Systematic Examination Techniques for Planning and Scheduling Among Saudi Arabian Construction Firms

by

Abdullatif Mohammad Hamad Al-Abdullatif

A Thesis Presented to the

FACULTY OF THE COLLEGE OF GRADUATE STUDIES

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This thesis, written by **ABDULLATIF MOHAMMAD HAMAD AL-ABDULLATIF** under the direction of his Thesis Advisor and approved by his Thesis Committee, has been presented to and accepted by the Dean of the College of Graduate Studies, in partial fulfillment of the requirements for the degree of **MASTER OF SCIENCE IN CONSTRUCTION ENGINEERING AND MANAGEMENT.**

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بسم الله الرحمن الرحيم

Dedicated to my beloved

Father and Mother

for their continuous support

and Encouragement.

And to my Brothers, Sisters, wife,

Friends and all of my Relatives,

who had put up with so much

while I worked on this thesis

and helped so much in the effort.

الإهداء

يسرني

اهدائه الى من كانوا سبب وجودي في هذه الحياة [illegible]

وعرفاناً ومحبة وتقديراً [illegible]

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وزوجتي وأقاربي وأصدقائي [illegible]

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الحمد لله [illegible] رب العرش العظيم

... والى وطني الكبير

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عنوان الرسالة : تقنيات وأساليب الأنظمة المنهجية لفحص الخطط والجدولة لصناعة التشييد في المملكـــــة العربية السعوديـــــة .
التخصـــص : هندسة وإدارة التشييد .
التاريـــخ : ربيع أول ١٤١١هـ .

انجز هذا البحث بإستخدام عينات إستبيانية لمسح ميداني وضع فيه كيفية فحص تطبيق الأساليب التقنية والإنتفاع منها وإعتبارها كأدوات فعالة للتخطيط المنهجي والبرمجة عبر جداول تنفيذية لمشاريع التشييد الصناعي في المملكة العربية السعودية . إن معظم مدراء ومقاولي التشييد وأصحاب المشاريع يناشدون المشاركة في الوصول إلى هدف واحد ألا وهو إختزال تكاليف المشاريع وتفادي تأخير تنفيذها مع الحدة من حدوث الدعاوي والشكاوي والمظالمات . وتحقيق ذلك يساعد ويؤمن لهم تطوير قدراتهم ويمكنهم من الحصول على مشاريع مستقبلية ويؤازرهم على إعتزاز مكانتهم ويجعلهم بإستمرار منخرطين بأعمال التشييد . ولايسعنا أن ننسى أن التخطيط والجدولة الفعالة لتنفيذ المشاريع تؤدي إلى تحسين طبيعة ونوعية التنفيذ لها وإنجازها في وقتها المحدد وفق الميزانية المرتبطة بها مع العلم أن هذا بحد ذاته من من أهم أهداف حكومة المملكة العربية السعودية . إن هذه الأساليب تعتبر كوسائل لتنظيم التخطيط وكأدوات للتحكم ولضبط عمليات التشييد ولكونها تساعد في تحديد المشاكل الناتجة عن الزيادة الباهظة في التكاليف والتقليل من حدتها . ومن هذا المنطلق يتوجب معرفة أساسيات وفرضيات كل أسلوب على حدة لدراسته والتمعن بمفاهيمه .

تتضمن الأساليب النظامية كل من البرامج والتقنيات التالية : طريقة المسار الشبكي الحرج لإنجاز العمل (CPM) ، إسلوب تقييم برامج العمل الشبكي ومراجعته (PERT) ، برنامج حق الأسبقية الشبكية لمسار العمل (PND) ، إسلوب رسم شبكي لبرنامج العمل ومراجعته(GERT) ، مخطط تقدم العمل (GBC) .

العينة الإستبيانية لهذه الدراسة شملت ٦١ شركة ومؤسسة في القطاع الخاص من ثلاث مناطق من المملكة . يحتوي المسح الميداني على أسئلة عدة منها الإستفسار عن كيفية تطبيق تلك الأساليب ، هيئة وسمة إستعمالاتها ، مستويات الإستفادة من إستخداماتها ، الفوائد الناتجة من إستعمالاتها ، مدى أهميتها ، مدى نجاحها ، العوامل المؤثرة لقياس النجاح ، أسباب النجاح ، أسباب الفشل في إستعمالاتها ..إلخ

إن جميع هذه العوامل رتبت حسب مؤشر دلالة الأهمية لإستعمالاتها وكذلك مؤشر دلالة النجاح في الإنتفاع منها . ولقد تم تفصيل كل ترتيب على حدة موزعة على ثلاث أطراف وهم الشركات الكبرى والوسطى والصغرى ومن ثم عُمل ترتيب آخر يضم جميع الأطراف حسب كل مؤشر . وتبين من الإختبارات الإحصائية أن جميع الأطراف متفقون على ترتيب جداول (مؤشر دلالة الأهمية و مؤشر دلالة النجاح) لتلك العوامل . وتيقن بواسطة فحص إحصائي للتأكد عن مدى صحة ماتقدم .

سيزود هذا البحث القارىء بفوائد ومنافع منها أكاديمية وعملية . ففي الحقل الأكاديمي هذا البحث الأول من نوعه في مضمار التجربة والإستقراء لإستخدامه أساليب التقنية لتقديم الخطط وبرمجة الجدولة الفعالة في المملكة وذلك لمعرفة تطبيقاتها ومميزاتها ومساوئها . أما في الحقل العملي فهذا البحث سيبين ويوضح للممارسين لمهن التشييد مدى وطبيعة مجالات التطبيقات العملية للأساليب التقنية التي تؤمن أنواع متعددة وفوائد مترتبة من تطبيق تلك الأساليب وسيعطي الأدارة العليا لمشاريع التشييد مناظر ووجهات توضيحية عن المشاكل المتعلقة بتطبيق أي برنامج أو مخطط زمني في منجزات التشييد .

ويمكن الإستفادة من نتائج الإستبيان التي بنيت على ضوءه عدة مقترحات ونصائح يستخلص منها في عملية تحسين كيفية تطبيق تلك الأساليب وطرح بعض المواضيع المتعلقة بأعمال التشييد في المملكة وإقتراح بعض الدراسات المستقبلية في مجال تطبيق تلك الأساليب في إختزال التكاليف والجدولة الفعالة عبر خطط زمنية منتظمة .

درجة الماجستير في العلـــوم

جامعة الملك فهد للبترول والمعادن- الظهران ، المملكة العربية السعودية

THESIS ABSTRACT

NAME : ABDULLATIF MOHAMMED HAMAD AL-ABDULLATIF

TITLE: SYSTEMATIC EXAMINATION TECHNIQUES FOR PLANNING AND SCHEDULING AMONG SAUDI ARABIAN CONSTRUCTION FIRMS

MAJOR: CONSTRUCTION ENGINEERING AND MANAGEMENT

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This thesis, using a sample survey, will examine the implementation and utilization of the Systematic Examination Techniques (SET) as an effective tool for planning and scheduling in the Saudi Arabian construction industry. Most construction managers, construction firms and project owners share the same objective of reducing project cost and avoiding delays and litigation or claims. Achieving this target helps every construction manager, project owner and/or any other concerned person in developing the process for getting new jobs and continuing to exist. Effective planning and scheduling leads to improved quality of construction projects by incentives, reduction of costs and completion of projects within their assigned budget and time constraints. This is one of the main objectives and policies of the Government of Saudi Arabia. SET are applied as effective planning and controlling assessment tools in construction settings for helping to define and limit the problems of increased construction project costs. To meet the abovementioned targets, the concepts and principles associated with each technique must be defined and studied carefully. The SET includes CPM, PND, PERT, GERT and GBC.

A survey of 61 construction contractors from three regions of Saudi Arabia was undertaken. The survey included questions asking for the technique implemented by the firms, aspects of use, user's levels, benefits obtained, the degree of importance, the degree of success, criteria for measuring success, reasons of success and reasons for failure. These factor categories are ranked according to both Importance Index (a measure of the level of importance) and Success Index (a measure of the degree of success). Ranking was done separately for large, medium and small groups as well as a combination of all respondents (all firms). A hypothesis that the three test groups, large, medium and small firms, generally agree on the ranking of importance and success indices was tested and shown to hold true.

This research will provide both academic and practical benefits. In the academic field, this research is the first to empirically utilize the SET for effective implementation and utilization of construction methods settings in Saudi Arabia in terms of their application. At the practical level, this research represents to practitioners the scope and nature of implementation of the SET by providing them with description of various types of benefits others have gained. In addition, this will provide top management with views on the problems associated with each of these tools. It can also benefit them by using the research findings and recommendations for improving the implementation of the SET and determining some aspects relevant to the application of them in Saudi Arabia. Topics for further research are suggested.

MASTER OF SCIENCE DEGREE

KING FAHD UNIVERSITY OF PETROLEUM & MINERALS

DHAHRAN, SAUDI ARABIA

CHAPTER 1

INTRODUCTION

The progress and development of nations are usually achieved over a long period of time. Economical, technological, cultural and industrial development may take a century or more to reach a highly advanced level. The Kingdom of Saudi Arabia has attempted to achieve that level of development in a matter of only two or three decades.

The construction industry is one of the most important sectors in any nation's development plan. The volume of construction is an indicator (barometer) of a nation's progress and economic prosperity. Saudi Arabia has experienced a construction boom of unprecedented volume during the past decade, attracting construction professionals from all over the world. The Saudi construction industry was the greatest contributor to the Gross National Product (GNP) during the first two national five year development plans.(9, 38) It made a significant contribution to both economic growth and employment.

The sheer enormity of the construction boom in Saudi Arabia and the rapid expansion of the economy has resulted in many drastic changes in the construction market. As a result, contractors and people involved in business and government are feeling a tremendous economic impact. This usually means that the construction cost control (by planning and scheduling) must be maintained while achieving the same or improved quality of work because this is the basic task for all concerned person involved in the construction process.(39, 51) In fact this decline has brought with it a lot of problems.

1.1 Saudi Arabia Development Plans

Saudi Arabia has had nineteen years of planning experience devoted to economic and social culture development. The First and Second Five Year Plans (1970-75 and 1975-80) were mainly concerned with developing the basic infrastructure. The expenditure spending during the First Five Year Development Plan was 80 billion Saudi Riyals (SR), which increased to SR800 billion during the Second Five Year Development Plan. In recent years, the Government has been laying the foundation for self-sufficiency: sustained balanced economic growth, and a reduction of national dependence on oil sales (Third Five Year Development Plan 1980-85, and Fourth Five Year Development Plan 1985-90). These two last Five Year Development Plans were concerned with other objectives as well, such as the completion of the infrastructure facilities, the establishment of operation and maintenance programs, the development of human resources and the cultural and social sectors, plus an increased contribution to the economic growth of the private sector.(38, 39, 51)

1.2 Significance Of The Study

The Saudi construction sector has experienced drastic changes which have resulted in problems such as fluctuation in the quality of buildings, lower profits, and the unavailability of projects in the market. This situation has led to a decline in the economic, social and contractual requirements, etc.(39)

The demand for housing, efficient infrastructure, and commercial municipal projects triggered the construction boom that started in the mid-Sixties and peaked at the end of the Second Five Year Development Plan (1975-1980). Saudi Arabia experienced a large number of projects in the field of construction due to the actual demand from both the private and public sectors.

However, the construction market has been experiencing a downward trend since the early 1980s. This decline could be attributed to several economic factors. First, many projects have been completed and become operational. Second, revenues to private contractors from government projects along with incentives, sometimes have not materialized. Third, the national budget has been reduced significantly due to the reduction of oil production and prices. This means that what is happening to the construction industry must be a matter of national concern.(3, 9, 51)

The current economic condition has influenced both contractors and Saudi government agencies to change their business attitude to a more competitive and a more conservative business approach. Therefore, the need for cost control and rapid project completion times in the most economical manner for project leads to work accomplishment improvement. This is emerged to satisfy the main Saudi Arabian government's objectives and policies which are to improve the quality of construction with incentives for construction cost reduction and related maintenance and to extend the scope of integrated research and economic development. The latter two parts affect the construction industry since it is an important sector in the overall economy of Saudi Arabia. The government wishes to build physical structure at the most economical manner and in the least construction time.(38, 39, 56)

On the other hand, contractors are forced to be more competitive in the high risk, low profit margin areas of the Saudi construction industry in order to reach a reasonable level of business success. A contractor's success is dependent on his ability to secure a good market share. Consequently, contractors are challenged to accomplish projects in the most economical manner. They can achieve this objective by managing their available resources effectively and efficiently. One of the methods of being competitive and qualified is to plan, schedule, control and analyze construction operations to reduce claims and litigation, while maintaining the same or improved quality of work. Generally, achieving the main target of cost control through planning and scheduling will help the contractors in developing processes and techniques for developing opportunities to get new jobs and to survive into the future.

In addition, owners and clients of construction projects may be directly affected by delays in the construction contract completion time. Delays may require expenditures beyond the project budget. For effective project control, a contractor should be aware of project progress, actual job conditions and methods of relevant financing, etc. One of the methods for improving control is to offer documentary evidence of each operation within its own time and cost constraints/limits (depending upon the type of contract) through planning and scheduling sheets. Providing these sheets will satisfy the project owner by verifying the work accomplishment.

Fundamentally, in order to reduce contractual restraints, claims and the potential problems associated with delays and litigation, the contractors should formalize an accurate and clear plan and schedule of projects by using Systematic Examination Techniques (SET) in the very early stages of the project construction phase.

The main function of information gathered for this study will enable engineers, architects and contractors to prepare plans of work activities and to schedule each phase and analyze all construction operations involved in a project. It is the intent of this study to aid contractors in selecting the most suitable method for planning, scheduling and controlling their projects which are intended for future execution. It attempts to provide contractors with a better visualization and understanding of SET for effective planning and scheduling utilization. It also assists contractors by helping them decide which technique would be most suitable for implementation, by providing a good level of utilization of the Systematic Examination Techniques (SET) and an understanding of the problems associated with them, and by taking into account the nature of the contractor's application of the methods on his project and showing the benefits obtained from implementing these methods. All of these benefits help construction parties to improve the construction management process and reduce the chance of delay, litigation, claims, conflict and other future diverse actions. The abovementioned factors are the reasons for this study, which have made this area of research an important field for future improvement in the construction industry.

1.3 Statement of the Problem

It is not uncommon that some construction projects to cost many times their fair value. This practice has a tremendous impact on the economy. However, nowadays, contractors and the Saudi government have changed their "anything goes" attitude to a more conservative approach because the general Saudi economic environment as related to construction is marked by more regulation and greatly increased competition for a declining volume in both public and private projects. The recent economic situation has had notable effects on contractors. They are forced to be more efficient in running their construction businesses. A construction company is forced to adopt an effective construction techniques such as cost accounting systems, cost control systems, cost reduction systems, value analysis, method improvements, and Systematic Examination Techniques for effective planning and scheduling.

