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THE ROLE OF MICROSOFT PROJECT PLANNER IN ENHANCING CONSTRUCTION PROJECT SCHEDULE PERFORMANCE: RESEARCH AGENDA

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Abstract: This paper presents the methodology used to develop a generic procedural framework for evaluating the effectiveness of construction project schedules, focusing on the impact of start date constraints within Microsoft Project. Literature reveals a gap in user guidance on selecting start date options when scheduling project activities, with most users opting for the "as soon as possible" (ASAP) setting, while fewer choose the "as late as possible" (ALAP) approach. The practicality and effectiveness of these choices remain uncertain. To investigate, two hypotheses were formulated to assess the relationship between start time constraint options and variances in activity start and finish times. A pilot survey was conducted, and Analysis of Variance (ANOVA) was applied to test the hypotheses. Results indicate an F-calculated value of 0.86, which is less than the critical F-values at both 1% (5.14) and 5% (10.9) significance levels. Consequently, the null hypotheses were rejected, confirming a significant relationship between the choice of start time constraint and activity start variance. Specifically, schedules employing the ALAP constraint exhibited reduced variability in activity start times, implying higher reliability and predictability in project execution. This finding suggests that adopting the ALAP scheduling option may improve schedule stability and accuracy. The study's framework offers a structured approach for project managers and schedulers to evaluate scheduling effectiveness and make informed decisions in project planning using Microsoft Project.

Keywords: Construction Scheduling, Start Time Constraints, Activity Variance, Microsoft Project, Schedule Effectiveness

INTRODUCTION

Research is a process of a systematic inquiry by which knowledge of how things are, why things are the way they are and how they might be changed is created. It is an intensive and ordered study of a subject aimed at learning new facts, making and testing scientific propositions and ideas.

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The purpose of this research whose methodology is described is to develop a generic framework for evaluating the effectiveness of aspects of construction project schedules. It is a 'What-if' implication study of decision options in construction scheduling. The study evaluated the performance metrics of construction schedules resulting from using three different scheduling options: early start schedule, late start schedule and differential early/late start schedule. The purpose is to evaluate which of these option produced which level of schedule performance measured in terms of variability of activity start time. Though the Microsoft project planner's guide gives instructions and displays useful information in relation to the selected option, they lack the ability to indicate case scenarios where selected options are best suited or 'what-if' implications of selected options. It is noted from literature (Efole, 2009) that category A, B and C construction tasks qualify for 'as soon as possible' schedules, while category D tasks qualify for 'as late as possible' schedules. Some research questions emerging from this knowledge: How will the schedule perform if all tasks are scheduled using early start schedules? How will the schedule perform if all tasks are scheduled using late start schedules? Yet, more grounded, how will the schedule perform should early start schedules be applied on tasks that ought to be scheduled with late start? What are the implications of choice beyond the default option? These focused research questions informed the hypothesis formulated and tested.

The Research Design

The methodology used in this study is presented in Figure 1. A preliminary literature in the domain problem and later a thorough and extensive review in this same area show that the problem of right choice of start date for project activities can be investigated by comparing the

'As-Built' schedule with the 'As-Planned' schedule. To confirm the length and breadth of the problem and to define how best to proceed with the investigation, a pilot survey was conducted for about four months. The literature and the further enlightenment gained from the scoping survey helped to identify the boundary of the research problem and also to define three research approaches to investigate the problem of right choice of start date for project activities. These approaches are:

(i)   In-depth case study of on-going and or completed construction projects scheduled with Microsoft project planner.

(ii)   A quasi-experiment to investigate the relationships between identified variables to assist examination of the direction, strength and causality of the relationships in view   of theory and literature.

(iii)   ANOVA statistical tool to test and verify the hypotheses formulated.

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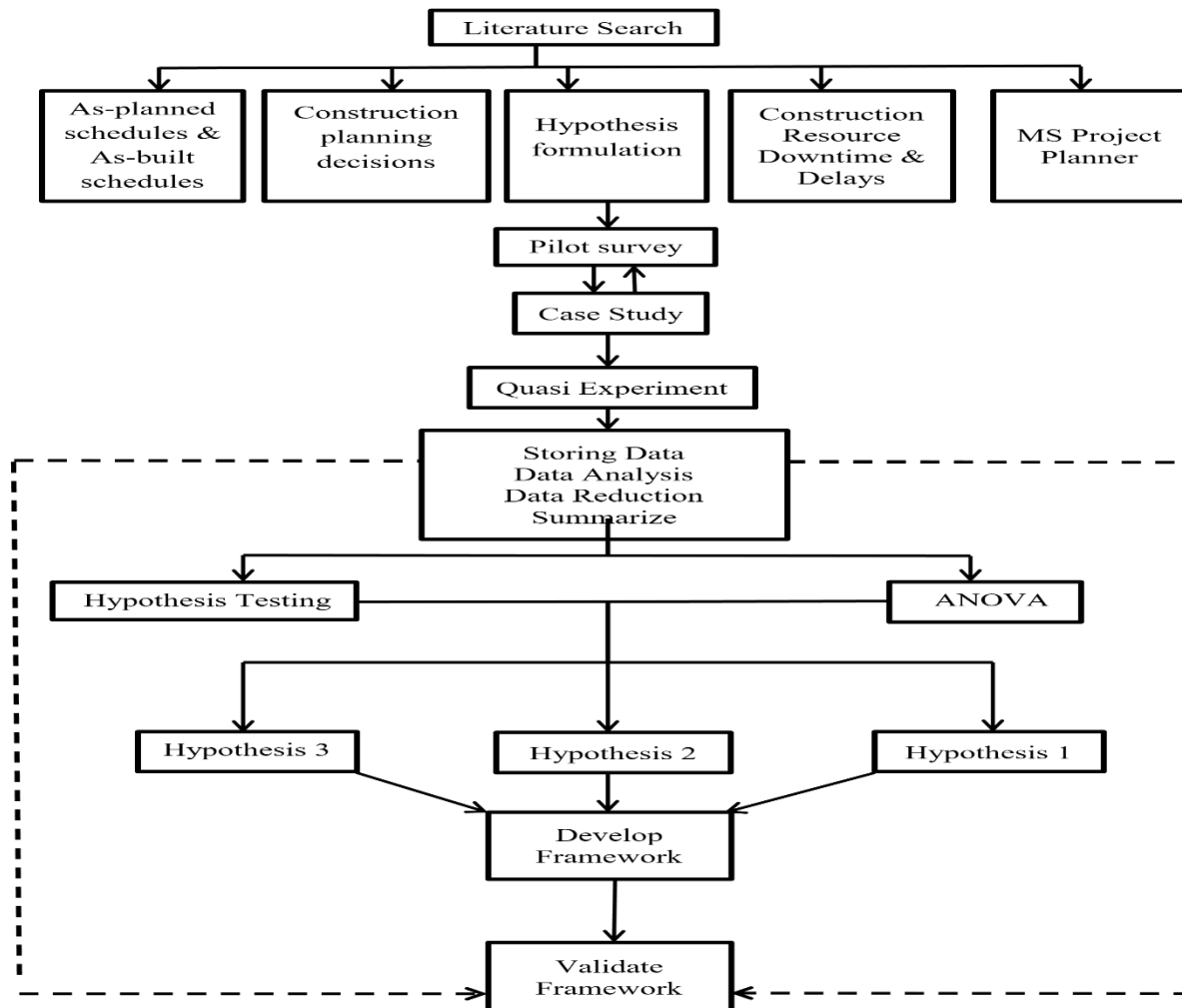
Figure 1. Flow Chart of Thesis Methodology

THE STUDY POPULATION AND SAMPLING

If practicable the entire population if known should be studied to make quality inference. If the population is precisely known but is large, a sample is selected to represent the entire population. Inferences and conclusion drawn should recognize relationship between the sample and the population. However, construction projects studies are unlike many other studies where the number of study subjects can be precisely known. There are no accurate registers of all construction projects ongoing at any particular time. Therefore it is safe to assume a scenario of an unknown population. This is because such properties like the population mean used in error, in data analysis could yield misleading and erroneous results. This is why a case study research design is proposed to collect data from five ongoing projects and replicate these through experimental research design.

