hence; dealing with uncertainties was a key factor. The programme evaluation and review techniques have a strong capacity to cope with uncertainties associated with likely completion times of activities.

Critical Path Method (CPM)
The critical path method was developed in the 1950's as a joint effort of two companies: Dupont and Remington Rand Univac. It is designed to be applicable to situations/ operations that are relatively repetitive or routine. In other words, less uncertainty in making estimates of time and costs. CPM brings more prominently into planning and control process, the concept of costs. It is most adapted to commercial organization, which are cost conscious.
O'Brien, James, J. et al (2010) highlight that in its applicability, the emphasis is on trade-off between costs of the project and its overall completion time, e.g. activities times are reflected in two alternate estimates: normal time, normal cost; crash time, crash cost. In this way, activity completion times may be decreased by spending more money (incurring more costs).

Frankly speaking, whether PERT or CPM is the applicable technique; there is no prejudice to the networking principles which remain the same. Network analysis is a vital technique in project management. It represents a systematic, quantitative structured approach to the problem of managing a project from start to successful completion. The PERT and CPM techniques avail of approaches to estimating time resources applied for activity completions in the overall networks.

The Sequencing Nature in Networks

Glen (1995:85) notes that effective planning of a project required careful thought and the application of logic. This is obvious because a project network consists of a range of successive activities with precedences and dependencies. Each of these activities must be successfully competed for the entire project execution to be achieved.

Step One: Listing of Relevant Activities

Here, a list of what is to be done is made. The emphasis is WHAT and not who is going to do those nor how they are to be done. The logical order of activities is not considered at this stage. Each task that must be done is regarded as an activity. To effectively manufacture a particular small item might require range of task activities (not in order of sequence) as: cutting, finishing, assembling, purchasing, machining, testing, designing.

Step Two: Determining the Order of Activities

Here, logical sequences of order of activities are determined. This order represents precedences and dependencies of activities. Activities are represented in a network as arrows and the accomplishment of each task or activity is marked as an event, represented as a node or circle. The assumption of infinite resources is made and only the most logical linkages are established. Who does what and how is not considered. So, the example above would have a logical sequence of activities as: designing, purchasing, cutting, machining, assembly, testing, finishing.

Rules in Networking Activities

A number of rules and constraints guide the sequencing of activities in a complete network,
(i)   One point of entrance (a start event) and one point of exit (an end event),
(ii)   Every activity must have one preceding (tail) event and one succeeding (head) event. A dummy activity may be introduced to preserve this rule.
(iii)   No activity can start until its tail event is reached.
(iv)   An event is not complete until all activities leading to it are complete.
(v)   Loops or series of activities which link back to the same event are not allowed.
(vi)   All activities must be integrated into the progression of the network. Danglers are not allowed,
(vii)   Event numbering must be done and in accordance with activity sequencing.
It is noted that activities in addition to being completed in succession, some of them can run consecutively or in parallel. Again, the resources available are assumed infinite and only the most logical precedence are factored in.

Step Three: Estimating Time Duration

Kerzner (2003) observes that resource requirement must always be estimated in each individual unit contribution and summed to determine the activity duration. This incorporates maximum flexibility in the planning process to enable addition of further resources later when the project begins to run late. Varying the quantity of human resource, i.e. increasing labour costs or even level of machine involvement can reduce activity duration. This could be an attractive option as

long as adequate supervision is administered. When each activity duration has been allocated, total project duration time can be obtained using the process of forward pass.

The Forward Pass

This process enables us to obtain the Earliest Start Time (EST) of a preceding activity. For the start event, the earliest start time is always O. Subsequently, the EST of a head event is obtained by adding the duration of the proceeding activity to the EST of the tail event. Where an activity is preceded by two or more activities, its EST will be the longer or longest of the EFT of all the proceeding activities.

The Backward Pass

This is the procedure for determining the Latest Start Time (LST) of a succeeding activity or the latest finish time (LFT) of a preceding activity. Here for the finish event, the LST is the same as the EST, which is the latest finish time (LFT) for the last activity in the network.

From the finish event, the LST is determined working backwards to the start event. The LST of a tail event is determined by misusing the duration of a succeeding activity from the LST of a head event. Where two or more activities succeeded from any event, the shorter or shortest of the LST of the succeeding activities is adopted as the LST of the tail event. Accordingly, the LST of the start event is always equal to zero.

Step Four: Determination of the Critical Path(s)

Kelly (1961) defines the critical path as the sequence of project network activities which add up to the longest overall duration. He further notes that this determines the shortest time possible to complete the project. Any delay of an activity on the critical path directly impacts the planned project completion date. In other words, there is no float on the critical path. A project may usually have several, parallel, near critical paths. An additional parallel path(s) through the network with the total duration(s) shorter than the critical path is known as sub-critical or non-critical path(s).