In many instances, a contractor is forced to think of cash liquidity, to ensure himself in realizing some marginal profit, eliminating delays and any considerable amount of the owner's administrative constraints and to ensure successful completion of projects within their designated time and cost requirements. So, a contractor must have the necessary expertise and appropriate tools for effective planning and scheduling. However, a construction contractor in Saudi Arabia has available several alternative techniques for planning and scheduling. He is faced with different competing techniques. Due to the attraction of international construction professionals during the early years of the Saudi construction boom, a great flow of construction management information has taken place. This occurred when foreign construction professionals, who came to Saudi Arabia from industrialized and developed countries, brought with them advanced technology such as planning and scheduling methods, cash predicting techniques, and method improvements. The transfer of technology between developed and developing countries occurred via other channels such as the literature provided by education centers, the exchange of technical staff, and from research agencies. This led to contractors having many different techniques and approaches at hand, but, consequently, the problem now is which one of them proceeds effectively and meet the contractor's intensions.

There are several alternatives in the Systematic Examination Techniques for scheduling and formalizing project planning, including the following:

1. Critical Path Method (CPM)

2. Precedence Network Diagramming (PND)
3. Program Evaluation and Review Technique (PERT)
4. Graphical Evaluation and Review Technique (GERT)
5. Gantt Bar Chart (GBC).

Effective planning and scheduling to reduce claims and litigation through implementation of the Systematic Examination Techniques (SET) are effective approaches to forecast time or cost budgets. It must be carried out and implemented in a certain way to maximize the various benefits related to it. These (SET) have been implemented in countries throughout the world. For example, in the American construction industry, SET has been used since the early 1960's, in France in the mid-1960's, while SET had started in 1955 in England.(51, 52) But each of these techniques had not yet reached a suitable level of practical application. Identification of the Systematic Examination Techniques, investigation of the method's advantages and disadvantages, comparisons of the methods, the degree of utilization, the benefits and problems associated with them, and the visualization and evaluation of the SET by construction contractors are very important, especially for future project accomplishment. Therefore, the problem here is to identify these techniques and examine them, to draw out the benefits, problem and effects associated with SET implementation. So, the problem is to choose the best one of the SET to proceed efficiently within the contract time for the construction contractors intention.

Project planning and scheduling by implementing the methods included in the SET might assist the actual formalization of projects into plans and schedules, and help to accomplish the project at the least cost and with the timeliest schedule. Further, these tools can reduce the possibility of delay, litigation, claims and contractual disputes which make projects cost much more than they should. Indeed, the SET can be utilized to eliminate any restraints which may occur. Generally, the Systematic Examination Techniques for planning and scheduling should be considered a fundamental criterion for any construction project.

1.4 The Study Objectives

The objectives of this study can be summarized in the following five points:

1. Identification and examination of the Systematic Examination Techniques (SET) which includes CPM, PERT, PND, GERT, and GBC.

2. Investigation of the advantages and disadvantages of each method of the Systematic Examination Techniques (SET) .

3. Determination of the differences between the main Systematic Examination Techniques (SET) by examining fundamental factors.

4. Investigation of the implementation of project planning and scheduling using the Systematic Examination Techniques (SET) by different companies in Saudi Arabia.

5. Evaluation of the Systematic Examination Techniques (SET) by Saudi Arabian construction contractors.

1.5 Scope of The Study

This study research is limited to construction firms in the private sector in the Kingdom of Saudi Arabia. It will also be restricted to those implementing Systematic Examination Techniques (SET) in the Eastern Province, Western Province and Central Province of the Kingdom of Saudi Arabia.

1.6 Definition

Systematic Examination Techniques (SET) are methods of construction project planning which are used for assisting project management in the basic managerial functions of planning, scheduling and control. The main functions which these SET are providing for the logical expression of the project plan in graphic form with analytical procedures for calculating work schedules, providing support for communicating complex planning sequences to different work groups, and controlling the project as work progresses. The SET must be performed technically accurately, intelligibly and compatibly with the proposed means of daily or weekly project progress reports. Consequently, the basic definitions of the SET, for planning, scheduling and control will be considered in turn.(21, 29)

A. Systematic Examination Techniques (SET)

Project planning, effective scheduling and controlling processes have focused upon the nature of the planning task. The SET are various management aids or tools which have been designed to define objectives and to provide reliable information which are necessary for effective planning. The SET include the Critical Path Method (CPM), Program Evaluation and Review Techniques (PERT), Precedence Network Diagramming (PND), Graphical Evaluation and Review Techniques (GERT), and the Gantt Bar Chart (GBC). All of these techniques in the SET except the Gantt Bar Chart are schematic representations of the work to be done, drawn in such a way that the relationships between work items are logically defined. The Gantt Bar Chart is a bar representation of the work in compatible format, but does not show the interrelationships between work items. There is a rapid increase in the use of these techniques throughout the world and they have become standard practice in project planning situations. These will be explained in further detail in this study.(1, 7, 12)

B. Planning Process

Planning in this thesis is defined as a "process of breaking down the project into activities and determining their task and order". There are two functions in selecting the objectives or strategic planning and establishing the logistics of achieving the objectives or operational planning. The planning phase of any construction project involves a listing of tasks or jobs which must be executed and performed to bring about the project's completion. The basic requirements for manpower, machines, and materials are determined and the preliminary estimation of duration and the costing of items must also be determined. The four M's - material, manpower, machines and money plus time are the main resources which need to be evaluated for the planning of any project. In other words, planning provides the answer to all common questions of objectives or tasks (what, how, where, why, who and when).(15, 28, 31)

C. Scheduling Process

The definition of a schedule by the British Standards Institute (BSI) (4335, 1972), is expressed as "the specification of the time (or date) at or on which activities are planned to start, the activity duration and the resources allocation." R.H. Clouch (1974) expressed his view of project scheduling in a single statement: "It is a calendar time schedule of project activities as well as dates for the completion of a project and for intermediate milestones." The scheduling phase of any construction project involves a laying out of the actual jobs of the project in the logical order in which they have to be performed and executed. Two resources, material and manpower must be determined, calculated and scheduled to perform each job item with respect of the completion time of each job involved in the project.(28, 31, 44)

D. Control Process

The construction process is usually dynamic in nature. The two phases of planning and scheduling are not an adequate process of good project management. This means that some changes may occur in the plan, and that necessary corrective action must be taken if needed. The project control phase of any construction project has two major functions:

monitoring and updating. Generally, the control process is the underlying managerial function. Monitoring is performed by reviewing and determining the progress of the work, while updating begins with determining the differences between the schedule and the actual performance. The analysis of this difference and solving by corrective action are the basic aspects of the control phase.(16, 32, 34)

Planning, scheduling and control are tools for managing a construction project of any size and level of complexity. These tools aid the contractors, the owners and the sub-contractors by minimizing delays in completing a construction project and by helping to resolve disputes involving delays which could lead to litigation. Since planning and scheduling are important areas in construction, any poor planning, errors in or incompleteness of any one of these two phases may result in delays or litigation. So, the definition of both delays and litigation must be well known by contractors in developing countries because they do not carry out management duties and they attempt to cut corners due to limited resources.(12, 15, 20)

E. Construction Delay

Delays usually occur during the construction phase of most projects, but in recent years they have become more frequent and severe. Construction delays can be caused by the contractor, owners or some third party. These delays include compensable delays (by owner), nonexcusable delays (by contractor), and excusable delays which occur by acts of God or by a third party. Several different kinds of delays occasionally occur concurrently. There are many reasons behind delays involving the complexity of the project, competition, a decrease in profit, high speed in construction, high inflation, contractor self-reliance and excessive government's bureaucracy and fluctuations in the economy.(15, 22)

F. Litigation

Litigation is a settlement through court action which represents a last resort solution. The court usually asks for help in technical problems. Use of a schedule to identify and support a reasonable delay is dependent upon, 1) the reliability of the schedule, 2) the substantive evidence by basic records, 3) the nature of changes, and 4) the work sequence by reasonable method to prove the work which was completed as scheduled. A schedule must be employed and followed as planned, and as adjusted schedule conditions, so that delays can be identified. The schedule sheets are useful tools and valuable evidence in the event of litigation and arbitration.(15, 21, 44)

1.7 Structure And Organization

Systematic Examination Techniques (SET) include CPM, PND, PERT, GERT, and GBC. These techniques will be throughly examined regarding their identification, and advantages and disadvantages. This survey study probably constitutes the most exhaustive examination of the use of these methods by firms in Saudi Arabia and the evaluation thereof by the same contractors. This research is divided into five chapters. The First Chapter gives general background information on the construction industry in Saudi Arabia, a statement of the problem, the objectives of the study and the scope and significance of the study. The Second Chapter examines all the Systematic Examination Techniques for planning and scheduling, looking at each one of them with their historical data, basic background, advantages and disadvantages. This chapter will focus on the comparison of the above techniques. The Third Chapter discusses the research methodology utilized in this study. It addresses questionnaire formulation and design, the sample size, the sample selection and the method of data collection. The Fourth Chapter presents and analyzes with data through statistical procedures. These chapters will be summarized by the Fifth Chapter which will present conclusions and recommendations. Also, it will include a summary and recommendations for further research.

CHAPTER 2

SYSTEMATIC EXAMINATION TECHNIQUES (SET) FOR PROJECT PLANNING AND SCHEDULING

SET provides the basic tools in construction management for planning, scheduling and controlling the various tasks or activities of any project. Effective project planning and scheduling through the implementation of the SET is one of the most important approaches that can provide a variety of benefits. Analytical techniques have been developed to meet the problems of management both for today and for the future. One of these techniques is the planning process which is defined as the process of selecting one method and the order of work that will be adopted for a project, considering the various sequences in which it might be done. On the other hand, the scheduling process is the determination of the timing data of the operations comprising the project and their assembly to estimate the overall completion time. Scheduling is usually done after a particular project plan has been formalized and modelled. The contracted project completion time, which accounts for construction project performance, is usually an important consideration for both the project client and contractor.(6, 18)

Construction projects today are far more complicated than they have ever been, involving several disciplines, multiple activities and increasingly large sums of both money and time. Engineers, managers, contractors, and workers who are looking for challenging work will find themselves responsible for projects that demand the greatest possible planning and scheduling skills. If they are concerned of the outputs from implementation of the SET, they can be assisted by knowing the limitations and advantages of the techniques. These SET provide means and objectives as the following: (13, 15, 19, 40)

1. Planning the projects. The evaluation of activitives in terms of both time and cost that can be realized. (List of activities).
2. Scheduling activities. The specification of the time (or date) at or on which objectives are planned. (Activity duration and resource allocation).
3. Controlling projects. Corrective action must be taken place if there is a negative difference between actual and planning performance.
4. Providing a means of cash-flow prediction and improving communication between the various departments and companies which are involved in the project.
5. providing a means of improving work methods through discipline.
6. Providing a means of quality improvements.
7. Aiding the construction project parties in the cost control aspects.

Consequently, the characteristics of an effective plan will consist of explicit, intelligible and capable planning and be capable of being monitored. Construction projects have four common objectives: time, cost, quality and goodwill. All parties involved in the planning process of any project may have to carry out the planning phase which includes the visualizing of all the operations of the project, arranging these operations in order, achieving the confidence that each operation is understood, acquiring the know-how and means necessary to achieve them, and assuring that the construction manager or planner is using the most economical methods to execute the project. The actual selection of a planning technique depends on several aspects such as familiarity with construction methods, field personnel output, limitation on resources, time restrictions and the selection of different alternatives (being open minded). In fact, to achieve the main objectives of planning and scheduling effectively, these two processes must be separated. The sequence should include planning - to define requirements by breaking down the project into activities and determining their order, and scheduling - to fulfill the requirements of the plan by both resource allocation and time planning without regard to the project's size.(12, 16, 31, 54)

A. The Necessity for Planning and Scheduling:

Any project involves various objectives and tasks. These must be well defined to accomplish the needs to be within certain time and cost parameters. Sometimes the complexity of a project generates the necessity for planning and requires specialized skills. Actually, each specialist has his own opinions, thoughts and specialization which sometimes leads to breakdown in communication among the planning team and construction team. This requires a method to control the communication between those teams. Another concern of planning is the allocation of capital. This is the one important factor that places a high emphasis on establishing schedules to verify project targets. The necessity for planning is made evident when there is inclement weather or a delay in the delivery of materials which may directly affect the progress of a project. Continuous planning revision is necessary in the above mentioned types of situations.(31, 35, 53) Madani[(1)] investigated the effects of project management (including planning and scheduling) on project time and cost. He found that whenever project management techniques are used as a structured system, better time and cost are achieved.

B. Objectives in Applying SET on Projects

The basic objectives in implementing any of the SET to a project is to achieve the project's completion in the best possible time at the least cost. To achieve such an objective, it is necessary to have a master plan that can be used as a working model of the project in order to identify the problem and to take corrective action. The primary objectives of planning are to coordinate all elements of the project according to their time schedule to complete the project in its planned time (control time) within its allocated time, at the least cost and with the fewest risks.(12, 31, 57)

The objective of a project planning phase are accomplished by: (5, 6, 7, 16)

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(1) M.S. Thesis submitted to the King Fahd University of Petroleum and Minerals, Dhahran, June, 1987.

1. Determining what is to be done and translating it into a work breakdown structure (wbs).
2. Establishing a project team based on the major tasks (elements) to determine the effort for each individual in each task.
3. Joining together the tasks and resources (which determines who does what).
4. Creating the key planning and control documentation.
5. Developing a network.
6. Establishing manpower needs.

The secondary objectives of planning and scheduling include studying and analyzing alternatives, developing optimum schedules, using resource allocations effectively, developing communication channels, refineing estimating criteria, and determining effective project controls and ease of plan revision. On the other hand, scheduling is utilized for many different phases of the construction process. It is used from the master plan of the overall project through the facilitation of both construction operations and maintenance. The utilization of scheduling has various purposes during the three phases of projects which include, pre-project planning, construction, and post-construction activities. The purposes associated with each phase of project are listed below: (12, 31, 34, 53)

Phase (1) : Before Starting

1.1 Provides an estimate of the time required for each portion of the project.

1.2 Establishes both the planned rate of progress and planned sequence of the Four M's - Material, Manpower, Machinery and Money.

1.3 Provides the basis for instructions.

Phase (2) : During Construction

2.1 Helps the project manager with many processes such as resource levelling and resource allocation.

2.2 Predicts the effects of changes and aids in the coordination of resources.

Phase (3) : After Completion of Construction

3.1 Aids analyzing and reviewing the project.

3.2 Provides historical data records.

Fundamentally, the concept of planning is a comprehensive process that should present a whole picture both by function and by means of suitable communication to those who have to implement the methods and, consequently, achieve the objectives. Any project may be completed within the cost and time limits and meet the project specifications and requirements set during the design phase, but the goodwill and quality of a project must be controlled through supervision during the construction phase. However, time and cost variables need managerial procedures to control the achievement of the project within the limits by implementing the SET.(28, 32, 50, 53)

These SET which will be discussed in this chapter are:

1. Critical Path Method (CPM) Method # 1
2. Precedence Network Diagramming (PND) Method # 2
3. Program Evaluation and Review Technique (PERT) Method # 3
4. Graphical Evaluation and Review Technique (GERT) Method # 4
5. Gantt Bar Chart (GBC) Method # 5

These five methods of Systematic Examination Techniques are useful tools for planning and scheduling construction projects whether simple or complex. Each one of the methods will be illustrated with a brief description of its advantages and disadvantages. These descriptions will be supported by the comparison of SET through fundamental features or factors.