CONVENIENCE, QUOTA AND PURPOSIVE SAMPLING

Three sampling techniques (convenience, quota and purposive sampling) are used to select a sample size of five ongoing projects. Eric (1998) said that convenience sampling is a method in which the sample sizes of those units that happen to be available at the time of data collection are considered. Quota sampling could yield more

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representative sample than convenience sampling because even though in general a researcher has considerable freedom of choice, there is the restriction that certain characteristics of the sample must be typical or representative of the group being studied. This restriction is the 'large' construction projects scheduled with Microsoft project. And purposive sampling is defined as a method of sampling which draws a sample to illustrate or represent some characteristics of interest. For instance selecting only case projects that have adopted a certain technology. In this case, projects scheduled with Microsoft project.

SAMPLING ERROR AND LEVEL OF SIGNIFICANCE

Eric (1998) opines that sampling error is the amount of imprecision that results due to the fact that an enquiry is limited to a part of the population rather than the entire population. While a random sample may give results that are generalizable to the entire population, it does not follow that sample estimates of population characteristics and properties will necessarily be exact as the true value of those characteristics or properties of the entire population. Rather a difference often exists between these estimates and the true population values.

Every sampling whether from a known or unknown population is inherently affected by sampling error. The error is more in the case of unknown population in which there is no wellstructured means of estimation. Osuala (1990) and Black and Champion (1976) describe types of errors and how to avoid them. If the research rejects a null hypothesis which is true and should not have been rejected indicate a type I error. And if the research fails to reject a null hypothesis which is false and should have been rejected indicate a type II error. Osuala (1990) submits that the 0.01 level of significance is more exacting than the 0.05 level. The premise of his argument is that the confidence with which an investigator rejects or retains a null hypothesis depends on the level of significance adopted. A similar view is held by Black and Champion (1976) who state that the level of significance as one of the decision rules is the amount of type I error the investigator is willing to permit in testing the hypotheses and making quality and meaningful inferences. Although any probability level can be selected as the amount of type I error permitted. Conventionally used levels of significance are 0.1, 0.05 and

0.01. A 0.05 level of significance permits 5 percent probability for type 1 error. A decision made to reject a hypothesis at this level of significance has 5 percent chance of being wrong in rejecting a hypothesis that is possibly true that should not have been rejected. If rejected at 0.10 level of significance there is a 10 percent chance that the decision is wrong. If rejected at 0.01 level of significance there is only 1 percent chance the decision is wrong, this supports Osuala (1990) that the 0.01 level of significance is more exacting than the 0.05 level.

EXPERIMENT AND QUASI-EXPERIMENT RESEARCH DESIGN

Fellows and Anita, (2003) opines that an experiment is an activity or a process which produces events, and possible alternative outcomes. Hicks, (1982) defines an experiment as a study in which certain independent variables are manipulated and the consequential effects on the dependent variables observed.

An experimental study is a type of enquiry in which a stimulus is applied to a subject and the effect observed. In classical experimental design, a researcher allocates randomly selected subjects, items or individuals to at least two groups. One group (experiment group) is subjected to an intervention or treatment while the other group (control group) is not. The effect of the treatment can be observed by comparing outputs in the two groups. The classical experimental studies have three integral requirements: Manipulation of treatment or intervention;

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Control; and Randomization. Manipulation means that the researcher does something to one group of subjects in the study. Control means the researcher introduces control groups mainly without the type of intervention in experimental group so that results can be compared. Randomization means that the researcher ensures that each subject is given an equal chance of being assigned to either group.

A quasi-experimental study on the other hand is a type of enquiry in which, even though at least one characteristic of a true experiment is missing, must always include manipulation of an independent variable that serves as the treatment or intervention.

RESEARCH INSTRUMENT VALIDITY

Validity of experimental results means that the conclusions of the study are true and reliable, that someone else using the same method in the same circumstances should obtain similar or same findings. Validity and reliability ratings of research conclusions may be: Neither valid nor reliable; Reliable but not valid; fairly valid but not reliable; Valid and reliable. One way this research tries to eliminate threats to validity is the selection of appropriate research design. Threats to validity include: confounding factors (i.e., rival or alternative explanations); unexpected historical factors; Bias; and Unreliability of the survey instrument. The strategies to deal with threats to validity adopted in this proposed research include: Unobtrusive methods of data collection; Careful design and pre-testing of survey instrument and scoping survey.

Ideally the study variables should be isolated through the design of the experiment such that only one of the possibly independent variables is changed and the consequential effects on isolated single dependent variable observed and measured accurately. Hick's definition raises the issue of the way in which the independent variable is chosen and manipulated. Although random variation is one approach, often for numerical variables particular values within a range of interest are assigned to the independent variable. While for categorical variables choice made is informed by the purpose of the research, theory and literature. This method of choice of the independent variable by the range of interest provides much practicality, but some restriction on the inference which can be drawn from the results is observed. This is obviously so because variation of restricted independent variables cannot yield results of other independent variables not considered in the experiment.

In construction management and construction project-based experiments, it is neither practical nor possible to allow only one independent variable to alter in value, nor is it possible to isolate individual dependent variables. Hence the usual approach to experimental design is to devise a study in which the main independent variables except the one of interest are held approximately constant and the consequences of the major dependent variables measured. Such an approach which restricts both the consideration of all possible independent variables as well as consideration of the consequential change of all dependent variables is called a quasiexperiment. In this research being proposed, such independent variables as organisational arrangements, different management styles of project managers, project types, site location and weather are held approximately constant to have least or no effect on observed consequential change in the dependent variables.

This experimental research design has answered the research questions and proposed solutions to the research problem. The objective of any theory building and knowledge production process is to support and facilitate making informed assertion and informed decision. In the case of experimental research, the decision and assertion concern inference about the relationships of variables of interest investigated. Thus it is important that the

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variables are clearly identified. Also statements of appropriate definitions, means of measurement and explicit assumptions of these variables is made to help in formulation of appropriate hypotheses.

Eric, (1998) said a variable can be numeric or category. Numeric variables are those whose different values are expressed in numbers e.g., person's age in years, weight in kg and distance in km and monthly income in Naira, Dollars or Pounds. Categoric variables are those whose values are expressed in categories; sex either male or female; colour: red, blue, yellow or green; occupation: medical doctor, pharmacist, trader, farmer or artisan. Types of variables considered in this study are: Dependent variables; Independent variables; Confounding variables and Background variables. Dependent variables are those which are used to describe or measure the problem or phenomenon under study. They are regarded as being caused or forced by other variables called independent variables. The variables that are used to describe or measure the factors that are assumed to cause or influence the problem or phenomenon are called independent variables. A confounding variable is directly associated with possible cause of the problem. It may either strengthen or weaken the relationship between the problem and the possible cause.