These results allow managers to prioritize activities for the effective management of project completion and to shorten the planned critical path of a project by pruning critical path activities, by fast-tracking, i.e. performing more activities in parallel, and/or by crashing the critical path, i.e. shortening the durations of critical path activities by adding resources.

Kelly and Morgan (1959) note that originally, the critical path method considered only logical dependences between terminal elements. Since then, it has been expanded to allow for the inclusion of resources related to each activity through processes called activity-based resource assignments and resource leveling. A resource-leveled schedule may include delays due to resource bottlenecks (unavailability of a resource at the required time). This may ultimately cause a previously shorter path to become the longest or most resource critical path.

Resulting from the situation above is a related concept called the critical chain. This attempts to protect activity and project durations from unforeseen delays due to resource constraints. Since project schedules may change on regular basis, critical path method allows continuous monitoring of the schedule allows the project manager to trace the critical activities and triggers alert as to the possibility that non-critical activities may be delayed beyond their total float, thus,

creating a new critical path and delaying project completion. In effect, in identifying the various paths in the network, one observes the critical path(s) as that longest path(s) and which also has the latest start time (LST) and the earliest start time (EST) of all the path(s) activities as equal. In other words, the slack value of every event on the critical path(s) is zero. This implies that no delay beyond allotted time is possible on any activity without any impact on the overall completion time of the project.

According to Glen (19995), with the arrangement of activities on the network and the identification of the critical and non-critical paths, a logical ordered and structured plan has been put in place and all that follows is to assign resources, put it into action and control the results.

Relevance of the Network in Planning and Control of Projects
Malcolm, et al. (1959) highlighted the following advantages/relevance of network analysis in projects planning and controlling;
i)   Network explicitly defines and makes visible, dependencies (precedence relationships) between the work breakdown system (WBS) elements.
ii)   Facilitates identification of the critical path and makes this visible.
iii) Facilitates the identification of the early start, late start, and slack for each event.
iv)   Provides for potentially reduced project duration due to better understanding of activity dependencies leading to improved overlapping of activities and tasks when feasible.
v)   The large amount of project data can be organized and presented in diagram for use in decision making.

Weak Points of the Network
According to Malcolm et al. (1959), these include:
i)   There can be potentially hundreds or thousands of activities and individual dependency relationships and thus very complicated to manage,
ii)   The network chart may tend to be large and unwieldy requiring several pages to print and requiring special size paper.
iii) The lack of a time frame on most PERT/CPM charts makes it harder to show status, although colours can help (e.g. specific colour for completed nodes).
iv)   When the PERT/CPM charts become unwieldy, they are no longer used to manage the project.
v)   Time estimates may be unrealistic in project scheduling, thus making execution difficult or impossible. Unexpected events or risks may also occur significantly, thus, rendering estimates unhelpful, and threatening timely execution.

METHODOLOGY
The study adopted descriptive survey research design in sourcing primary data. This was considered appropriate as it enabled the researcher to have face-to-face interaction with the respondents. Data were sourced from two business organizations in Enugu metropolis. The organizations include Kamp Engineering Associates and Glitter Ventures Limited. The sample size for the study comprised of one hundred (100) management staff employees from the two

organizations. The data used for the study were both primary and secondary. Primary data were sourced using Likert structured questionnaire, while secondary data was obtained from review of publications books, journals, internet and periodicals. A test re-test method was carried out to achieve reliability. Content validity was adopted to ensure validity of instrument. Data analysis was done by the use of bar charts and cumulative percentages. Hypotheses were tested using Pearson Correlation Coefficient (F-statistic).

DATA PRESENTATION AND ANALYSIS
Table 1: Network analysis leads to prioritization of critical path activities leading to timely completion

		Frequency	Percent	Valid Percent	Cumulative Percent
	VLE	25	25.0	25.0	25.0
	LE	28	28.0	28.0	53.0
Valid	U	8	8.0	8.0	61.0
	SE	18	18.0	18.0	79.0
	VSE	21	21.0	21.0	100.0
	Total	100	100.0	100.0	