2.1 Critical Path Method (CPM)

The Critical Path Method (CPM) is defined as "the representation of a project plan by a schematic diagram or network that depicts the sequence and interrelation of all the component parts of the project and the logical analysis and manipulation of this network in determining the best overall program of operation".(8, 11)

CPM is one of the most practical dynamic tools for effective planning and scheduling of various type of projects. It is the representation of the project plan by a network system which shows the sequenced components and interrelationship of all activities involved in project. It is a new and powerful tool for the planning, analyzing, controlling and managing individuals involved in construction. It is an important method that enables engineers, architects, contractors, and other related to construction to preplan, schedule and control construction operations in order to reduce the cost of the construction operations involved in project. It has many names, including network analysis, critical path analysis, critical path scheduling, least-cost estimating and scheduling and critical path method (CPM). The letters CPM have traditionally meant Critical Path Method. This system could be more accurately called complete project management (CPM).(10, 11) The system has proved to be valuable mainly in assisting managers with the carrying out of their project management responsibilities. In recent years, it has become a useful technique which has been used in planning, analyzing and controlling construction projects for engineers, architects, contractors and other persons associated with the construction projects. It has been used effectively on many types of projects, usually with great success. Many government and private agencies require the preparation of this method when planning a project at the bidding phase.

2.1.1 Historical Development

CPM was developed independently and simultaneously during the late 1950's by the Dupont Company in conjunction with the Univac Division of Remington Rand Corporation.(3) This method was originated in 1956 by James E. Kelly of Remington Rand Corporation and Morgan Walker of the Dupont Company.(3, 7) Essentially, the Dupont Company during that period was interested in scheduling refining projects, and these projects required both their time and cost be accurately estimated. A major consideration of their scheduling was the cost of project speed-up and they wanted a schedule that was optimally economical for time completion and the total project cost.(10, 18) Dupont and a team of people from the Univac Division of the Remington Rand Company developed a project planning and scheduling technique.(34) This technique is called Project Planning and Scheduling (PPS). Indeed, Dupont Company used (PPS) with great success. The Company found this technique covered the design, construction and maintenance work required for several large and complex jobs and it required only about half as much effort as other planning and scheduling techniques which they had previously used and the company saved considerable amounts of money because of using this mechanism.(14, 54)

2.1.2 Purpose and Uses of CPM Network

CPM has become so widely accepted as a planning tool that many construction managers and owners require the contractor to submit a CPM plan along with their bid. The purpose of a CPM network is to aid in the planning and control of one-time projects and in determining the most economical project cost. Also, it assists in clarifying critical relationships and identifying missing elements or unclear aspects which occur during the planning period. It aids in the control of the actual progress of project implementation. It has been used to plan, schedule and control a wide variety of projects such as: (3, 4, 6, 7, 8, 10, 13)

1. Construction of large, complex and public works
2. Research program and development of new processes
3. Maintenance problems of large projects
4. Sales promotions
5. Related operation in other industries
6. Manufacturing computers
7. Accounting and electrical or mechanical projects.

2.1.3 Advantages of CPM Network (3, 8, 10, 15, 30, 52)

1. It provides the most economical use of available resources (labor, equipment, finance, etc.) based upon the optimum time required for each job.
2. It may be as detailed as desired to suit existing construction

hazards.

3. During the execution of the project, it permits systematic reviewing of current situation as they arise so that allowances can be made for the effects of uncertainties in the original planning, as well as enabling a resolution of future uncertainties.
4. The use of CPM enables the most economical planning of all operations to meet desirable completion dates.
5. It replaces judgement based on experiences with one that rapidly determines with certainty the best completion date for the project.
6. It provides a means of assessing the effect of all variation and improving communications.
7. It is an open ended process that permits different degrees of involvement by management to suit their various needs.
8. The project is seen in its entirety.
9. All critical activities are identified so they are tightly controlled at the operational level.
10. Duplication of effort is minimized.
11. A decision on time can be made with full knowledge of effects on costs.
12. It is sometimes described as management by exception, as it enables management to concentrate on anything that goes wrong (exceptional occurrences) and they try to work out its correction.
13. It is best used when the operations of a project have a deterministic duration.
14. It permits a clear definition of responsibilities.

2.1.4 Disadvantages of CPM Network (3, 6, 7, 17, 21, 30, 52)

1. The system is not applicable for all personnel at all levels within an organization.
2. The possibility of error is extremely high when the project involves hundreds of activities; one error occurring at the beginning of the calculation renders the whole network useless.
3. The CPM is only as valid as the quality and the experience of the persons who conceived it.
4. It does not solve all the problems of the project manager's duties and there is a considerable area in which human decisions must be taken.
5. It does not assist the manager in visualizing the accurate completion time of each operation from the network diagram itself.

2.1.5 Basic Data for CPM Network

CPM permits a manager to complete a project in the shortest period of time with minimum expenditure for overtime and without additional resources or at extra cost to the project. To analyze a project by using this method, it is necessary to divide the project into activities. The number of units of work required to complete each activity should be determined. The time required to complete each activity should be estimated in appropriate units, e.g. days, weeks, or months. Also, it is necessary to establish the time sequence in which the activities should be conducted. Fig. 2.1 shows a simple example for project involving only eleven activities

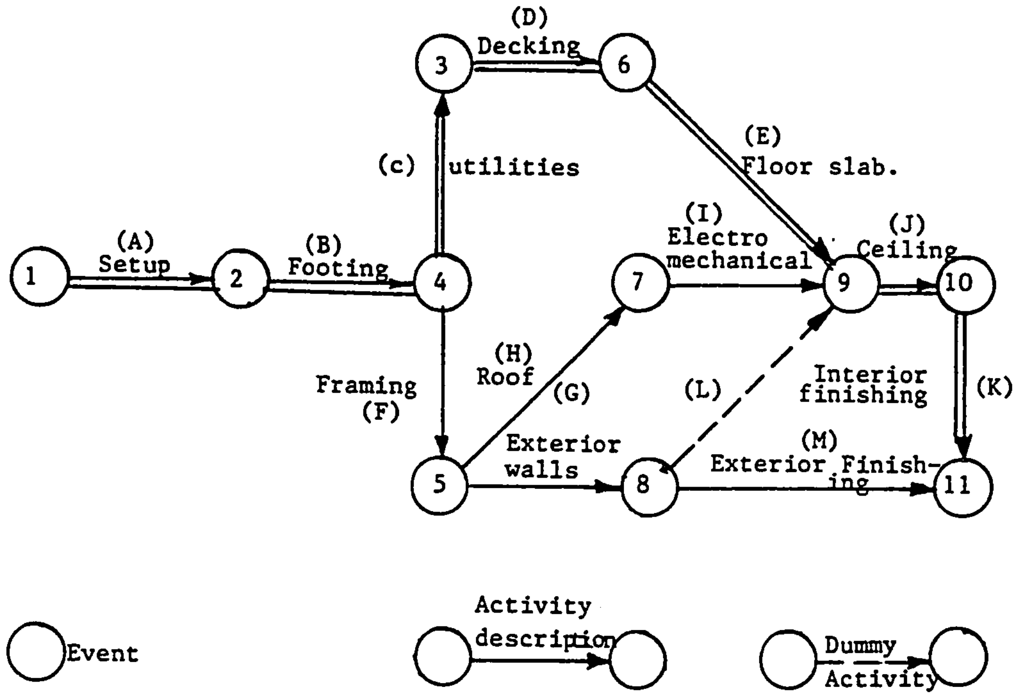

Figure (2.1) CPM network diagram.
Source: Ref: 12

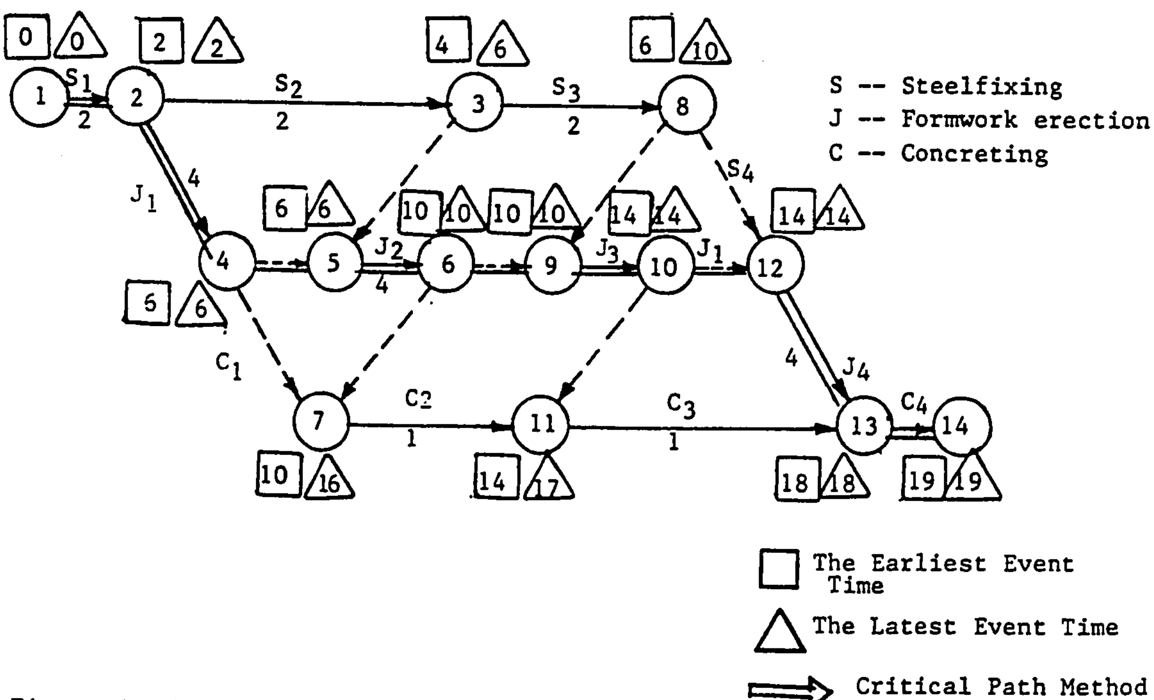

Figure (2.2) A network diagram of Reinforced Concrete retaining wall.
Source: Ref: 40

designated by the letters, A, B, C, etc.(12) (The time periods are estimated to be 4,5,3,6 and 8 days, respectively). Activities A and B cannot be started at the same time. Activities C and F cannot be started until B is completed. Activity E cannot be started until D is completed. By referring to Fig. 2.1, we can see that the minimum total time required for the project is the sum of the duration of the activities in the critical path. The construction activities require certain resources, e.g. materials, construction equipment and manpower. By the application of this method we can control the cost of the project by controlling the equipment, labor, and materials.(3, 6, 10, 30) Another illustration of a network diagram for a reinforced concrete retaining wall is a CPM diagram of the project shown in Fig. 2.2. It might be possible to divide the work into three gangs such as one gang of steel fixers, one gang of carpenters and one gang for masons. This represents how the wall would be constructed if it were divided into four such sections.(21, 44, 53)

2.2 Precedence Network Diagramming (PND)

This method is often known as CPM, but in this study CPM (as previously described) and PND are treated as separate method of project planning, scheduling and controlling. Originally, Precedence Network Diagramming was called "Precedence Network Analysis for Planning and Control."(10, 12)

PND arrow diagram is made of nodes and linkages which is developed with more detailed rather than both PERT and GBC (which are discussed later). It differs from the other techniques because it is a job or activity on nods-oriented. Linking the portion of jobs to each other in a sequence without special identification of the connection medium or points represents the relationship among nodes. Some of the environmental factors which have an important role in determining the elements of the PND technique include, the location of project, size of project, level of uncertainties, and the specific dominant of the organization and identification of project cost.(10, 16)

The actual emphasis in implementing this method is that instead of assigning the activity to the link as in CPM, it places the activity on the node. The link-lag between the nodes of the network represent the actual relationships among the activities involved in the network.(28, 40) This type of diagramming is easily formalized by using computer especially when the planner performs the network calculations because this device is very efficient for formalizing this type of method.

PND is established as a model, which uses "Circle and Connection lines" for all nodes of operations involved in the project, which are intended to be accomplished. It has been referred as the "the activity on the node" technique and J.David Craig (18, 40) has called this method a "Precedence Diagram" with only the type of the start to finish relationships.(16, 18, 28, 40)

2.2.1 Historical Development

The development of CPM included the formulation of the use of the arrow diagrams which are included in the network, but PND was formulated to place activity in nodes. PND was initially developed by Professor John W. Fondahl of Stanford University in 1961.(16) He developed and established the foundation of the Precedence Network Diagramming Technique. Another contributor in the development of PND is the Integrated Engineering Control group of E.I. Dupont Company around the above-mentioned date. The company decided that they were dissatisfied with existing methods of project control which were applied to the construction of major chemical plants in America. So, they considered that some sort of technique was required which would bring together all the details to enable management to control such a project. The company found this technique covered the design, construction and maintenance work required for any large-scale project.(18, 19, 28) This planning tool has satisfied all objectives of a project such as controlling the work required, reducing the overall costs and scheduling the various operation involved in any project.(34, 40, 52)

2.2.2 Purposes and Uses of PND Network

PND permits computations easily and effectively and a simple number can identify the network itself. The purpose of the precedence network is to aid in the planning and controlling of on-time completion and cost containment of any project. Basically, this technique is used to produce an initial plan or work schedule which can be continuously updated and revised. It was originally a simple method because the size and complexity of a project were usually reduced by the removal of many redundant activities. It can be defined as a method of planning and controlling projects by recording their interdependence in a diagrammatic form that enables each fundamental area involved to be tackled separately.(16, 30, 40)

The precedence network diagramming technique represents their purpose in the following steps: (30, 40, 52)

Step 1

It presents in a diagrammatic form a picture of all the jobs (or activities) to be achieved. In fact, the way in which this is done is to construct a set of arrow diagrams which is known as a network diagram in which each job is represented by an arrow or box on the diagram as illustrated in Figs. 2.3 and 2.4. The arrows and boxes involved in the network indicate the dependencies of the jobs on each other.