Eric, (1998) further asserts that regarding an association between, say variables X and Y, a researcher can conclude that X causes Y only if it can be demonstrated that Y was consequent upon X and that no other factors may have caused Y. So to provide a true picture of cause and effect, the confounding variables must be taken into account. On the other hand, background variables are indirectly associated with possible cause of the problem. A note is here made that the three important variables or statistics considered in this research are: A variation of different scheduling option (categorical variables); Different projects (categorical variables) and Defined outcome of key performance indicators (numerical variables).

Clearly, the measurement of variables is crucially important. Experimental design considers the degree of accuracy which can be achieved and the method for achieving it. Fellows and Anita (2003) discuss three approaches for selecting the independent variables so that consequential change in the dependent variables can be observed and measured. These are: Randomized change selected ranges of variables; The most restrictive or a convenient approach. For such experiments, the main independent variables are identified by scrutiny of theory and literature. Use of extreme values of the variables should result in maximum effects on the dependent variables. This is why in the experiment proposed the two extreme categorical values of 'as soon as possible' and 'as late as possible' are being considered because they result in maximum effects on the dependent variables. The most restrictive or the most convenient approach is adopted to control the independent variables rigidly.

A universal and desirable feature of experimental research is replication. Replication facilitates increased numbers of observations and measurements of the variables under identical treatments. It assists provision of an estimate of experimental error, identification and quantification of sources of error, and leads to a reduction in standard errors thereby increasing precision. For instance as the number of observations, 'N' increases the standard error of the dependent variable reduces as illustrated in equation 1

$$S_Y = \sqrt{S^2} \qquad \qquad \text{equation} \quad 1 N$$

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Source: Fellows and Anita (2003)

where:

S_Y = Standard error of the mean of the dependent variable Y

S^2 = Sample variance

N = Number of observations

This formula suggests that the standard error will reduce with increase in number of observations made possible by replication. Clearly therefore, replication assists inference. As replication increases, so a wide variety of situations and variables can be subject to the experiment thereby yielding a greater range of conditions to which the results may apply. This is why Petersen (1985) suggests that, due to the nature of standard errors, the accuracy of experimental results can be improved by increasing the size of the experiment by replication, incorporating more treatment values of the independent variables. He further states that due to the nature of standard errors, the accuracy of experimental results can be improved by: Increasing the size of the experiment by replication incorporating more treatments of the values of the independent variables; Refining the experimental method to achieve reduction of experimental error through reducing sample variance; Measuring a concomitant variable, or another associated independent variable to facilitate covariance analysis or the variance of the combination of the variables which may yield reduced experimental error.

Table 1 presents the experimental design in which varying treatments are applied in scheduling projects $1 - k$, while possible outcomes are represented as $X_{11}, X_{12}, X_{13}...X_{1k}$. The table presents a construct of projects' key performance indicators due to different treatments 1, 2,....j. Treatments '1 to j' represents different scheduling options applied. Performance outcomes are shown as $X_{11}, X_{12}, X_{13}, X_{14}, ...X_{1k}$. Key performance indicator 1 in project 1 due to treatment 1 is shown as (X_{11}), key performance indicator 1 in project 2 due to treatment 1 shown as (X_{12}), key performance indicator 1 in project 3 due to treatment 1 shown as (X_{13}), up to and including key performance indicator 1 in project K shown as (X_{1K}) due to treatment

1. And $\ddot{X}_{1k}$, $\ddot{X}_{2k}$, $\ddot{X}_{3k}, \ddot{X}_{jk}$, representing observed group average due to the respective treatments. Similarly, treatment 1 can generate data for outcome of key performance indicator 2 for the same projects 1, 2, 3, 4.......K.

Table 1: Notation for ANOVA Two Factor Experiments

	Block or Project					
	1	2	3	......	k	
Treatment 1	X_{11}	X_{12}	X_{13}	....	X_{1k} $\ddot{X}1k$	
Treatment 2	X_{21}	X_{22}	X_{23}	....	X_{2k} $\ddot{X}2k$	:
:	:	:	:	:	:	
Treatment j	X_{j1}	X_{j2}	X_{j3}	....	X_{jk}	
$\ddot{X}jk$						
	$\ddot{X}_{1j}$	$\ddot{X}_{2j}$	$\ddot{X}_{3j}$	....	$\ddot{X}_{kj}$	

Source: Spiegel and Larry (2008)   Where:

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Treatment j = A categorical variable which represents start time constraint options eg. As Soon As Possible and As Late As Possible

Block or Project = On-going or completed Projects from which data are obtained

X_{jk} = Observed key performance indicator due to treatment j on project k

$\ddot{X}_{jk}$ = Mean within group of treatment j

$\ddot{X}_{kj}$ = Mean within block of project due to treatments 1-j

The purpose of this classification in the quasi experiment is to test whether there is a significant difference in the observed data (means) or whether it can be concluded that observed trend is due simply to chance. According to Spiegel and Larry (2008) problems such as this are solved by using ANOVA. Which can systematically show or otherwise that the different treatments applied have created the observed outcomes on the different case projects. This experiment employs method of agreement of cause and effect, method of difference and method of concomitant variation to draw conclusion on logical proof of the effects of start date constraint on performance of construction schedules. Method of agreement entails both the positive agreement and the negative agreement. By positive agreement it is meant that when two or more cases of a particular phenomenon have one and only one condition in common, then that condition is regarded as the cause or the effect of that phenomenon. If we observe phenomenon Y in every case that we introduce condition X, it can be concluded that X and Y are causally related. Or simply put, if factor X is always found wherever Y is observed, X could be the cause of Y. The inherent weakness of this logical proof is that some factors may not have been taken into account. It is possible that X operates fully only when other conditions not considered are present. Moreover Y may have had a different cause in each of the cases, (Eric, 1998). On the other hand, the negative method of agreement holds that when factor nonX is observed to be associated with phenomenon non-Y, a causal relationship between X and Y may be concluded. Thus whenever an absence of factor X is associated with an absence of Y, it may be accepted that a causal relationship exists between X and Y. But it is possible that many important factors were left out of the consideration. Perhaps non-X leads to non-Y only when other factors are either present or absent. Or that non-Y may have had a different cause in each of the cases.

The method of difference design of logical proof proposes that if in two or more cases, phenomenon Y can be observed in one of them, while it cannot in the other; and if factor X takes place when phenomenon Y is observed and does not take place when phenomenon Y is observed, then it is possible that there is a causal relationship between X and Y. While the first observation leads to a conclusion that X could cause Y, the second shows that other factors (not taken into account) could possibly cause Y.

Besides the problem of recognizing and controlling the variables which are thought to be most important in the research, the design of proof can be undermined by the fact that the causal relationship may not be clear or even weak. The difficulty lies in the fact that the relationship between X and Y could be any of the following possibilities, (Eric, 1998):

X is the cause of Y.

Y is the cause of X.

X and Y are both caused by another variable unknown or hidden.

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A or B may also be the cause of Y but this relationship is obscured by other unknown factors. X may cause Y but only when other unknown factors are present.

X does not cause Y because any indication to the contrary is a mere chance or fortuitous occurrence.