Figure 1: Network analysis leads to prioritization of critical path activities leading to timely completion
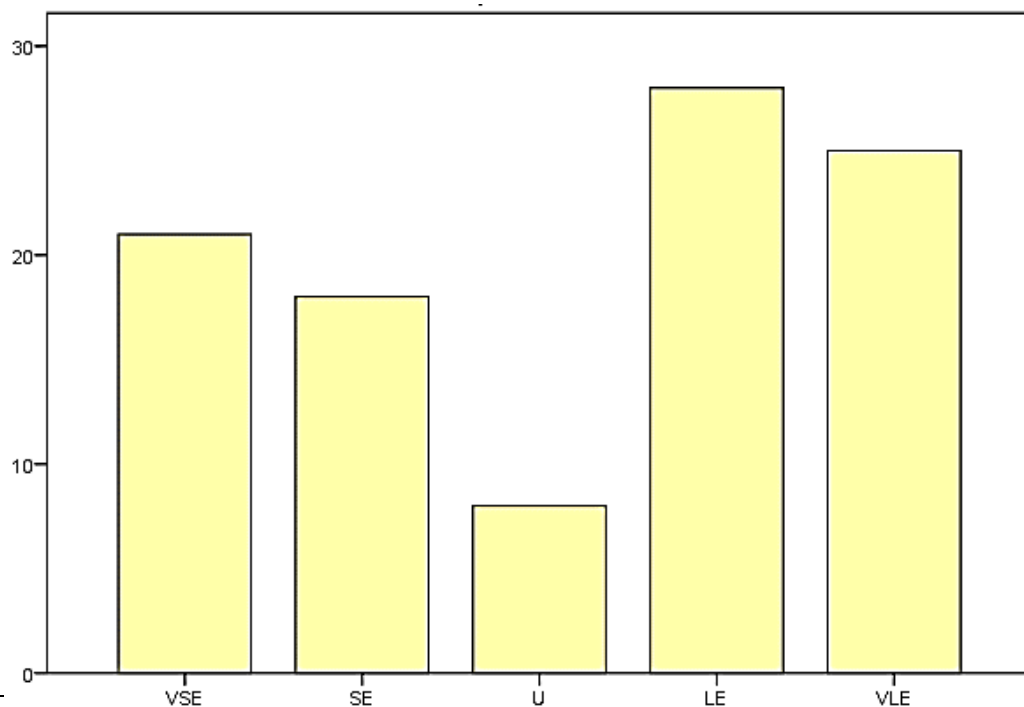
From table 1 and Figure 1, it could be seen that 25 respondents were of the opinion that network analysis leads to prioritization of critical path activities leading to timely completion to a very large extent, 28 respondents opined that network analysis integrates activities leading to timely completion to a large extent, 8 respondents were undecided, 18 respondents said that network analysis leads to prioritization of critical path activities leading to timely completion to a small extent and 21 respondents opined that network analysis leads to prioritization of critical path activities leading to timely completion to a very small extent. This shows that network analysis leads to prioritization of critical path activities leading to timely completion to a large extent.

Table 2: Network analysis results to critical resource allocation leading to cost minimization

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	VLE	32	32.0	32.0	32.0
	LE	30	30.0	30.0	62.0
	U	9	9.0	9.0	71.0
	SE	11	11.0	11.0	82.0
	VSE	18	18.0	18.0	100.0
	Total	100	100.0	100.0	

Figure 2: Network analysis results to critical resource allocation leading to cost minimization
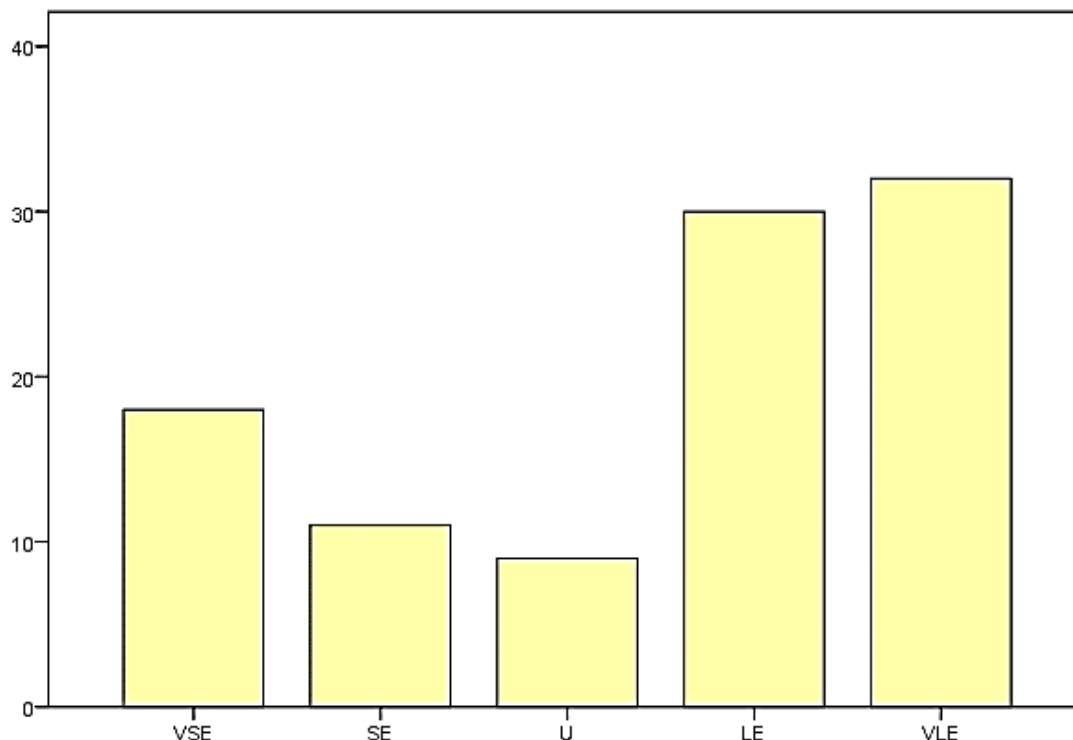
Table 2 and Figure 2 revealed that that 32 respondents were of the opinion that network analysis results to critical resource allocation leading to cost minimization to a very large extent, 30 respondents opined that network analysis results to critical resource allocation leading to cost minimization to a large extent, 9 respondents were undecided, 11 respondents said that network analysis results to critical resource allocation leading to cost minimization to a small extent while 18 respondents opined that network analysis results to critical resource allocation leading to cost minimization to a very small extent. This indicates that network analysis results to critical resource allocation leading to cost minimization to a very large extent.