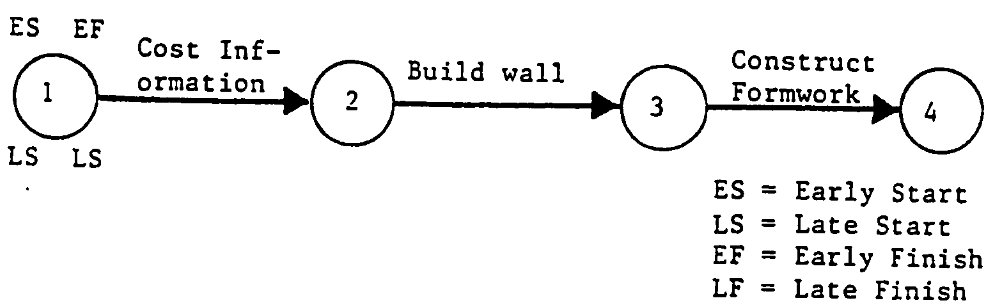

Fig. 2.3 : "Arrow" Representation Sequence
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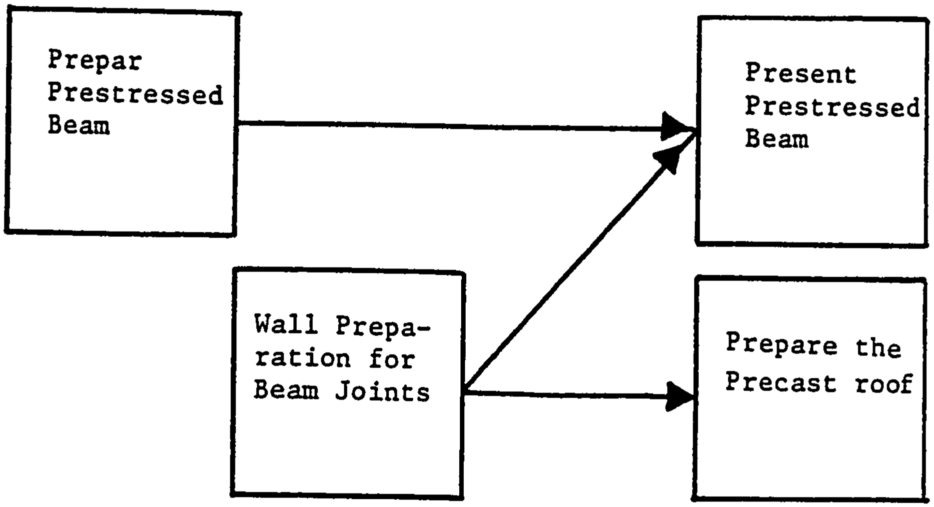


Fig. 2.4 : "Box" Representation of Sequence.

Source: Ref: 40

Step 2

They indicate the limitation of the availability of labor, equipment, money and material resources. Also it represents the estimated time required to do each job.

Step 3

They apply the estimated job time to the network diagram and then analyze the network according to the estimated task completion time and the work to be done for each activity to find the critical activity or path due to the analysis. (In other words, the calculation of the total length of time involved in each path through the network represents the critical task.)

Once a network has been constructed, it is necessary to check that it is a valid network - that is, that it does not contain impossible situations. A useful basic check is to start from the final completion date and to work backwards along the various paths. Consequently, precedence network has already become a more accurate method which reflects the sequence of engineering operations as they occur in construction phase.(40, 52)

2.2.3 *Advantages of PND Network* (10, 16, 20, 30, 40, 52)

1. A single number can be assigned to identify each activity and it separates the planning of the sequences of jobs from the scheduling dates for the jobs.
2. The rules are simple and comprehensive and the basic principles can be understood in a short time.
3. Dummy activities are not used so that there is no friction and it shows the interdependencies between jobs.
4. It enables people to see both the overall plan and the ways in which their own activities depend upon or influence those of others.
5. Simplicity; the network can be analyzed and drawn by utilizing computer or it may be done manually.
6. It shows clearly where things are going wrong with a project, and conversely where they are going so well that resources can be supplied to the troubled areas.
7. It enables resource and time constraints to be included in the plan before its evaluation. For example, a minimum delivery period for material is one of the time constraints.
8. By splitting the project into smaller activities it will help in the esti-

mation of their duration so it leads to more accurate target dates.

9. A major change in time-scale need not imply re-drawing the network again.

10. Computation and simplification of procedures can make the control that will be applied and any deviation from schedule is quickly noticed.

11. It allows modification of policy to be built in easily and the impact of these modifications may be analyzed quickly if the plan is formalized on a computer system.

2.2.4 Disadvantages of PND Network (10, 12, 28, 30, 40, 52)

1. The cost of manual operation rapidly becomes uneconomic, but it is no more difficult to carry out than on the computer.

2. The consideration of various alternative plans also becomes impossible, because of the large tasks involved in the network.

3. The network is only as valid as the quality and the experience of the person who conceived it.(16)

4. It does not solve all the problems occurred in a project so the project manager is still responsible for the planning and must still make the necessary decisions.

5. It does not help the manager to know the actual time for each operation from the network diagram.

2.2.5 Basic Data for PND Network

The PND (activity on node) has been widely used in industrial construction. This method is based upon the logical relationships between the activities and arranging the diagram in sequence to allow computation. Sequence identifications are powerful in aiding both drawing and numbering the network, and in permitting greater clarity of the activity on a node and links lags as a presentation for the whole network. The general rules of performing Precedence Network Diagramming include the following: (16, 28, 40)

1. Develop an activity list of all tasks involved in the project.
2. Determine dependencies.
3. Remove redundancies.
4. Determine sequence step numbering.
5. Draw the network according to the sequence.

Contractors must follow the abovementioned rules to be in line with the assumptions of PND including that the network must be continuous, avoid dummy activities, and avoid network line-crossing if possible.(10, 11, 19, 34, 40)

2.3 Program Evaluation and Review Technique (PERT)

PERT is a significant management technique for minimizing product delays. It is used as a means of evaluating and measuring the progress of the construction performance. It is a method which provides for common communication through the overall job. This management tool is used effectively for controlling, analyzing and scheduling any type of project. The application of PERT to planning and scheduling progress requires a reasonably accurate estimate of time and cost for each task in the project, all of which is formalized in a network plan.

PERT has proved to be significant management tool on design. development, and defense projects.(11, 18) The main objective of the PERT system is to provide information which can be used to maintain project costs within a specific budget. Consequently, PERT was developed with the objective of being able to manage uncertainties in activity completion time. It was used to plan and control the design and development of the Polaris Missile Project. PERT and CPM have the same general purpose and utilize the same technology. Fundamentally, PERT is a tool to aid managers in visualizing what costs a project will incur and when.(27, 31)

This event network evolved from a combination of the Gantt Bar Chart and the Milestone Charts. On both charts are identified particular points in time of interest to management. It includes capabilities for handling variables of uncertainty activity time and its conventional approach which required three time estimates for each activity, all based on the same mechanism with different assumption. Finally, it has great advantages over CPM, Precedence and GERT Methods when the time achievement of project goals is relatively uncertain.(23, 27, 32, 44)

2.3.1 Historical Development

PERT was developed from Gantt bar Charts and the Milestone Charts which represent the project components as bars on a horizontal calendar scale. It was developed by the special office of the U.S. Navy's Polaris Missile Project in 1957.(31) Some of subcontractors were involved in the development of PERT such as Booz-Allen, the Hamilton Company and the Missile Systems Division of Lockheed Aircraft Corporation. In this initial application, the techniques saved some two years on the completion date, and it was eventually adopted by U.S. Government departments as a standard device in most of their large and complex projects. In this first use of PERT in the U.S. Navy Project, which involved over 3000 different sub-contractors who had to be coordinated, PERT provided an adequate means of communication. It is succeeded in reducing the development time of the Polaris Missile by over two years, at a reduction of some 45% of the overall cost.(31, 34, 44, 45)

2.3.2 Purpose and use of PERT Network

PERT is a powerful tool for minimizing conflicts among the various parts of the overall job and for speeding up the completion of the project. The main purpose of the PERT network is to aid in the planning and control of one-time projects. The use of PERT simplifies for the manager his task of controlling and reducing the costs of a project and provides him with more accurate information from which to prevent losses occuring.(31, 40, 44)

PERT have been used to plan, analyze, schedule and control a wide range of projects such as: (12, 27, 32, 53)

1. Research and development of new products.
2. Construction of plants, buildings, bridges, etc.
3. Construction of large-scale equipment.
4. Design and installation of many systems as manufacturing, accounting, computers, etc.

2.3.3 Advantages of PERT Network (11, 18, 23, 27, 31, 44)

1. It provides a means of communication between a wide variety of departments and companies involved in a project.
2. It provides an explicit correlation at all times between progress and expenditure.
3. It is the best method to apply when very little background information is available.(34)
4. It makes the collection of data and statistics a formal function within an organization.
5. It is more useful than the other methods because of the three time estimates for each activities duration which results in optimizing costs and time for a project.
6. It provides an unified system of planning and scheduling.(45)

7. It gives a clear view of the scope of the project, and the objectives are presented.
8. It provides the capability for periodic rescheduling and evaluation at any time.
9. It involves simulations which make possible the evaluation of alternate plans.
10. The ability of line personnel is utilized and responsibility is fixed.
11. Manpower requirements can be controlled effectively subject to availability and project duration.
12. It simultaneously presents the interrelationships and responsibilities between the general managers and the various departments involved in a project.
13. A decision on time can be made with full knowledge of effects on costs.

2.3.4 Disadvantages of PERT Network (11, 27, 31, 34, 53)

1. Because PERT and CPM have the same general purpose and utilize much of the same terminology, PERT has many of the same disadvantages of CPM.
2. Sometimes, it concentrates too much on analysis of what has happened to date, which means it is providing a historical analysis.
3. It requires extra computational effort and additional overhead cost.(55)
4. The utility data of PERT are not sufficiently accurate, especially when many of the activities require considerable research and development.

2.3.5 Basic Data for PERT Network

The environmental factors which affect the development of PERT include the size of the program, overlapping responsibilities, difficulty in defining objectives, time and cost uncertainty. PERT is used for projects that involve research and development work in which the intellectual effort and the manufacture of component parts is essentially new and is usually being attempted for the first time. The time and cost estimates never can be predicted with adequate certainty, and probabilistic concepts are used to obtain three duration estimates. The activities in the PERT network are denoted by events and the arrows which indicate the direction of flow of operations and their sequences as shown in figure 2.5 and 2.6. To analyze any project by using PERT, we perform the following steps:

Step 1: Develop a list of activities that includes all phases or operations of the project including immediate predecessors.

Step 2: Draw a network corresponding to the activity list made in Step 1.

Step 3: Estimate the expected activity time and the variance for each activity.

Step 4: Using the expected activity time which is estimated in Step 3, determine the earliest start time and the earliest finish time for each activity. The earliest finish time for the complete project corresponds the earliest finish time for the last activity. This

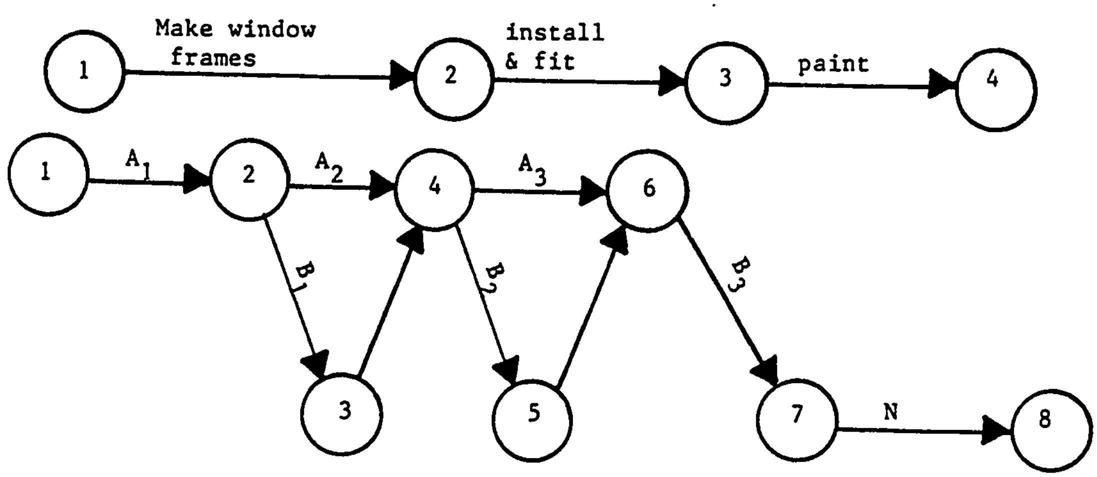


Fig. (2.5) "(Arrows)" and "(events)" Representation.
Source: Ref: 11

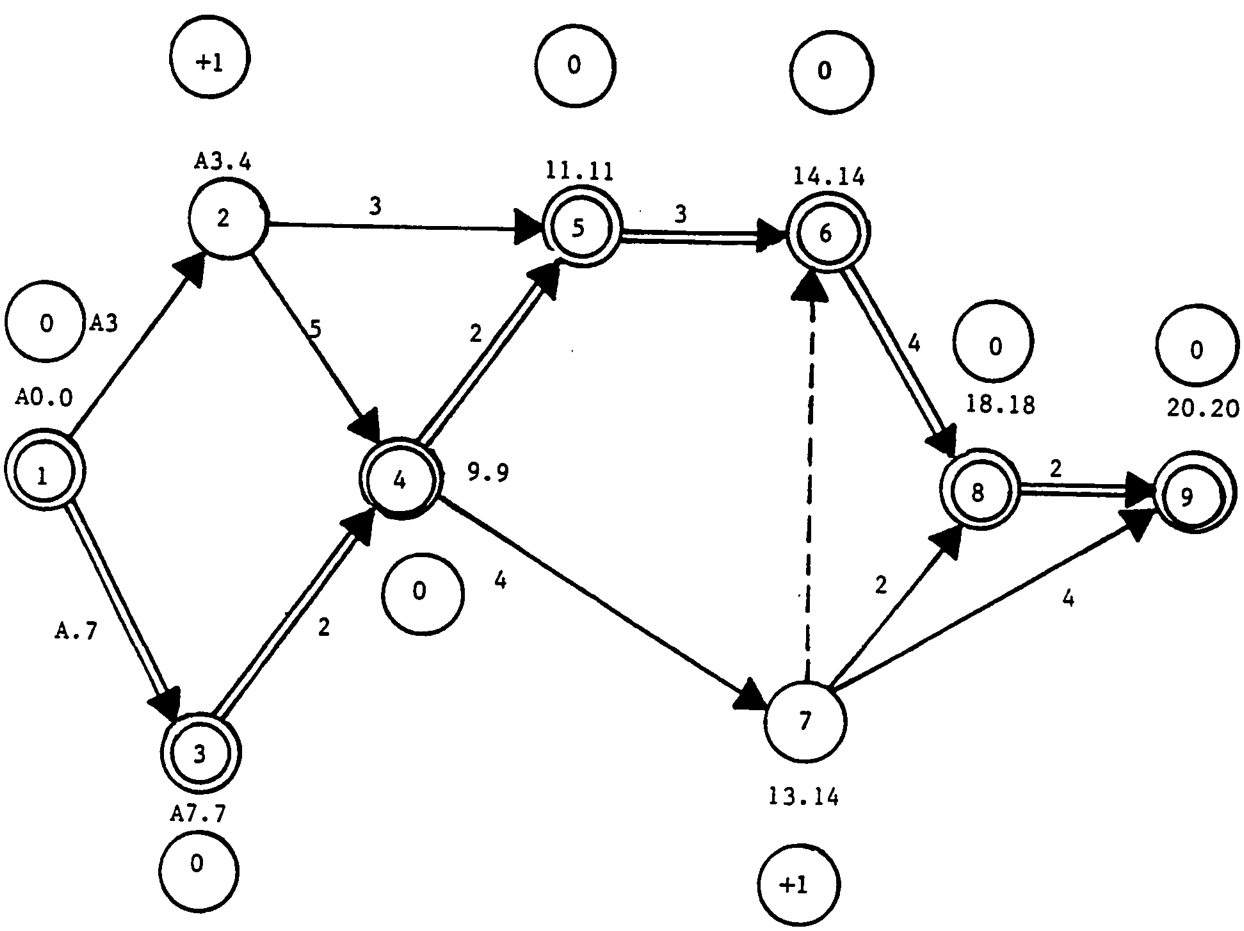


Fig (2.6) PERT Diagram involving only nine operations.
Source: Ref: 34

represents the earliest estimated project completion time.