According to Eric, (1998), the method of concomitant variation investigates the concomitant relationships between the variables. Concomitant means association or in agreement. Concomitant variation amongst a set of data therefore explains how the change in one data set affects the other in the association. This method states that if a change in the amount of one variable causes comparable change in the amount of another variable in more than one case, and the latter change does not occur in absence of the first change, one change is the cause (or effect) of the other. There are many types of hypothesized relationships that are possible, with this kind of logical proof, (Eric, 1998): Perfect positive correlation; Perfect negative correlation; Perfect curvilinear correlation and Very low correlation. As such, the method of concomitant variation is applied today as correlation analysis. The connections between variables X and Y, if considered as causal under this method, pose similar problems as in the method of agreement and method of difference. Problems such as the direction of causality and the presence of unknown factors need to be carefully considered. In this research it is assumed that the only factors which cause change on the dependent variables (project performance metrics) are the variation in scheduling treatment.

THE STUDY HYPOTHESES

A key aspect of knowledge building is concepts, hypotheses and empiricism. According to Fellows and Anita (2003), a hypothesis is a statement of conjecture, a hunch, a speculation, or an educated guess. It is a supposition which is tested rigorously by research to remove as much of the supposition (or uncertainty) as possible. This uncertainty is replaced with knowledge that is certain, more realistic, less risk of being correct and more probability of being correct. The Chambers English dictionary in Fellows and Anita (2003) defines a hypothesis as: A supposition; A proposition; A theory to be proved or disproved by reference to facts; A provisional explanation of an idea. This proposed research therefore has drawn on literature, Efole (2009) to identify variables (dependent and independent) to formulate hypotheses to be tested. These hypotheses act to focus the research and define the boundary of the study. Three dependent variables, activity Start Variance, activity Finish Variance and project end date variance; and two independent variables, start time constraint options and project types are used in the hypotheses formulation.

Table 2. The Fields used for Tracking in Microsoft Project (Key Performance Indicators)

Tracking fields			
Current schedule	Baseline	Variance	Actual
~~Start~~	~~Baseline start~~	~~Start Variance~~	~~Actual start~~
Finish	Baseline finish	Finish Variance	Actual Finish
Duration	Baseline duration	Duration Variance	Elapsed Duration
Remaining Duration			
Work	Baseline work	Work Variance	Work complete

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Remaining work Cost	Baseline cost	Cost Variance	Cost to date

Remaining cost

Source: Tim Pyron (1998)

Table 2 illustrates the key performance indicators of the project which may have been created as a result of the start time constraints employed in developing the schedule:

As soon As possible	(ASAP);	As Late As possible	(ALAP);
Start No Earlier Than	(SNET);	Start No Later Than	(SNLT);
Finish No Earlier Than	(FNET);	Finish No Later Than	(FNLT);
Must Start On	(MSO);	Must Finish On	(MFO)
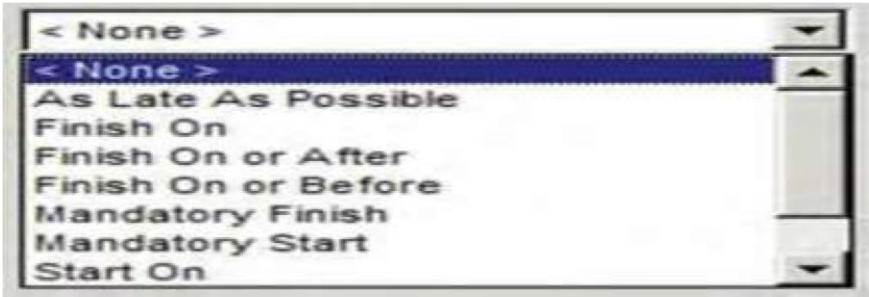
Figure 2- The Constraint Pull down menu in MS Project

Source: Carl and Timothy (2010)

It is noted that aside from the two extreme start time constraints, As soon As possible (ASAP); and As Late As possible (ALAP); the others are mandatory start or finish options used only when certain scenarios are present and therefore it is not necessary to hypothesize their effects on project performance metrics since they satisfy a mandatory need which cannot be otherwise satisfied.

The two independent variables, project types and start time constraints are categorical variables while the three dependent variables activity start variance, activity finish variance and project end date variance are examples of numerical variables. These are represented in Figure 2, tables 1, 2 and 3. In this research it is not necessary to attempt to assign numeric values to the categorical variables because the categorical variables are only taken as different treatments which when changed causes the dependent variables to change.

Table 3. Constraint Types in MS project

Constraint Category	Constraint Types	Means of A ction
Flexible	As Soon As Possible (ASAP)	Project will schedule a task to occur as soon as it can occur. This is the default

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constraint		when scheduling from
the		project start date.
	As Late As Possible (ALAP) Project	will schedule task
		to occur as late as it can
	occur. This is the default	
		constraint type applied
all	to	non critical tasks when
scheduling		from the project finish
date.		

Source: Carl and Timothy (2010)

It is observed that a hypothesis is a statement of conjecture which suggests a relationship between a dependent and independent variable. This statement concerns the nature, direction, strength and causality of the relationship. For example, 'the method of scheduling construction projects employed by contractors influences project performance and hence stakeholders satisfaction'. Apart from the criticism of the language construct, this hypothesis contains two dependent variables: project performance and stakeholders' satisfaction. This type of hypothesis with two or more dependent variables is difficult to test because test result may support one part and not support the other. This is why Fellows and Anita (2003) suggest a split of such hypotheses into two main hypotheses, not auxiliary hypotheses to be tested. Two hypotheses are now formulated:

HYPOTHESIS I: START TIME CONSTRAINT AND ACTIVITY START VARIANCE

Null hypothesis: There is no significant relationship between start time treatment options and activity start variance on any row j, and column k (X_{jk}). $H_0 : \ddot{X}_{1k} = \ddot{X}_{2k} = \ddot{X}_{jk}$

Alternative hypothesis: There is a significant relationship between start time treatment options and activity start variance (X_{jk}). $H_1 : \ddot{X}_{1k} \neq \ddot{X}_{2k} \neq \ddot{X}_{jk}$

The treatment options used in the hypotheses are: As Soon As Possible (ASAP) and As Late As Possible (ALAP) as illustrated in table 3. The philosophy behind using the means of activity start variance and activity finish variance to formulate the hypotheses in this manner is that if indeed there is no relationship between the dependent variable and the independent variable, then the observed means will be the same as shown in the null hypothesis. And if the converse, the alternative is true (i.e., there is a relationship), this will show in the fact that the observed means of the dependent variables will vary along the row as treatment number 1 is being applied to projects 1, 2,…. k. And it will also vary as different treatments 1, 2, …. J, are being applied to a particular project along the column representing different projects or different blocks. The degree of variability which ANOVA seeks to unveil is a measure not only of the strength, but that of direction of the relationship between the variables of interest.

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HYPOTHESIS II: START TIME CONSTRAINT AND ACTIVITY FINISH VARIANCE

Null hypothesis: There is no significant relationship between the start time option treatment and activity finish variance on any row j, and column k (X_{jk}).