Testing of Hypotheses
Hypothesis One
H_0:   The application of analysis of project network will not significantly result in minimizing project completion time.
H_1:   The application of analysis of project network will significantly result in minimizing project completion time.

Table 4.3: Correlations

		The extent at which the application of analysis of project network resulted in minimizing project completion time is very low	The extent at which the application of analysis of project network resulted in minimizing project completion time is very high
The extent at which the application of analysis of project network resulted in minimizing project completion time is very low	Pearson Correlation Sig. (2-tailed) N	1 100	.949(**) .000 100
The extent at which the application of analysis of project network resulted in minimizing project completion time is very high	Pearson Correlation Sig. (2-tailed) N	.949(**) .000 100	1 100

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

In hypothesis one, the researcher sought to ascertain the extent to which the application of analysis of project network has resulted in minimizing project completion time. In testing this hypothesis, Pearson correlation tool was used. The result showed that relationship occurred at 0.949. This means that the correlation is positive and very strong. Again, the correlation is

significant at 0.00 which is less than 0.05. This also means that the correlation was significant. The implication is that the extent at which the application of analysis of project network resulted in minimizing project completion time is very high.

Hypothesis Two
H_0:   The application of analysis of project network will not significantly result in minimizing project completion cost.
H_2:   The application of analysis of project network will significantly result in minimizing project completion cost.

Table 4.4: Correlations

		The extent to which analysis of project network resulted in minimizing project completion cost is very low	The extent to which analysis of project network resulted in minimizing project completion cost is very high
The extent to which analysis of project network resulted in minimizing project completion cost is very low	Pearson Correlation	1	.934(**)
	Sig. (2-tailed)		.003
	N	100	100
The extent to which analysis of project network resulted in minimizing project completion cost is very high	Pearson Correlation	.934(**)	1
	Sig. (2-tailed)	.003	
	N	100	100

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

In hypothesis two, the researcher sought to examine the extent to which analysis of project network has resulted in minimizing project completion cost. In testing this hypothesis, Pearson correlation tool was used. The result showed that relationship occurred at 0.934. This means that the correlation is positive and very strong. Again, correlation is significant at 0.03 which is less than 0.05. This also means that the correlation was significant. The implication is that the extent to which analysis of project network resulted in minimizing project completion cost is very high.

Summary of Findings

1. Majority of the respondents (53%) agree to a large or very large extent that network analysis leads to prioritization of critical path activities, leading to timely completion of projects. Using Pearson correlation coefficient to test the hypothesis, there exists high degree of relationships at 0.949.
2. Majority of the respondents (62%) agree to a large or very large extent that network analysis results to critical resource allocation, leading to project cost minimization. In testing the hypothesis, the relationship occurred at 0.934, which is positive and strong.

Conclusions

In spite of obvious constraints in the application of analysis of project networks, this comprehensive schedule has remained indispensable in the planning, execution and controlling of projects. Critical path method (CPM) has significantly helped business organizations in achieving substantial trade-off between time and cost and, yet achieving profit and early project completion. PERT represents the most dynamic response to the modern institutional need for early project completion in situation when cost is not of essence. Their respective integration to the project network has aided the process of activity-based resource (time) assignment. Further, proper tracking of critical activities ensures overall network effectiveness.

Recommendations

1. Knowledge of analysis of project network though popular should be applicable in all relevant organizations to facilitate activity scheduling; sequencing and early completion at minimum cost.
2. All organization staff especially project and engineering units must be fully educated and oriented on the need to adhere to the order of scheduling.
3. Relevant organizations must ensure that activity durations along the critical path are not delayed beyond allotted time, this requires meticulous efforts in order to avert the danger of late completions.

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