Step 5: Using the project completion time as the latest finishing time for the last activity, work backward through the network to compute the latest start and latest finish time for each activity.

Step 6: Compute the slack time with each activity and determine the activities with zero slack which are the critical path activities.

Step 7: Use the variability in the activity times to estimate the variability of the project completion date and use these estimates to compute the probability of meeting a specified completion date of the project.

The PERT technique has proved to be the most effective and applicable to large-scale research and development (R and D), systems engineering programs, and industrial factories of a large degree of uncertainty.(31, 45)

2.4 Graphical Evaluation and Review Technique (GERT)

CPM, PND and PERT are models which describe many different systems. Each one of them has its own system which was developed through theoretical principles. GERT is a physical model that demonstrates, designs, describes and analyzes systems as well as other. It provides a network representing all of the information needed for effective planning and scheduling. This method can improve communication among all parties of construction project.

GERT is useful when the performance of all operations is not necessary for the completion of a project. Basically, it determines the probability of the realization of a node based on statistical data collected through simulation. Indeed, it is a combination of network theory, probability theory, and simulation to yield a readily applicable modern management tool for system analysis.(32) This model could be analyzed automatically, so that it is an effective tool for providing all information related to any activity needed.(33)

2.4.1 Historical Development

GERT was initially developed by A. Allen B. Pritsker for a study of the terminal countdown of an Apollo Space System in 1970.(47, 48) It has become apparent that many of the features provided by GERT can be incorporated into larger-scale industrial systems analysis. Also, it includes the modeling of systems in a network form and provides analysis through simulation. GERT has already become a very useful method in situations in which the realization of a node is dependent on the completion of not all, but one or more activities preceding this model and in which the performance of these activities is probabilistic.(49, 52)

2.4.2 Typical GERT Application Problems

Many applications of the GERT system have been made around the world. GERT networks have been designed, developed and used to analyze the following situations: (31, 32, 46, 47, 48)

1. Claims processing in an insurance company.
2. Production lines.
3. Quality control in manufacturing systems.
4. Assessment of job performance aids.
5. Burglary resistance of buildings.
6. Capacity of air terminal cargo facilities.
7. Judicial court system operation.
8. Equipment allocation in construction planning.
9. Refueling of military airlift forces.
10. Planning and control of marketing research.
11. Planning for contract negotiations.
12. Risk analysis in pipeline construction.
13. Effects of funding and administrative strategies on nuclear fusion power plant development.
14. Research and development planning.
15. System reliability.

2.4.3 Basic Data and Procedure of GERT

A) Basic GERT Data:

The basic data necessary for performing GERT simulation can be classified into three categories:

1. **Data Relating to Network:**

The basic data related to Network includes, project identification, number and type of nodes, identification of source, sink statistics and mark nodes, number of activities, number of times of the simulation is to be performed, random number seed, and network modification data.(33, 46)

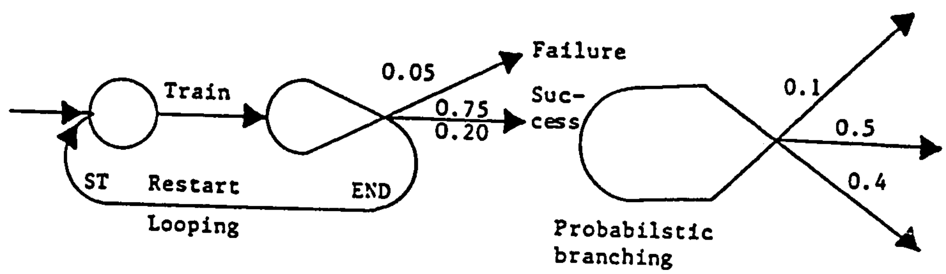
2. **Data Relating to nodes:**

The necessary data related to nodes includes, the number of releases required to realize a node for the first time and subsequent output, histogram characteristics and the type of statistical information to be collected.(43, 46, 47)

3. **Data Relating to branches:**

The general data related to branches includes, parameters of time variables associated with activities, probability of realization and distribution type.(97) Using the listed data, GERT performs and indicates the simulation of a network by passing from event to event. Basically, the GERT procedure uses the parameter number of distribution type to obtain a cumulative distribution. The procedure is repeated for all branches, keeping track of the finish time of each branch either on a deterministic or probabilistic basis as shown in Fig. 2.7.

The node symbolism of GERT indicates graphically the number of activity releases required for the first and for subsequent realization of the node. In Fig. 2.8, the number 3 in the upper left portion of the node denotes that any combination of three releases of activities ending at that node is required to realize the node, the first time (including repeat releases, value in lower left of node) of any combination of activities. The realization logic for the input side of the nodes is independent of the output of the node. Also, the node on which each branch is incident, must be checked. The number 4 on the output inside the node is the node identification number.(33, 46, 47, 49)



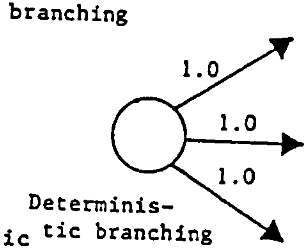


Fig.2.7 : GERT branching node
symbolism
Source : Ref: 33

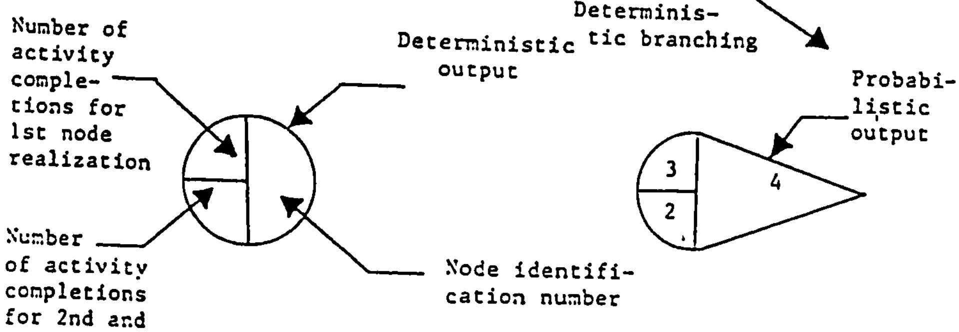


Fig.2.8 : Node Realization
Symbolism .
Source: Ref: 33

B. Procedure of GERT

Since GERT is used for the analysis of complex stochastic (probabilistic) systems, the background for the development of GERT lies in the area of stochastic networks. A stochastic network has the following properties:

1. Each network consists of nodes that denote logical operations and transmitances. (Transmitance branch and activity are synonymous).
2. A transmitance is arranged with the probability that the activity represented by it in the network will be performed.
3. Other parameters describe activities that the transmitances represent.
4. The realization of a network is the realization of a particular set of transmitances and nodes that describe the network for one experiment.
5. If the time associated with a transmitance is a random variable so that a realization must be implied then a fixed time must be selected for each transmitance.

GERT is a procedure that combines the disciplines of flow graph theory and moment-generating functions. It is claimed that the procedure makes it possible to analyze complex systems and problems in a less inductive manner than ever used before. In Fig. 2.9, each activity has three descriptions coded in parenthesis over the activity. The activity number is in the square below the activity.(33, 49)

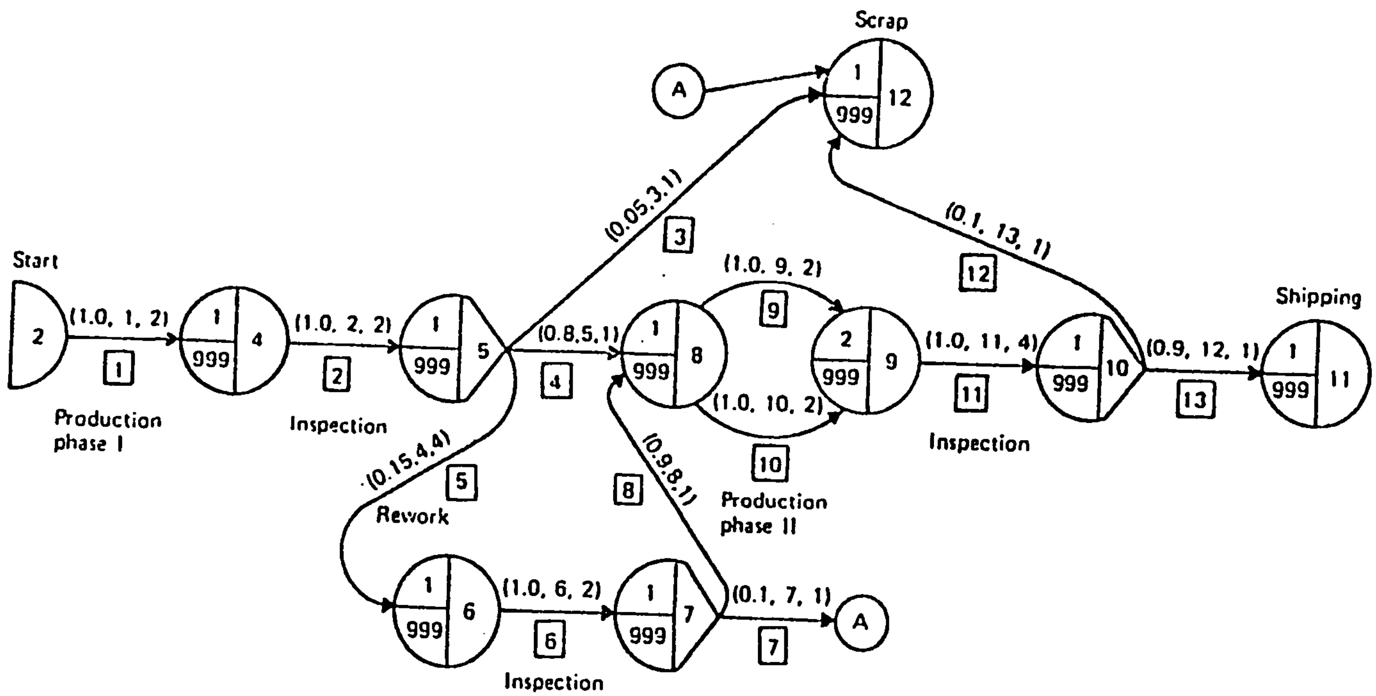


Fig. 2.9: GERT network of production example
Source: Ref: 49

2.4.4 Advantages of GERT (32, 33, 46, 47, 48)

1. It is the easiest method for assessing the effect of any logic change in the operations of the project.
2. It makes the most economical use of available resources (labor, equipment, finance, etc.), based upon the optimum completion time and cost of the project.
3. It permits clear definitions of responsibility.
4. It provides a more accurate estimate of the total project completion time.
5. It makes the collection of data and statistics a formal function within an organization.
6. It gives more useful information concerning the expected project time and critical path than do the other methods.
7. It allows the network modeler to choose from many different alternatives.
8. It allows multiple sink node in the network representing completion of the project which denotes different possible outcomes.
9. It allows the specification of the number of releases required for the next coming realization.
10. It allows looping that implies that certain activities may be repeated, greatly increasing power in the network.
11. Restrictive assumptions are not required.
12. It is best used when the performance of activities is probabilistic.
13. It is best used when the realization of a node is dependent on the completion of one or more activities.

2.4.5 *Disadvantages of GERT* (33, 46, 47, 48, 49, 52)

1. It is difficult to present the GERT method in a network diagram.
2. It is difficult to study and understand because it involves many different releases and alternatives.
3. It is difficult to apply because it contains probabilistic branching and deterministic branching.
4. Its diagrams are not useful as working documents at schedule level.
5. It is difficult to use because its physical, economical and financial boon of the systems approach become complex when it is associated with various loops.
6. It is difficult to follow flow paths.
7. It does not help the manager to visualize the accurate completion time of each operation (activity) included in the project.

2.5 Gantt Bar Chart (GBC)

Project planning and scheduling are the most basic of engineering and construction management services. Gantt Bar Chart (GBC) is one of the oldest techniques used for formalizing project planning and scheduling. A construction project's component items are studied and analyzed and the results are set out in the form of a chart. It is widely used because of its simplicity and visual effectiveness. GBC is defined as "the graphical prevention in the form of bars which show the estimated start and finish dates of each task of the construction projects."(4) This technique provides a method of integrating the project tasks into an overall plan. It is a planning tool that provides a means for calculating the time at which various resources such as materials, labor and equipment are needed for the project. The fundamental feature of any bar chart is that it represents a process as a line or bar, the length of which is proportional to the duration of the process. A bar represents a succession of activities performed by one man, one team or a machine. This technique gives the manager, contractor or any other concerned person a means of recording the actual progress of the project. It is an approach used to quickly determine whether the construction project is progressing according to plan or not.

A GBC depends on the local circumstances and the decision of application which depends on the type, size and degree of complexity of construction project. In any case, a GBC should be recognized as a temporary measure to span a period of time with respect to the activities involved in the project and their sequential relationships. There are four types of GBCs, which are a consecutive Job Bar Chart, a cross-connected Bar Chart, a float-linked Bar Chart and hybrid Bar Chart.(1, 4, 6, 7, 12)

2.5.1 Historical Development

GBC is one of the oldest scheduling systems, and was developed during the early days of Scientific Management. It was introduced by Henry C. Gantt in the early 1980s.(1, 15)

It is interesting to note that Gantt further developed this approach in the context of a military requirement during World War I. He worked with Army Bureau of Ordinance. He realized that a graphical method was required to portray plans and status for the munitions program operating at that time. He recognized that time was the one common denominator by which program plans with their positive and negative progress, could be most quickly assessed.(12, 13)

A GBC rests on the basic foundation of standard times, or relatively certain estimated times for set-up and processing. However, Gantt himself knew the difficulty of his approach, especially of obtaining realistic time estimates when a standard is not available.(1, 7, 12)

2.5.2 Purpose and Uses of GBC

For many tasks, a Gantt Bar Chart has been widely used all over the world because it is successful in planning, scheduling and monitoring many types of projects. It is a visual presentation of a construction program especially for short-term project work because it ensures that work proceeds in accordance with the overall program. It was developed as a means of planning the output of fixed production equipment.

A GBC provides an overall assessment of the tasks to be accomplished in the process of application. It helps construction managers to plan, schedule and control the construction project. It can be more readily applied to the output of products rather than to highly variable types of construction production.

Consequently, a GBC has many different areas of implementation such as maintenance (production for repetitive product), short-run overhaul work, research and development and other business areas. It may be applied to the construction industry for projects such as warehouses, factories and office buildings.(1, 4, 10, 12, 28)

2.5.3 Advantages of a Gantt Bar Chart (1, 4, 15, 27, 44, 53)

1. It is simple and gives a clear picture of the overall project.
2. It is readily understood at all level of management, starting from manager to the director and from the foreman to the laborer.
3. It is a flexible means of illustrating and updating the actual schedule with planned schedule. It is a dynamic proposition.
4. It is a visual method showing the relationship of planned to actual performance by marking up as the job progress.
5. It easily lends itself to updating without complete redrafting.
6. It readily shows the relationship between master program and any

subsidiary programs.

7. The format (Static Dimension) enables it to show the course of the work.

8. It is so clear that a GBC is used to indicate the demand for resources over each week or month by entering values and summing under the appropriate working days.