H_{0b}: $\ddot{X}_{1k} = \ddot{X}_{2k} = \ddot{X}_{jk}$

Alternative hypothesis: There is a significant relationship between start time option treatments and activity finish variance (X_{jk}). H_{1b}: $\ddot{X}_{1k} \neq \ddot{X}_{2k} \neq \ddot{X}_{jk}$

ANALYSIS OF VARIANCE (ANOVA)

Earl, (1986) opines that analysis of variance applies the logic of statistical significance. The ANOVA technique initially developed for use in agriculture and biology by Fisher makes use of the F distribution at defined degrees of freedom. Spiegel and Larry (2008) notes that the ANOVA technique can be applied to investigate the consequential effect of four different chemical treatments of soil on the produced wheat yields in an agricultural experiment. The four different chemical treatments of soil produced mean wheat yields of 28, 22, 18, and 24 bushels per hectare. ANOVA is used to test for differences within and between subgroups of the sample. The technique reveals if there is a significant difference in these means and further if observed spread is due to chance or that quality inferences can be drawn that the difference in wheat yield is due to the different application of chemical treatments. There are two common forms of ANOVA, one-way and two-way Analysis of variance. In one-way classification or one-factor experiment, measurement or observations are obtained for 'a' independent groups of samples, where the number of measurement in each group is 'b'. This means there are 'a' treatments, each of which has 'b' repetitions or replications. In the example given above if each chemical treatment is applied repeatedly on a single soil location perhaps during different years the result is a one-factor experiment or a one-way ANOVA and is presented in table 4.

Table 4: Notation for ANOVA One-factor experiment

Treatment 1	X11, X12, X1b	X_1
Treatment 2	X21, X22,…………..X2b	X_2
⋮ ⋮ ⋮	⋮ ⋮ ⋮	⋮ ⋮ ⋮ $\ddot{X}a$
Treatment a	Xa1, Xa2, Xab	
		$\ddot{X}_{1k}$, $\ddot{X}2k$, $\ddot{X}bk$

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Source: Spiegel and Larry (2008)

It is a one-factor experiment because the one treatment is repeated on the one soil location several times. If however the different treatments are applied to different soil locations investigating the consequential effects of different treatment on different soil location results in a two-factor experiment because apart from varying applied treatment the soil location is also varied. The variation of these two factors, different chemical application and different soil location may have probably partially accounted for the different mean wheat yields of 28, 22, 18, and 24 bushels per hectare. A two-way ANOVA permits a simultaneous examination of two or more variables giving the effects of the two explanatory variables in a manner similar to that of partial correlation where observed key performance indicators of the project may be explained partially due to the different scheduling treatment on the one hand and partially due to project type scenarios on the other. The result of a two-factor experiment or a two-way ANOVA is presented in table 1. The two factor experiment proposed measures consequential effect of Treatment j: start time options (As Soon As Possible and As Late As Possible) applied on different Blocks or Projects and the observed key performance indicators due to the treatments. Tables 5 and 6 explain the procedure for estimating F calculated in both one-factor and two-factor experiment in ANOVA. The procedure is simple and involves estimating variation observed within treatment as well as between treatments. And by applying the degrees of freedom as shown in the tables, the mean square are estimated which are used to calculate the F statistic. 'a' is number of rows while 'b' is number of columns in tables 1 and 4.

Table 5. Procedure for Estimating F Calculated in ANOVA Two-Factor Experiment.

Sources of variation	Degrees of Freedom	Mean square	F Statistic
Between treatments	$S^2_R = V_R$	FC = S2R	S2E
$V_R = b\Sigma(\ddot{X}_j - \ddot{X})^2$	a - 1	a-1	With a-1 and ab(c-1)
J Degrees of freedom			
Between blocks	$S^2_C = V_C$	FC = S2C	S2E
$V_C = a\Sigma(\ddot{X}_K - \ddot{X})^2$	b − 1	b-1	With b–1 and ab(c-1)
K Degrees of freedom			
Residual or random	$S^2_I = V_E$		
$V_E = V - V_R - V_C$	(a-1)(b-1)	(a-1)(b-1)	
Total			
$V = V_R + V_c + V_E$	ab -1		
$V = \Sigma(X_{jkl} - \ddot{X})^2$			

Source: Spiegel and Larry (2008)   Where:

j = 1,2,3…..a k = 1,2,3….b

X_{jkl} = each term of all entries

N = Total number of all entries

$\ddot{X}$ = $\frac{\Sigma X_{jkl}}{N}$ = mean for all entries

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$\ddot{X}_j$ = mean within treatment group (row mean)

$\ddot{X}_k$ = mean within project or block (column mean)

$V = V_R + V_c + V_E$ equation 2

$V = \sum_{jkl} (X_{jkl} - \ddot{X})^2$ equation 3 used to confirm equation 2

$V_{E=}$ Variation due to error or chance $= \sum_{J,k} (X_{jk} - \ddot{X}_j - \ddot{X}_k + \ddot{X})^2$ equation 4

$V_{R=}$ variation between rows (treatments) $= bc \sum_{j=1}^{a} (\ddot{X}_j - \ddot{X})^2$ equation 5

$V_c = ac \sum_{k=1}^{b} (\ddot{X}_k - \ddot{X})^2$ equation 6

Table 6. ANOVA Table for One-Factor Experiment

Sources of variation	Degrees of Freedom	Mean square	F Statistic
Between treatments $V_B = b \sum_J (\ddot{X}_j - \ddot{X})^2$	$a - 1$	$S^2_B = \dfrac{V_B}{a-1}$	$F_C = S^2_B \quad S^2_W$ With a-1 and a(b-1) Degrees of freedom
Within treatments $V_W = V - V_B$	$a(b-1)$	$S^2_C = \dfrac{V_W}{a(b-1)}$	
Total $V = V_B + V_W$ $V = \sum_{Jk} (X - \ddot{X})^2$	$ab-1$		

Source: Spiegel and Larry (2008)

DECISION RULES IN ANOVA

The F statistic is the property of the sample which indicates the degree of variability of the data obtained in the experiment. Though by visual inspection, the nature and the direction of this variability can be evident, ANOVA helps to test if the observed data trend is due to applied variation of the different treatment. The decision rule in ANOVA is simple. It involves assessing and comparing two statistics, the F calculated and the F obtained from

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table at stated significant level with defined denominator and numerator degrees of freedom (Spiegel and Larry, 2008). If $F_{CAL} > F_{TAB}$: H_1 is rejected and H_0 is accepted. If $F_C < F_T$: H_1 is accepted and H_0 is rejected.