9. It lends itself to indicate the demand for material procurement and aids in requirements and key date symbols for material control.

2.5.4 Disadvantages of a Gantt Bar Chart (10, 11, 12, 28, 44)

1. It does not clearly show the interrelation dependencies among the project activities.

2. There is no special emphasis on critical activities in working up to project completion. It directly affects the total cost of the project by increasing the project duration.

3. The sequential relationship is not completely prescribed. Activities can be freely overlapped in term of time which may influence the actual performance of oncoming activities.

4. Complex, interrelated operations cannot be identified because the breakdown of the project into its components is very general in nature and some activities may be missed.

2.5.5 Basic Data for GBC

Gantt Bar Charts have been widely used in industry since Henry Gantt invented it in the early part of this century. A typical GBC is represented by a series of bars plotted against a calendar scale and each bar represents the begining, duration and end in time of some item process of the total job to be done. The static dimension of the bars together makes up a schedule for the whole project. The general principle steps of constructing a GBC for any project are listed below: (26, 28, 45, 53)

1. Establish a logical sequence of operations involved in the project.
2. Establish each activity to its dates (starting and finishing dates) with the quantity to be performed.
3. Avoid exceeding the capabilities of the resources that are available.
4. Provide for continuity of operations.
5. Start project control (long activity duration) activities early.
6. Plot the bars according to plan, dates, sequence, quantity of work and labor, etc.
7. Make decisions for resource leveling.

A typical GBC is shown in Fig. 2.10 which demonstrates the static dimension of graphical representation of one project. The project tasks are listed vertically and beside each task is the quantity of work to be performed. The bars plotted are associated with their starting estimated time and with their estimated finishing time for each of the activities involved. The times (start and finish) illustrated in this Figure are related to the calender dates of the year.

In addition, the schedule of activities is shown on the horizontal bar with their estimated times. These represent the estimated progress while the cross-hatched bar represents the actual progress. The difference between the estimated and the actual time, either positive or negative, helps the manager or contractor to know whether the progress of the task is on schedule or behind.

It must be recognized that a Gantt Bar Chart can be used as a tool for achieving timely completion, economy, and control of a project which involves many parameters such as: (7, 10, 12, 37, 44, 45, 53)

(a) Manpower Schedule (MS): It represents the total number of workers required to accomplish one activity. A sample of this schedule is illustrated in Fig. 2.11,

(b) Bill of Materials (BM): This shows the quantity of material needed to achieve or complete the task. An example of this schedule is demonstrated in Fig. 2.12.

(c) Equipment Schedule (ES): This schedule contains many subschedules for fuel, working hours for equipment drivers, types of machines, etc. The ES shows the main requirements such as the type, the date and the length of time needed. This type of schedule illustrated on Fig. 2.13.

(d) Expediting Line Schedule (ELS): This indicates the dead lines for the preparation and approval of shop drawings

Project ______________ Date ________

Location ______________ Pre. by ________

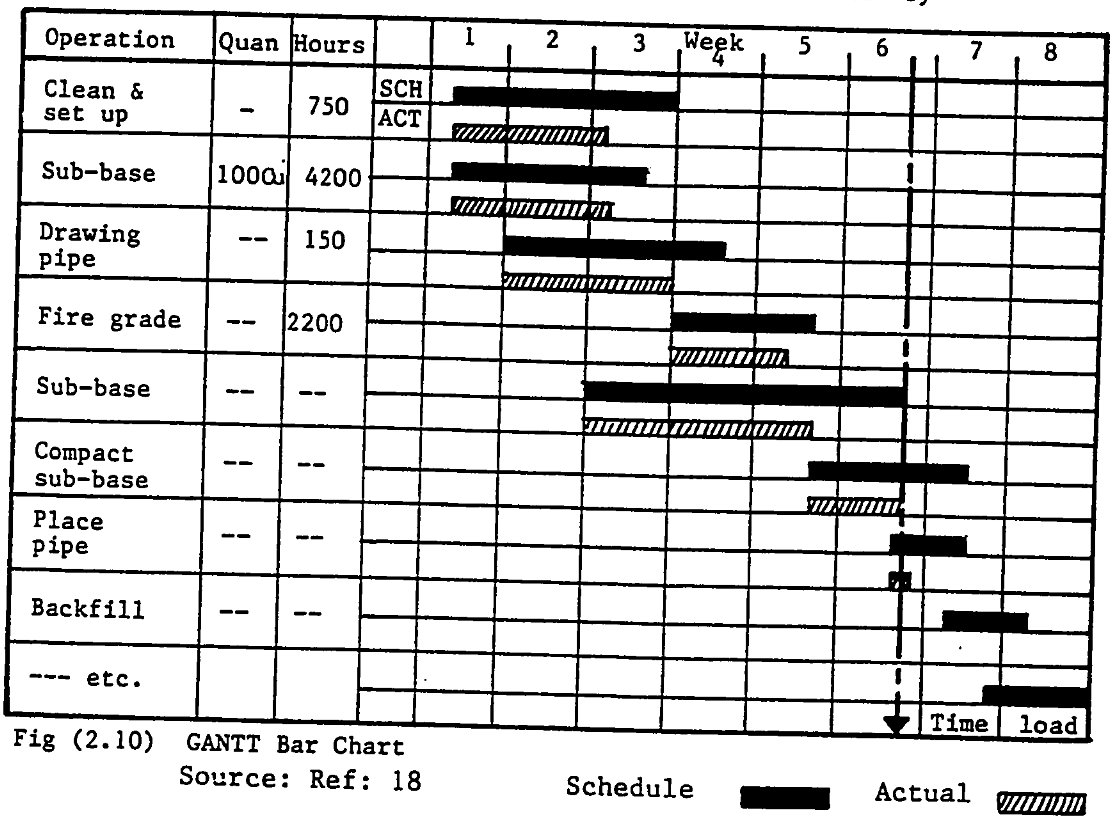


Fig (2.10) GANTT Bar Chart
Source: Ref: 18

Project ________
location ________
date ________

Trade	date 1	2	3	4	5
Backhole					
Crane operator					
Hoistoper					
Laborers					
Carpenters					
Masons					

------ etc.					

Fig (2.11) Manpower Sch.
Source: Ref:7

Project ________
location ________
date ________

	Material	Unit	Qual	
1.	Single precast concrete 6m wide	m^2	69000	
2.	-- --	-- --	-- --	
3.	- - - --- etc.	-- --	-- --	

Fig (5.12) Bill of Material
Source: Ref:44

Project ________
location ________
date ________

Equipmt.	Date 1	2	3	4	6
Crane					
Back hole					
Hoist					
-- -- --- etc.					

Fig(2.13) Equipmt. Sch.
Source: Ref: 44

Because of the simplicity of a Gantt Bar Chart many construction managers prefer to use it for planning and scheduling their construction projects. The decision as to whether or not to use GBC or any other time scaled presentation must in the end depend on local circumstances and top management's decision.

2.6 Fencing a Bar Chart (CPM/PERT/GBC) (FBC)

Planning and scheduling by any technique has always been part of project operation management. Managers and contractors are always looking for effective and efficient ways of planning and controlling the operations in a project. A Fenced Bar Chart (FBC) is a new graphical planning and control method used in construction. This technique provides management with: (10, 26, 27)

a) Detailed information on the progress and the outlook for accomplishing the tasks of the program.

b) Optimum measures of the validity of established plans and schedules for the effective accomplishment of total program objectives.

c) A means of predicting the impact of actual or proposed changes on the program.

d) Information about the negative or positive effects of changes after the process of corrective action.

e) Formal representing of both the logic and critical activity involved in the overall process.

Construction parties still have a strong preference for the Gantt Bar Chart (GBC). The different reasons for the preference include the simplicity of it, its ease of use, and wide familiarity with it, even among lower level personnel. However, GBC has some shortcomings such as the inability to represent interrelationships of activity, and the inflexibility of the chart for reflecting slippages or changes and the inability to reflect uncertainty.(3, 7) Most of the Systematic Examination Techniques have some shortcomings as mentioned earlier. A project manager must search for an effective method that can clarify all disadvantages and deficiencies and attempt to minimize the consequences of delays and litigation. Fencing Bar Chart (FBC) is the method that has all the advantages of both Gantt Bar Chart and networks such as CPM and PERT.(10, 26)

2.6.1 FBC as Accumulative Project Progress

The Fenced Bar Chart retains the simplicity of a GBC, yet presents the complete picture of the project and the sequences involved. This technique looks like a bar chart so that lower level personnel quickly understand what is being shown. It also represents the logic of a network which is found in both CPM and PERT. It provides diagrams which eliminate cross-over among paths. Recently, construction parties have changed from using networks (precedence or arrow) to bar charts in their application of CPM and PERT for effective planning and controlling projects. (10, 26, 27) The reasons for this change from Network to FBC are discussed below.

2.6.2 Human Factors and Communication Problems of both CPM and PERT

The main reasons of contractors' transferring is because of the human factor problems and communication problems in both CPM and PERT. CPM and PERT are complicated, but GBC requires a lesser degree of knowledge for skilled labor to understand. CPM and PERT require a higher level of training because the arrangement and placement of activities for large or complex networks becomes more critical as the network increases in size and complexity.(7, 10)

On the other hand, the communication problem is one of the most vexing troubles occurring between the lower and higher levels of management. CPM and PERT are difficult to understand by lower level personnel and by some managers and supervisors. Large and complex CPM and PERT networks (precedence or arrow) for large projects might be developed but not without difficulty of understanding even for top management, managers, specialists or supervisors whose job is to carry out and to be responsible for such parts of the project which are associated with the network plan.(3, 7) Actually, combining a Gantt Bar Chart with CPM and PERT will provide a technique which is effective for resolving the troubles arising from the implementation of CPM or PERT only.

2.6.3 Advantages of FBC (3, 7, 10, 26, 27, 31, 53)

1. It usually shows the logic involved in the network (precedence and arrow) and the usual information in Gantt Bar Chart.
2. It is an effective means of communication between the project manager and others involved in project.
3. It is a valuable means of tracking the progress of the project.
4. It readily indicates the interdependencies so that the planner can indicate why an activity is critical, or show the consequences of an activity delay.
5. It doesn't require excessive training to use it in all phases of project.
6. It encourages innovation by displaying the current and proposed

schedules.

2.6.4 *Determination of the Planning and Scheduling Information on the Fencing Bar Chart (FBC)*

The Fenced Bar Chart with two broken fences do not only shows the logical constraints, but also shows the required time when each activity is to be done and the float of each path to be considered. Therefore, any delay of an activity is clearly indicated. When an FBC is used to plan, schedule and control any construction project, it will obtain the overall functions and information shown in the network and Gantt diagram. This technique illustrates the combination data of the PERT, CPM and GBC which include the following: (3, 7, 26, 27)

1. Task duration.
2. Identification of each activity.
3. Indication of relationship between each activity and other activities.
4. Shows the total floats and free floats.
5. Indication of the critical activities.
6. Progress character
7. Shows the early start and early finish for each activity.

Figure (2.14a, b and c) illustrates the planning and scheduling of one project plotted by network, precedence and Fenced Bar Chart. The above information allowed the manager to answer the "What if we change this?" question quickly and accurately. The planner can trace and record actual progress while still updating the current plan for the project's remainings tasks.(26, 27)

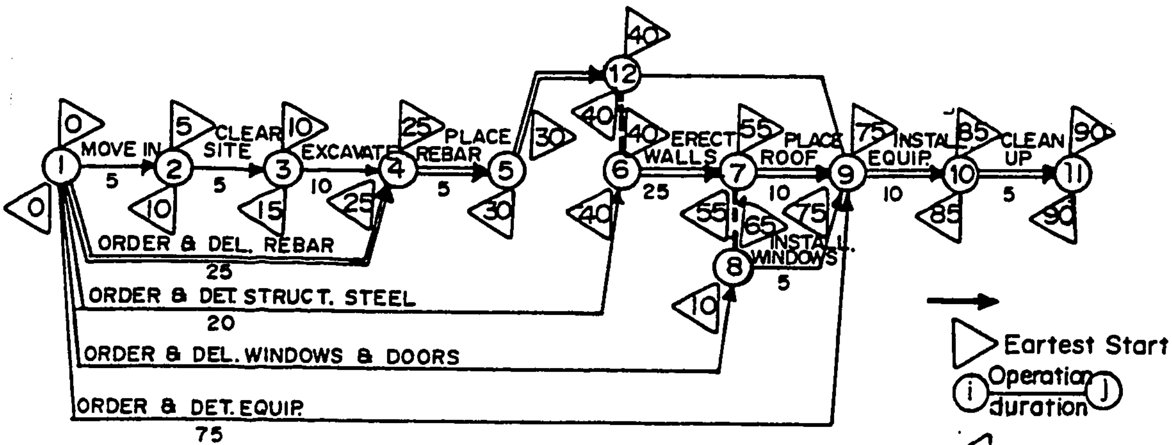


Fig (2.14a): A Network Diagram of Warehouse Project.
Source: Ref: 37

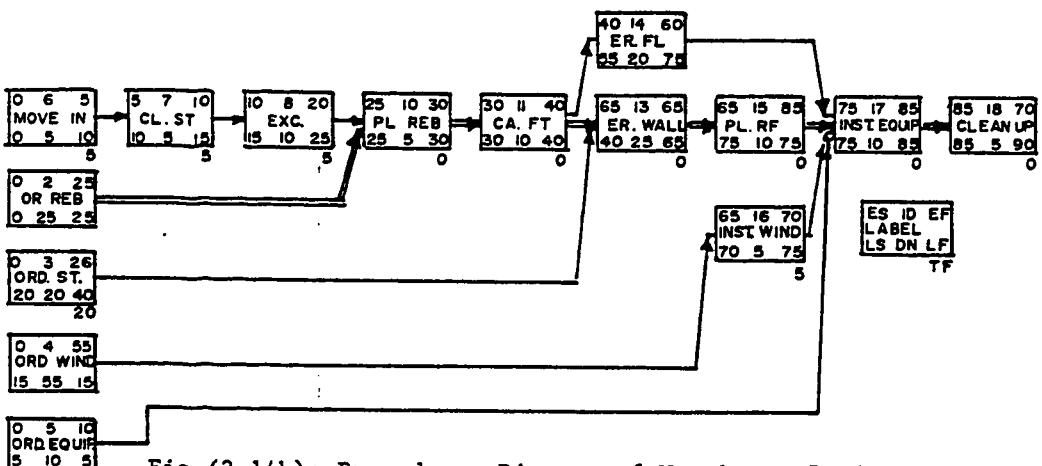


Fig (2.14b): Precedence Diagram of Warehouse Project.
Source: Ref: 37

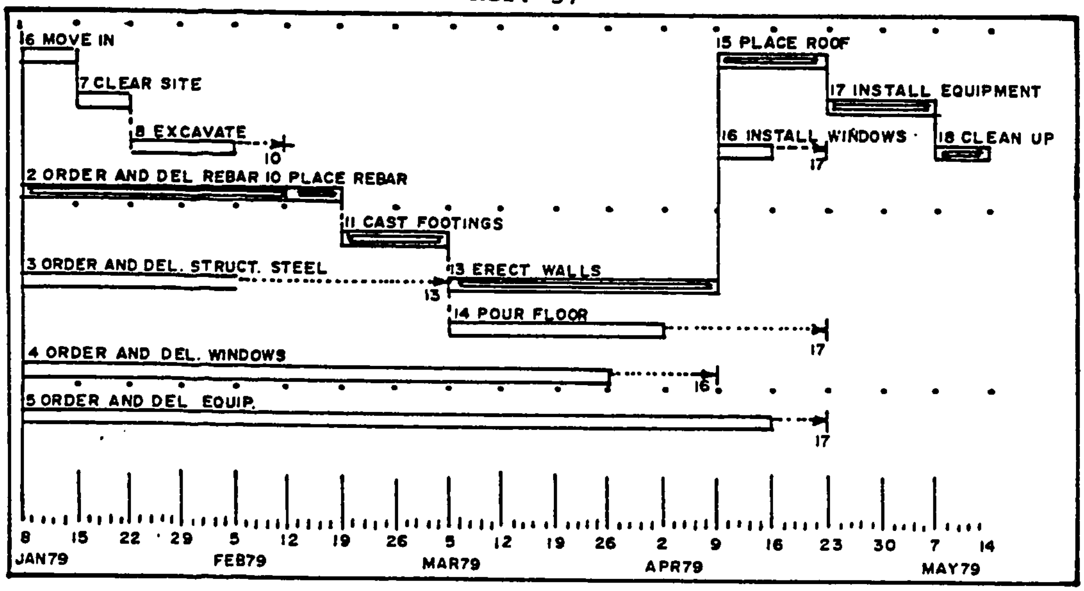


Fig. (2.14c): Fanced Bar Chart of Warehouse Project.
Source: Ref: 37

2.6.5 *Basic Data for FBC*

A Fencing Bar Chart shows the logic of the network and sequential relationship of activities in a GBC. The activities in an FBC are organized in a sequentional path order so that each path is clearly visible. The activity on the left of a fence is like the branches of tree and must be completed before any of the activities on the right side of the fence may start. Summing up the general procedure for drawing an FBC can be illustrated as follows: (3, 7, 26)