A PILOT SURVEY OF THE RESEARCH

The purpose of the scoping survey is to use objective data to assess whether or not a problem exist as defined in the problem statement and if solution can be sought in the way and manner conceived. Bills of quantities are prepared for a simple 5-Bedroom duplex building to determine the quantum of work. And using empirical field survey of production output, deterministic duration estimates are used to schedule the construction as shown in Figure 3. Table 8 illustrates the project activities showing activity names and the 'i-j' dependency relationships.
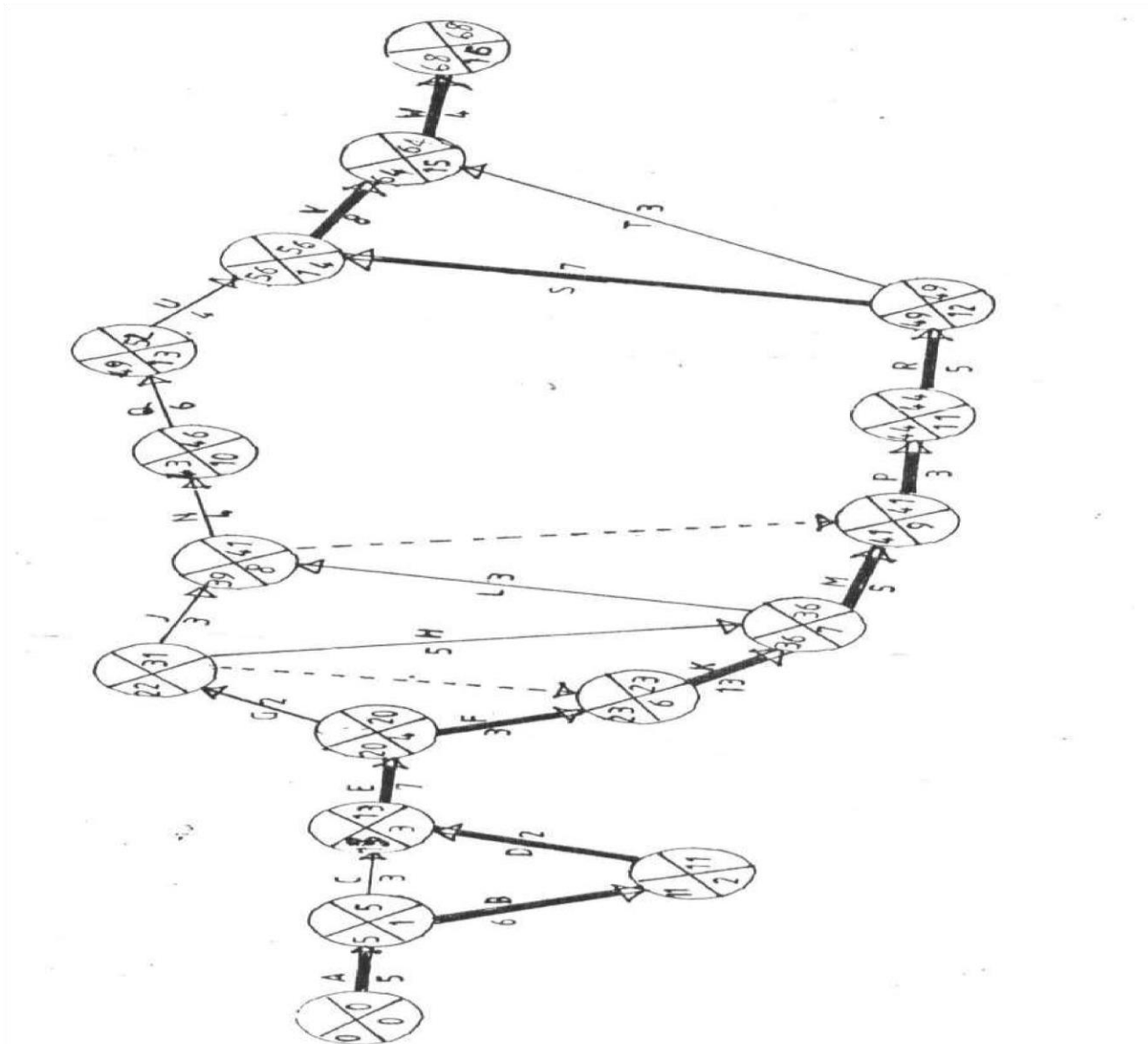
Figure 3. CPM Schedule of a Case 5-Bedroom Duplex Building

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Table 8. Project Activities and 'i-j' Dependency Relationships

Item	Activity	i-j	Activity Description	Duration (Weeks)
1	A	0-1	Mobilization to site, site preparation and preliminaries	5
2	B	1-2	Setting out and excavate column bases	6
3	C	1-3	Excavate foundation trenches	3
4	D	2-3	Earthwork support and surface treatment	2
5	E	3-4	Con. In foundation footing and col. bases	7
6	F	4-6	Foundation walls, h/c filling, Backfilling & disposal	3
7	G	4-5	Ground floor slab	2
8	-	5-6	Dummy	-
9	H	5-7	230mm Blockwork in load bearing walls	5
10	J	5-8	150 mm Blockwork in load bearing walls	3
11	K	6-7	Conc. in superstructure cols, beams, stair cases and suspended floors	13
12	L	7-8	Timber roof members and roof covering	3
13	M	7-9	Metal first fix (door and window frames)	5
14	-	8-9	Dummy	-
15	N	8-10	Metal second fix (Glazing)	4
16	P	9-11	Woodwork first fix (doors, frames, skirting, kitchen cabinet and dado rails)	3
17	Q	10-13	Woodwork second fix (Flush doors)	6
18	R	11-12	Internal and External rendering	5
19	S	12-14	M & E Installations	7
20	T	12-15	Internal and External painting	3
21	U	13-14	Floor Finishings	4
22	V	14-15	Fencing Drainage and External works	8
23	W	15-16	Clean site, Mobilisation from site and Handover	4

Source: Illustrative example

Table 9. Event Time Analysis and Float Estimates

S/NO	Activity	Activity i-j	Duration (Weeks)	Earliest Start	Fin	Latest Start	Fin	Float Total	Free	Remark
1	A	0-1	5	0	5	0	5	0	0	C/A
2	B	1-2	6	5	11	5	11	0	0	C/A
3	C	1-3	3	5	8	10	13	5	5	N

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4	D	2-3	2	11	13	11	13	0	0	C/A
5	E	3-4	7	13	20	13	20	0	0	C/A
6	F	4-6	3	20	23	20	23	0	0	C/A
7	G	4-5	2	20	22	29	31	9	0	N
8	-	5-6	-	22	22	23	23	1	1	N
9	H	5-7	5	22	27	31	36	9	9	N
10	J	5-8	3	22	25	18	41	16	14	N
11	K	6-7	13	21	36	23	36	0	0	C/A
12	L	7-8	3	36	39	38	41	2	0	N
13	M	7-9	5	36	41	36	41	0	0	C/A
14	-	8-9	-	39	39	41	41	2	2	N
15	N	8-10	4	39	43	42	46	3	0	N
16	P	9-11	3	41	44	41	44	0	0	C/A
17	Q	10-13	6	43	49	46	52	3	0	N
18	R	11-12	5	44	49	44	49	0	0	C/A
19	S	12-14	7	49	56	49	56	0	0	C/A
20	T	12-15	3	49	52	61	64	12	12	N
21	U	13-14	4	49	53	52	56	3	3	N
22	V	14-15	8	56	64	56	64	0	0	C/A
23	W	15-16	4	64	68	64	68	0	0	C/A

Table 9 illustrates event time analysis, showing earliest/latest dates events can occur and float estimates. The schedule shown in Figure 3 has 23 activities and the events are scheduled from start date to begin on the 17th of March 2014 and end on 3rd of July 2015 using Microsoft project planner, as illustrated in Figure 4 and Table 10.

Table 10. Early Start Schedule

ACTIVITY ID	ACTIVITY START DATE	ACTIVITY FINISH DATE	ACTIVITY DURATION
1	17.03.14	18.04.14	5WKS
2	21.04.14	30.05.14	6
3	21.04.14	09.05.14	3
4	02.06.14	13.06.14	2
5	16.06.14	01.08.14	7
6	04.08.14	22.08.14	3
7	04.08.14	15.08.14	2
8	15.08.14	15.08.14	DUMMY
9	18.08.14	19.09.14	5
10	18.08.14	05.09.14	3
11	25.08.14	21.11.14	13
12	24.11.14	12.12.14	3

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13	24.11.14	26.12.14	5
14	12.12.14	12.12.14	DUMMY
15	15.12.14	09.01.15	4
16	29.12.14	16.01.15	3
17	12.01.15	20.02.15	6
18	19.01.15	20.02.15	5
19	23.02.15	10.04.15	7
20	23.02.15	13.03.15	3
21	23.02.15	20.03.15	4
22	13.04.15	05.06.15	8
23	08.06.15	03.07.15	4

Footnote: This is the default scheduling option where all non-critical activities are scheduled to occur as soon as possible.