1. Draw a Gantt Bar Chart and fill in the time units according to the calculation of a network diagram.
2. List all activities in the left according to their network sequence.
3. Begin to draw, activity by activity, by beginning its early start and early finish and the scaled bar will represent the duration of the activity.
4. Identify the critical activities and the initial activities, and indicate the all floats and represent them by a denoted line or blank bar.

An FBC is one of the most effective tools of the project management profession. It helps a project manager in planning, scheduling and controlling all construction project phases. This new system provides managers and planners with a tactical planning technique. It improves longitudinal and horizontal communication in a simple manner among groups involved in a project.(3, 7, 26).

2.7 Comparison of SET as a Planning and Scheduling Tools

CPM, PND, PERT, GERT and GBC arrived on the industrial scene at different times, and as essentially independent developments. The technique used by managers, engineers, planners, and contractors depends upon some principle assumptions and some factors in which project to be applied. These can be a set of valuable management tools if they are given adequate support, thought and effort. Comparisons among Systematic Examination Technique (SET) for planning and scheduling are made according to certain logical criteria such as their applications, objectives and characteristics. The actual comparison is due to fundamental factors in terms of network preparation and the type of project to which the method is to be applied. This comparison of the SET is the result of studying the above mentioned techniques. The comparison is formed in order to help the planner, the engineer or the manager to visualize the most appropriate technique to be implemented in any project. It also gives the construction parties, especially the planner, a complete idea when deciding which technique is most suitable for the project. Indeed, some methods are not applicable in such project because there are some changes which happen due to project conditions and the experience of the construction manager. The comparison outcome will assist the planner or engineer in planning carefully for its use, in obtaining the full support of management, in utilizing supervisory leveling and in providing adequate training for those who will use the technique. It is essential to follow up the comparison with positive action to restore, correct and clarify all problems caused by the implementation of any technique for planning and scheduling. The problems in the acceptance of SET have arisen due to human resistance to change, carelessness in preparing the network and failure to follow up during the implementation of the project.(3, 4, 6, 7, 15, 32, 36)

2.7.1 Comparison between CPM and PERT

CPM and PERT are two techniques represented as mathematical mechanisms, which can evaluate either time or cost or both in order to complete the project within its time and financial limits. These two techniques have similarities between them. Both are arrow diagrams to graphically model a project. There are likewise some significant difference between the two techniques. The basic difference between PERT and CPM is in the objectives which their application are meant to attain. In using PERT, the U.S. Navy was primarily interested in reducing the duration of the Polaris missile project, irrespective of cost, but in using CPM, the Dupont Company was primarily concerned with cutting the overall costs of the plant overhaul.(27, 31)

PERT requires extra computational effort and hence additional costs are occurred. It is most valuable when very little background information is supplied, but CPM does not require any extra effort or additional cost. CPM is accurate, reliable and valuable when a project involves specific start and end times. In addition, CPM is particularly useful where a large number of interrelated tasks are to be carried out, so many of which may occur simultaneously.(31, 40, 43) In other words, the two major differences between CPM and PERT are based on both activity and assumptions of time. The first is the emphasis in PERT which is placed upon the activity stressed for completion data, whereas in CPM, emphasis is placed upon the activities to be accomplished. The second major difference is that CPM assumes the activity duration is deterministic with small variance, but PERT activities are assumed to be distributions of time with large variance.(23, 34, 53) A reliable comparison between CPM and PERT through various fundamental factors or features is represented and listed in Table 2.6.1.

2.7.2 Comparison between PERT and GERT:

GERT and PERT are somewhat similar to each other in such a way that they consist of events and activities connected in a logical order to form a model of some system of interest. Indeed, a PERT network must be completed, thus branching from a network node where all deterministic branches must be taken. However, GERT contains probabilistic or deterministic branching or some combination of the two. There are no loops allowed in PERT. On the other hand, GERT allows looping to be included. All activities in PERT are terminating at an event must be completed before that event can be realized, no event can be realized more than once in PERT. The GERT approach yields more useful information concerning the expected project time and critical path than does the standard PERT approach. Actually, GERT provides a consistently more accurate estimate of the project time and the standard deviation, while PERT may yield an estimate over or under the reliable estimate.(32, 44, 49, 57)

Generally GERT is a more accurate estimate of the total project completion time while PERT consistently presents an overly optimistic estimate. There are many other factors of planning and scheduling methods utilized for comparison between these two methods which are illustrated in Table 2.6.1.

2.7.3 Comparison of SET

Table 2.6.1 illustrates and describes a comparison of the Five Systematic Examination Techniques for planning and scheduling. This table provides a guide for the planner in deciding which technique is most suitable for his project. In fact, the project manager and the management team are responsible for the planning and they still make the necessary decisions based upon the information supplied, and, they choose which planning technique is most useful for their project based on the information they have. As pointed out earlier, the PERT network analysis will be valuable when uncertainly exists in performance time and costs. On the other hand, CPM network is sometimes unsuitable for the planner to analyze and control a project where uncertainty of time exists. The manual GERT technique for planning analysis is too difficult in terms of the technique involved in preparing network planning. The reader, in studying this table (2.6.1), will form an idea of which method must be used according to which type of project being handled and of what is required for the application of any system approach to planning, scheduling and control. Anyone interested in applying any of these procedures or in extending the concepts further can refer to the many books available on the subject of a network analysis. There are many examples of networks being used in

Table (2.6.1): Comparison of (SET) as planning & scheduling technique through Fundamental Features.

FEATURES ON SYSTEMATIC EXAMINATION TECHNIQUE (SET) FOR PLANNING & SCHEDULING	SYSTEMATIC EXAMINATION TECHNIQUE (SET)				
	1: CPM(1)	2: PND(2)	3: PERT(3)	4: GERT(4)	5: GBC(5)
1. Ease of format	By fencing bar chart (FBC)(6)	Acceptable by computer	By fencing bar chart (FBC)(6)	Difficult	Simple
2. Ease of communication	Improve	Moderate	Improve	Low	High for lower level
3. Emphasis on activities (activity time)	Moderate	Excellent	NEVER	NEVER	Moderate
4. Emphasis of events (Event time)	NEVER	NEVER	High	Highest	NEVER
5. Emphasis of BARS (Bar time)	None	None	None	None	Highest
6. Completion oriented	Reasonable	Moderate	Excellent	Excellent	Acceptable
7. Milestones	Acceptable	Acceptable	Acceptable	Difficult	Easiest
8. Skeletonizing	Rarely	Difficult	Acceptable by design	NEVER	Not usually
9. Complete redrafting after updating	Possibly	Possibly	Not usually	Rarely	NEVER
10. Ease of logic change	Difficult to impossible	Easy	Most difficult	Easiest	Not shown
11. Overlapped activities/ sequencing requirements	Require an extra activity	Easiest	Most difficult	Difficult	Not shown
12. Ability to follow float paths	Easiest	Difficult	Moderate	Most difficult	Not appear
13. Ease of presentation as diagram	More acceptable	Best	More acceptable	Acceptable	More possible

(Contd...)

Table (2.6.1): Comparison of (SET) as planning & scheduling technique through Fundamental Features.

FEATURES ON SYSTEMATIC EXAMINATION TECHNIQUE (SET) FOR PLANNING & SCHEDULING	SYSTEMATIC EXAMINATION TECHNIQUE (SET)				
	1: CPM(1)	2: PND(2)	3: PERT(3)	4: GERT(4)	5: GBC(5)
14. Likelyhood to misinterpret output	Least	Moderate	Moderate	Most	More least
15. Ease updating/correcting logic	Moderate	Strong	Low	Low	Moderate
16. Overall picture	By Fencing Bar Chart (FBC)	Moderate	By Fencing Bar Chart (FBC)	Poor	Best
17. Relationship of Planning to actual performance	By progress Plot	By progress Plot	By progress Plot	Moderate	Best
18. Demand of Resources (Resource levelling)	Reasonable	Moderate	Moderate	Difficult	Excellent
19. Relationship of Master Plan to subsidiary	Required Sub-Network	Sometimes shown	Extra-Network	Poor	Clearly shown
20. Ease of material control	Moderate	Difficult	Possible	Most difficult	Best
21. Ease of key date symbols	Strong	Moderate	Moderate	Not strong	Excellent
22. Delay clearly shown	Warning signal	Not strong	Acceptable	Not strong	Clearly appeared
23. Inter-related activities at preparation level	Excellent	Good	Good	Moderate	Not shown
24. Defining the critical activity	Easiest	Easy	Easy	Easy	Difficult
25. Ease of preparation of network	Easy	Easiest	Easy	Possible	Bar oriented

(Contd...)

Table (2.6.1): Comparison of (SET) as planning & scheduling technique through Fundamental Features.

FEATURES ON SYSTEMATIC EXAMINATION TECHNIQUE (SET) FOR PLANNING & SCHEDULING	SYSTEMATIC EXAMINATION TECHNIQUE (SET)				
	1: CPM(1)	2: PND(2)	3: PERT(3)	4: GERT(4)	5: GBC(5)
26. Fast of determination of responsibility for work	Strong	Strong	Moderate	Low	Low
27. Ease of time-scaling diagram	Moderate	Moderate	Moderate	Not strong	Excellent
28. Need of special symbol	Sometime	Sometime	Needed	Most Needed	Acceptable
29. Usefulness of diagram as working document at performance level	Moderate	Usually	Not usually	Low	Best
30. Usefulness of diagram as working documents at scheduling level (Engineering data record)	Best	Low	Moderate	Lowest	Excellent
31. Fast of manual calculation	Highest	Low	Moderate	Lowest	Usually
32. Standardizing influence in terminology and presentation	Sometime	Never	High	Highest	Possibly
33. Simulation oriented	Never	Never	Never	Of course	Never
34. Stochastic structure of Model	Not	Not	Not	Of Course	Not
35. Determistic structure of model	Of course	Not	Of course	Not	Slightly
36. Direction of flow in network	Undirectional	Undirectional	Undirectional	Forward & Backward	Now shown
37. Determination of criticality index	Best	Strong	Strong	Moderate	Not.

(Contd...)

Table (2.6.1): Comparison of (SET) as planning & scheduling technique through Fundamental Features.

FEATURES ON SYSTEMATIC EXAMINATION TECHNIQUE (SET) FOR PLANNING & SCHEDULING	SYSTEMATIC EXAMINATION TECHNIQUE (SET)				
	1: CPM[1]	2: PND[2]	3: PERT[3]	4: GERT[4]	5: GBC[5]
38. Ease of Reading & Understanding	Moderate	Moderate	Moderate	Difficult	Best
39. Stochastic parameter of Model	Not	Not	Of course	Of course	Not
40. Deterministic parameter of Model	Of course	Of course	Not	Not	Slightly
41. Warning signal before problem	Best	Moderate	Moderate	Not strong	Not strong
42. Evaluation effect of changes	Best	Good	Good	Low	Moderate
43. Simplifying by computer	Good	Best	Good	Good but time consuming	Possibly
44. Single numbering draw the network	Never	Best	Never	Never	Never
45. Course of action at work	Moderate	Moderate	Moderate	Low	Best
46. Help management for decision	Strong	Strong	Strong	Not strong	Strong
47. Powerfull for specific start of project time	High	Moderate	Moderate	Moderate	High
48. Clear view of scope	Best	Moderate	Moderate	Low	Strong
49. Avoidence of fictitious demands	Acceptable	Best	Possible	Moderate	Not shown
50. Uncertainty renovation	Not strong	Not strong	Best	Strong	Poor

practice with great success for which references are available in the bibliography.(3, 19, 33, 35, 41, 42)

2.7.4 Selection of SET By Construction Parties

Construction management is a difficult field and traditional structures have often proved to be ineffectual in carrying out all duties assigned. The construction manager is responsible to top management for getting the job done on schedule within the allowable cost. However, this goal must be accomplished by employing the efforts of many separate organizations and workers, most of which are not under his direct supervision. SET have been developed primarily to assist the construction manager in planning, scheduling and controlling the work under his supervision. By utilizing the SET for planning and scheduling on the project, a manager knows which activities are critical and so require special attention, or what effect a delay and what a failure in one activity will have on others following it or on the success of the project as a whole.

The master plan of all project segments need to provide the manager with an up-to-date overall picture of the operation at all times, and should employ a technique understood by all parties. The SET are developed and designed to fulfill the above mentioned needs. These techniques can be regarded as warning signals for any effect of change in the overall project and certain decision making functions must be taken place. All parties to the construction must look after a new method or technique to provide its management with a measure of the validity of the established plan and the schedule of the total program objectives, thus providing a means of predicting the impact of actual plan of the total program objectives and information on progress to date.

Decision making by selection of the best technique in the SET depends on project size, type, degree of complexity and availability of all resources needed to accomplish the project. Usually, construction managers or any other concerned person look for a technique which will supply certain information needed by them in a timely, useful and understandable manner.(3, 19, 35, 42, 57)

Fundamentally, the initial "doing-not doing" decision depends on the manager's view of such problems based on his experience and the project conditions. Table 2.6.1 may enable responsible managers to design and implement better techniques of planning and scheduling in their own companies. Generally, if this table is effectively workable in helping managers to make more effective use of Systematic Examination Technique for planning and scheduling, it will benefit shareholders with large profits, employees with higher wages and the customers with better value for their money.