Table 11 presents the late start schedule where all non-critical activities are schedule to occur as late as possible. Events are scheduled from start date to begin on the 17th of March 2014 and the project still ends on the 3rd of July 2015.

ACTIVITY ID	ACTIVITY START DATE	ACTIVITY FINISH DATE	ACTIVITY DURATION
1	17.03.14	18.04.14	5WKS
2	21.04.14	13.06.14	6
3	26.05.14	13.06.14	3
4	02.06.14	13.06.14	2
5	16.06.14	01.08.14	7
6	04.08.14	22.08.14	3
7	04.08.14	15.08.14	2
8	22.08.14	22.08.14	DUMMY
9	20.10.14	21.11.14	5
10	24.11.14	12.12.14	3
11	25.08.14	21.11.14	13
12	24.11.14	12.12.14	3
13	24.11.14	26.12.14	5
14	26.12.14	26.12.14	DUMMY
15	15.12.14	09.01.15	4
16	29.12.14	16.01.15	3
17	12.01.15	20.02.15	6

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18	19.01.15	20.02.15	5	**Table 11. Late Start Schedule**
19	23.02.15	10.04.15	7	
20	18.05.15	05.06.15	3	
21	16.03.15	10.04.15	4	
22	13.04.15	05.06.15	8	
23	08.06.15	03.07.15	4	

Footnote: All non-critical activities are scheduled to occur as late as possible using all available free float. This is the default option when scheduling from predetermined project end date.

Table 12 presents activity start dates for differential early/late start schedule. This scheduling option applies differentially early and late schedule on selected non-critical activities based on project specific attributes. In this option events are scheduled from start date to begin on the 17th of March 2014 and the project still ends on the 3rd of July 2015.

These three different scheduling outcomes seem to present similar scenarios of the project starting and ending on the same dates. The effects of the different scheduling options however, will become apparent when all unexpected events that could occur have taken place and when built into the schedule, MS project recalculates new updated schedules illustrated in Tables 13,14 and 15; and Figures 7, 8 and 9.

Table 12. Differential Early/Late Start Schedule

ACTIVITY ID	ACTIVITY START DATE	ACTIVITY FINISH DATE	ACTIVITY DURATION
1	17.03.14	18.04.14	5WKS
2	21.04.14	30.05.14	6
3	26.05.14	13.06.14	3
4	02.06.14	13.06.14	2
5	16.06.14	01.08.14	7
6	04.08.14	22.08.14	3
7	04.08.14	15.08.14	2
8	15.08.14	15.08.14	DUMMY
9	18.08.14	19.09.14	5
10	18.08.14	19.09.14	3
11	25.08.14	21.11.14	13
12	24.11.14	12.12.14	3
13	24.11.14	26.12.14	5
14	12.12.14	12.12.14	DUMMY
15	15.12.14	09.01.15	4

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16	29.12.14	16.01.15	3
17	12.01.15	20.02.15	6
18	19.01.15	20.02.15	5
19	23.02.15	10.04.15	7
20	18.05.15	05.06.15	3
21	23.02.15	20.03.15	4
22	13.04.15	05.06.15	8
23	08.06.15	03.07.15	4

Footnote: This scheduling option applies differentially early and late schedule on selected

Non-critical Activities based on project specific attributes, task specific attributes and resource specific attributes.

Table 13. Updated Early Start Schedule

ACTIVITY ID		ACTIVITY START DATE	ACTIVITY FINISH DATE	ACTIVITY DURATION
1		17.03.14	18.04.14	5WKS
2		21.04.14	30.05.14	6
3		21.04.14	09.05.14	3
4		02.06.14	13.06.14	2
5		16.06.14	01.08.14	7
6		04.08.14	22.08.14	3
7		04.08.14	15.08.14	2
8		15.08.14	15.08.14	DUMMY
9		18.08.14	19.09.14	5
10		18.08.14	05.09.14	3
11		25.08.14	21.11.14	13
12		24.11.14	12.12.14	3
13	X	15.12.14	16.01.15	5
14		12.12.14	12.12.14	DUMMY
15	X	05.01.15	30.01.15	4
16		19.01.15	06.02.15	3
17		02.02.15	13.03.15	6
18		09.02.15	13.03.15	5
19		16.03.15	01.05.15	7
20		16.03.15	03.04.15	3
21		16.03.15	10.04.15	4
22		04.05.15	26.06.15	8

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| 23 | 29.06.15 | 24.07.15 | 4 |

Footnote: Updated Early start schedule when start of activities 13 & 15 are each delayed for three weeks.

Table14: Updated Late Start Schedule

ACTIVITY ID		ACTIVITY START DATE	ACTIVITY FINISH DATE	ACTIVITY DURATION
1		17.03.14	18.04.14	5WKS
2		21.04.14	30.05.14	6
3		26.05.14	13.06.14	3
4		02.06.14	13.06.14	2
5		16.06.14	01.08.14	7
6		04.08.14	22.08.14	3
7		04.08.14	15.08.14	2
8		22.08.14	22.08.14	DUMMY
9		20.10.14	21.11.14	5
10		24.11.14	12.12.14	3
11		25.08.14	21.11.14	13
12		24.11.14	12.12.14	3
13	X	15.12.14	16.01.15	5
14		26.12.14	26.12.14	DUMMY
15	X	05.01.15	30.01.15	4
16		19.01.15	06.02.15	3
17		02.02.15	13.03.15	6
18		09.02.15	13.03.15	5
19		16.03.15	01.05.15	7
20		18.05.15	05.06.15	3
21		16.03.15	10.04.15	4
22		04.05.15	26.06.15	8
23		29.06.15	24.07.15	4

Footnote: Updated Late start schedule when start of activities 13 & 15 are each delayed for three weeks

Table 15. Updated Differential Early/Late Start Schedule

ACTIVITY ID	ACTIVITY START DATE	ACTIVITY FINISH DATE	ACTIVITY DURATION
1	17.03.14	18.04.14	5WKS
2	21.04.14	30.05.14	6
3	26.05.14	13.06.14	3
4	02.06.14	13.06.14	2

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5		16.06.14	01.08.14	7
6		04.08.14	22.08.14	3
7		04.08.14	15.08.14	2
8		15.08.14	15.08.14	DUMMY
9		18.08.14	19.09.14	5
10		18.08.14	05.09.14	3
11		25.08.14	21.11.14	13
12		24.11.14	12.12.14	3
13	X	15.12.14	16.01.15	5
14		12.12.14	12.12.14	DUMMY
15	X	05.01.15	30.01.15	4
16		19.01.15	06.02.15	3
17		02.02.15	13.03.15	6
18		09.02.15	13.03.15	5
19		16.03.15	01.05.15	7
20		18.05.15	05.06.15	3
21		16.03.15	10.04.15	4
22		04.05.15	26.06.15	8
23		29.06.15	24.07.15	4

Footnote: This is updated activity start and activity finish dates for differential CPM schedule.

Table 16. Variance for Early Start Schedule

ACTIVITY ID	ACTIVITY START VARIANCE	ACTIVITY FINISH VARIANCE
13	15.12.14 -24.11.14 = 3 WKS	16.01.15 -26.12.14 = 3 WKS
14	12.12.14 – 12.12.14 = 0 (DUMMY)	12.12.14 – 12.12.14 = 0 (DUMMY)
15	05.01.15 – 15.12.14 = 3	30.01.15 – 09.01.15 = 3
16	19.01.15 – 29.12.14 = 3	06.02.15 – 16.01.15 = 3
17	02.02.15 – 12.01.15 = 3	13.03.15 – 20.02.15 = 3
18	09.02.15 – 19.01.15 = 3	13.03.15 – 20.02.15 = 3
19	16.03.15 – 23.02.15 = 3	01.05.15 – 10.04.15 = 3
20	16.03.15 – 23.02.15 = 3	03.04.15 – 13.03.15 = 3
21	16.03.15 – 23.02.15 = 3	10.04.15 – 20.03.15 = 3
22	04.05.15 – 13.04.15 = 3	26.06.15 – 05.06.15 = 3
23	29.06.15 – 08.06.15 = 3	24.07.15 – 03.07.15 = 3
	$\ddot{X}$ = 3	$\ddot{X}$ = 3

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Footnote: Corresponding dates in updated early start schedule minus dates in initial early start schedule.

Table 17. Variance for Late Start Schedule

ACTIVITY ID	ACTIVITY START VARIANCE	ACTIVITY FINISH VARIANCE
13	15.12.14 – 24.11.14 = 3 WKS	16.01.15 – 26.12.14 = 3 WKS
14	26.12.14 – 26.12.14 = 0	26.12.14 – 26.12.14 = 0
15	05.01.15 – 15.12.14 = 3	30.01.15 – 09.01.15 = 3
16	19.01.15 – 29.12.14 = 3	06.02.15 – 16.01.15 = 3
17	02.02.15 – 12.01.15 = 3	13.03.15 – 20.02.15 =3
18	09.02.15 – 19.01.15 = 3	13.03.15 – 20.02.15 = 3
19	16.03.15 – 23.02.15 = 3	01.05.15 - 10.04.15 = 3
20	18.05.15 – 18.05.15 = 0	05.06.15 – 05.06.15 = 0
21	16.03.15 – 16.03.15 = 0	10.04.15 – 10.04.15 = 0
22	04.05.15 – 13.04.15 = 3	26.06.15 – 05.06.15 = 3
23	29.06.15 – 08.06.15 = 3	24.07.15 – 03.07.15 = 3
	$\ddot{X}$ = 2.4 WKS	$\ddot{X}$ = 2.4 WKS

Footnote: Corresponding dates in updated late start schedule minus dates in initial late start schedule.

Table 18. Variance for Differential Early/Late Start Schedule

ACTIVITY ID	ACTIVITY START VARIANCE	ACTIVITY FINISH VARIANCE
13	15.12.14 – 24.11.14 = 3 WKS	16.01.15 – 26.12.14 = 3 WKS
14	12.12.14 – 12.12.14 = 0 (DUMMY)	12.12.14 – 12.12.14 = 0 (DUMMY)
15	05.01.15 – 15.12.14 = 3	30.01.15 – 09.01.15 = 3
16	19.01.15 – 29.12.14 = 3	06.02.15 – 16.01.15 = 3
17	02.02.15 – 12.01.15 = 3	13.03.15 – 20.02.15 =3
18	09.02.15 – 19.01.15 = 3	13.03.15 – 20.02.15 = 3
19	16.03.15 – 23.02.15 = 3	01.05.15 - 10.04.15 = 3
20	18.05.15 – 18.05.15 = 0	05.06.15 – 05.06.15 = 0
21	16.03.15 – 23.02.15 = 3	10.04.15 – 20.03.15 = 3
22	04.05.15 – 13.04.15 = 3	26.06.15 – 05.06.15 = 3
23	29.06.15 – 08.06.15 = 3	24.07.15 – 03.07.15 = 3
	$\ddot{X}$ = 2.7 WKS	$\ddot{X}$ = 2.7 WKS

Footnote: Corresponding dates in updated differential early/late start schedule minus dates in initial differential early/late start schedule.

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Table 19. Project End Date Variance

TREATMENT	PROJECT END DATE VARIANCE
I	24.07.15 – 03.07.15 = 3WKS
II	24.07.15 – 03.07.15 = 3WKS
III	24.07.15 – 03.07.15 = 3WKS

Footnote: Project end date variance is the updated end date minus initial end date.

DISCUSSION of PRELIMINARY RESULTS OF HYPOTHESIS I

From the variance analysis presented in Tales 16, 17, 18, and 19, Table 20 is generated. Table 20 is similar to table 4 which shows different scheduling options adopted and observed variance during project implementation. And using the formulae proposed in table 6, the F_{CAL} is obtained to test the hypothesis that there is no significant relationship between the start time options (treatments) and activity start variance. H_{0b}: $\ddot{X}_{1k} = \ddot{X}_{2k} = \ddot{X}_{jk}$

Since $F_{CAL} < F_{TAB}$, we accept H_1: That there is a significant relationship between start time options and activity start variance. This means that the trend in table 20 has not occurred by chance. It is concluded that treatment II (Late start schedule) is a much more level headed and desirable schedule with reduced activity start variability. This is the incremental contribution to knowledge.

Table 20. ANOVA Table for One Factor Experiment of Pilot Survey

		ASV	AFV	PEV	
Treatment I		3	3	3	$\ddot{X}_J = 3$ WKS
II	2.4	2.4	3	= 2.6	
III	2.7	2.7	3	= 2.8	

Footnote: ANOVA table for one factor experiment obtained from tables 16 -17.

Where: ASV: Activity start variance, AFV: Activity finish variance, PEV: Project end date variance, b: number of variables considered and $\ddot{X}_J$: within treatment average.

Between treatments variation
$$V_B = b\Sigma(\ddot{X}_j - \ddot{X})^2$$
$$J$$
Within treatment variation
$$V_W = V - V_B$$

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Total variation

$$V = \Sigma(X_j - \ddot{X})^2$$
$$J$$

$\ddot{X} = \Sigma X_{jk} =$ mean for all entries $= 2.8$

$$\overline{}$$
$$N$$

$V_B = 3[(3 - 2.8)^2 + (2.6 - 2.8)^2 + (2.8 - 2.8)^2] = 3 [(0.04) + (0.04) + (0)] = 0.12$

$V = [(3 - 2.8)^2 + (3 - 2.8)^2 + (3 - 2.8)^2 + (2.4 - 2.8)^2 + (2.4 - 2.8)^2 + (3 - 2.8)^2 + (2.7 - 2.8)^2 +$
$(2.7 - 2.8)^2 + (3 - 2.8)^2]$

$= [(0.04) + (0.04) + (0.04) + (0.16) + (0.16) + (0.04) (0.01) + (0.01) + (0.04)] = 0.54$ $V_W = V - V_B = 0.54 - 0.12 = 0.42$

$S^2_B = V_B = 0.12 = 0.06$ a-1   2

$S^2_W = V_W = 0.42 = 0.07$
     a(b-1)   6

$F_{CA} = \dfrac{S^2_B}{S^2_W} = \dfrac{0.06}{0.07} = 0.86$

$F_{TAB} = 5.14$ Obtained from table at 1 % level of significance
     $= 10.9$,   5 %   ,

CONCLUSION

The extent to which early start schedule is or is not a practical and effective scheduling option being in question is confirmed in this study. A significant relationship between start time constraint options (treatments) and activity start/finish variance is shown very clearly in the study. Therefore building and civil engineering contractor should schedule some project activities as late as possible while others which meet the criteria are scheduled as early as possible. If this rule is followed as demonstrated in this research project events are likely to occur as planned which ensures more schedule effectiveness.

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