CHAPTER 3

RESEARCH METHODOLOGY

This Chapter describes all the procedures that have been followed for achieving the objectives set for this study. The following sections describe the research approaches, the research design, the essential required data, data collection, source of data and the sampling techniques used to select the key information in this study.

3.1 General Research Approach

The complete research design of this study which includes the literature review, questionnaire utilized, data collection and analysis, results of findings and the conclusions, and recommendations is summarized on the analysis diagram of research design and methodology in Figure 3.1. The methodology of this research consists of five steps that have been taken in achieveing the objectives stated in the statement of the problem. These steps can be summarized in the following phases :

Phase One : An intensive review of the related literature was conducted to study the Systematic Examination Techniques (SET) for planning and scheduling, including CPM, PERT, GERT, PND and GBC. This literature review focused on identification and description of each method, and a comparison among them.

Phase Two : The first survey search was conducted for gathering the necessary data through a preliminary questionnaire . Interviews, site visits, telephone contacts and discussions with concerned firms were conducted for obtaining data.

Phase Three : The second survey search was conducted by formulating the final questionnaire by utilizing the intensive literature review and the preliminary interviews. These questionnaires were distributed to and collected from construction firms.

Phase Four : Data analysis through statistical techniques was conducted on the data which was previously gathered.

Phase Five : Recommendations based on the analysis of the collected data were made and these are supported by conclusions and suggestions.

The analysis of the preliminary questionnaire resulted in the formation of the final survey questionnaire (Appendix A) which was distributed by mail or by hand and collected on a second visit. Numerous field visits were conducted to different construction companies' offices. The data gathered from the discussions were assembled and carefully studied in order to develop the final questionnaire format. This stage was necessary to assure that the questionnaire covered the full dimension of the subject

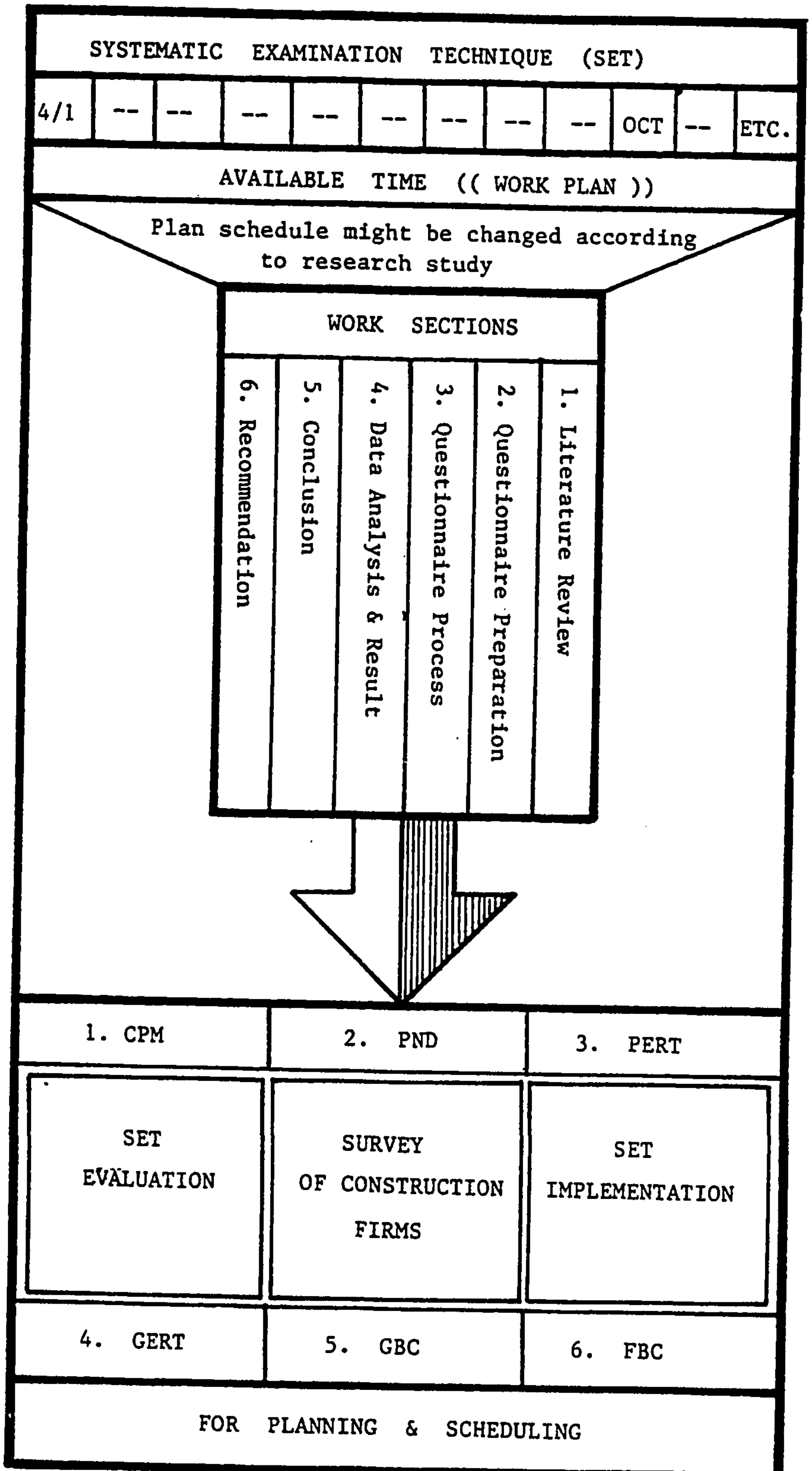


Figure (3.1): Analysis Diagram of Research Methodology with respect to assigned objectives.

Special care was exercised in the abovementioned phases such as the way the contacts were made, the way the research was introduced, and the guidelines and the logical sequence of personnel. These steps were followed to achieve the objectives assigned for this study. The purpose of the first phase is to achieve objectives 1, 2 and 3 set for this study and to set the foundation for achieving the other two objectives. The last phase was held to achieve the last two objectives of this research.

3.2 Required Data

An intensive literature review concerning the main Systematic Examination Techniques was conducted for the purpose of identifying and presenting the Systematic Examination Techniques . The identification and presentation requirements include historical data on each method, the basic procedure, and the advantages and disadvantages of each technique.

The advantages and disadvantages were stated clearly for each method in order to provide a broad significant appreciation of the nature and uses of the methods involved in the set. The advantages represent the benefits obtained by utilizing a technique while the disadvantages concern the limitations and difficulties of implementing any one of the sets. For Objectives 1 and 2, the essential data review was conducted as a basis for both comparison criteria and questionnaire development.

In addition, a study of all types of Systematic Examination Techniques has been performed to make a comparison study among the methods through fundamental factors such as the emphasis placed on events or activities which comprise the differences of notation among the techniques. Each method is either a network by event or an arrow diagram by node. The other factors for comparison include, 1) completion oriented (the problem of uncertainty of time duration for individual job), 2) ease of logic chance (modification by action required and new schedules could be developed), 3) ease of preparation of the technique (either by simple number or depending on activity or event tables), 4) ease of determination of the responsibility of work (capability of investigating the actual responsibility of each individual), 5) ability to flow the float path through the diagram or the network, ease of time scaling diagram (the degree of preparation of the network sequence of jobs by time scale method, 6) Ease of balancing the resource allocation, 7) need of special symbol (in the notation of the system), simulation oriented (estimated the time duration by simulation), 8) direction of flow in network (either one way or two way directions) and 9) the level of communication between lower level personnel and upper level of the top management and amongst other factors and features such as their flexibility of utilization, availability, ability, capability and optimization among all the work function items of the methods (for Objective 3).

The literature review established the basis for the questionnaire development. A survey study of the Systematic Examination Techniques was conducted to establish the nature of implementation and the level of importance of these methods among Saudi Arabian construction contractors. These questionnaires were distributed by mail to different firms in different regions in Saudi Arabia for the purpose of collecting the needed information for this study (for objectives 4 and 5).

3.3 Data Source

Two prime sources were used for securing the necessary data. The first source was the literature, which includes books and periodicals. The literature is rich in data needed. The second source was the industry, which means the construction contractors in different regions in Saudi Arabia. The second stage in the study involved field visits, interviews and discussions with Saudi construction contracting companies. It focused on the identification of the nature and uses of planning and scheduling methods, the aspects of utilization, the user's levels, the level of importance, the degree of success, the causes of success and causes of failure in using these methods. The questionnaire was the medium for collecting information needed from the construction industry.

3.4 Sample Survey's Data Collection

A survey among construction companies in the Saudi Arabian construction industry was conducted. A structured questionnaire was utilized as the main vehicle for gathering data from the contractors. The preliminary questionnaire was designed to cover the overall issues in formalizing the final questionnaire . The issues included frequency of users of Systematic Examination Techniques (SET), the aspects of implementation, the different users of information gathered from using these methods, the benefits obtained, the major concerns with regard to each method and the level of importance of implementation, the successful utilization of methods, and descriptive characteristics of respondents. The main function of this questionnaire was to secure information relevant to the scope and nature of the use of the SET among large construction firms. In addition, it was the purpose of the questionnaire to get top management assessment on the benefits and problems associated with the use of these methods as well as their importance to the firm (for objectives 4 and 5). Additionally, structured interviews were used as a medium of data collection for this research in order to avoid any major difficulties such as any misinterpretation of an amount of data have been guaranteed due to the variety of terminology in the construction field.

3.5 Sample Survey's Questionnaire Development

A similar questionnaire was utilized in 1962 to study the application of planning and scheduling technique with CPM. This first survey on CPM was developed by editorial with CPM and survival published in the Engineering New Record.(11) The same survey was conducted by Robinson (35) in 1965 with similar questionnaires; another study was carried out by Schederbeck (31) in 1965 for studying the application of PERT. Mansfield (45) in 1969 performed a study of technical innovation and limitations among a large number of companies in various industries in England. Davis (20) in 1974 studied through survey the CPM application among American construction companies. Farage (8) ran the same questionnaire of Davis in Kuwait. All the questionnaires utilized in the above studies are similar and concerning CPM method only.

All the above studies, especially Davis, set the foundation for the development of the questionnaire that is used in this study. The questionnaire utilized in this research is extended to the application of five techniques of planning and scheduling such as CPM, PERT, GERT, GBC and PND which are included in the Systematic Examination Techniques .

The questionnaire in this study has been modified from Davis's questionnaire and extra questions have been added. Some of Davis's questions have been deleted and other questions have been modified and organized differently in a more compact format. Davis's questionnaire involved only CPM uses by the top 400 construction firms in the U.S., but this study was extended to five techniques instead of only the one method of that survey. For collecting the data, personal site visits and personal interviews and discussions were conducted with corporate officers, planners and engineers in selected firms.

3.6 Sample Survey's Questionnaire Design

The analysis diagram of the sample survey questionnaire design methodology is shown in Figure 3.2.

A cover letter was sent to selected construction companies along with the final questionnaire (Appendix A). The letter asked the respondents to fill out the questionnaire . The questionnaire was either picked up on a second visit when the information was aided in the completion or the set returned by mail. Data were collected through the questionnaire which was left to be answered or filled by a key informant, who was either the

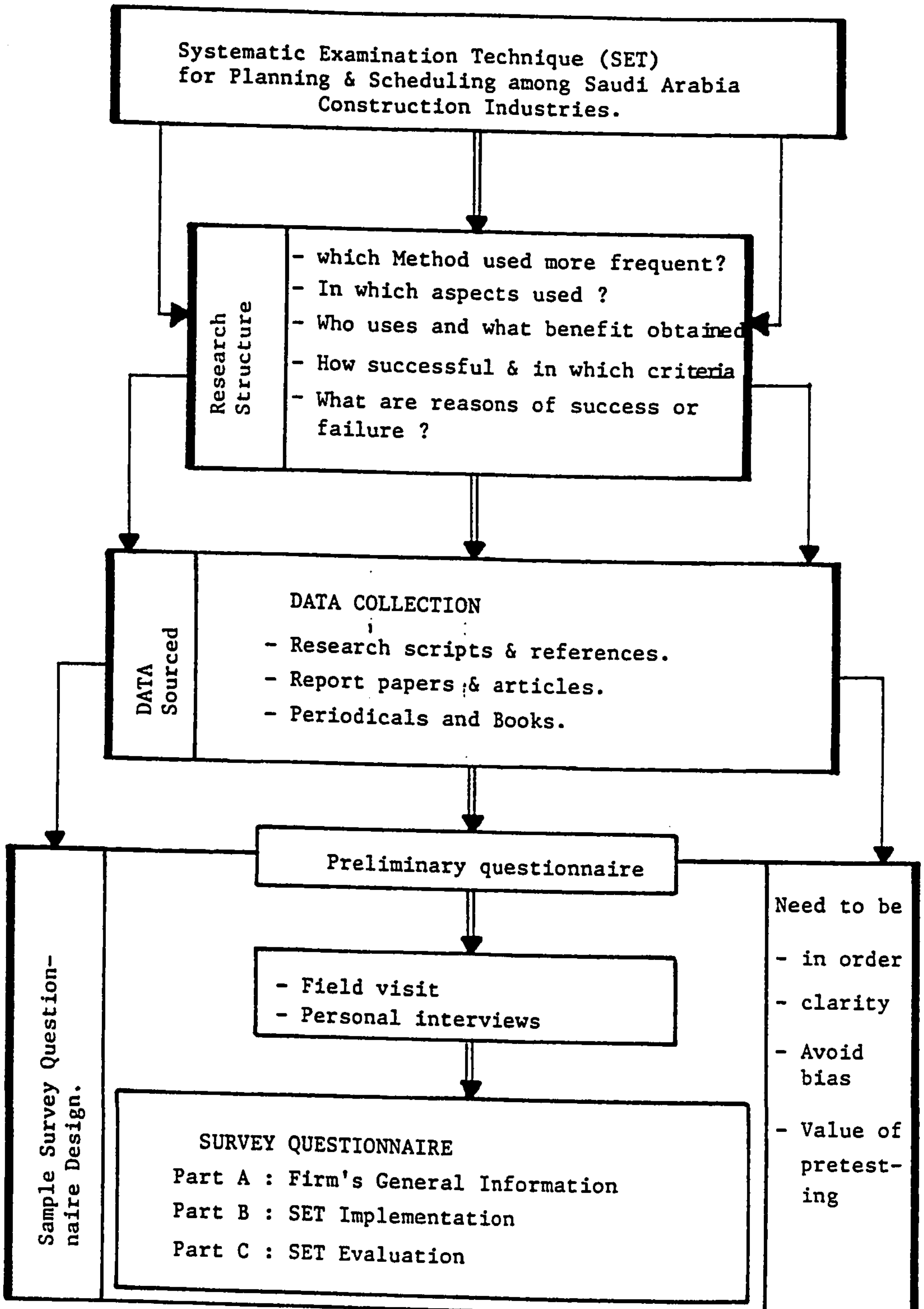


Fig (3.2) Analysis Diagram of Sample Survey Questionnaire Design Methodology.

construction project manager, the planner, cost engineer or a subordinate manager.

The questions sought information on the firm's general description and the contractor's personal characteristics. The application of SET for planning and the scheduling and the evaluation of the SET in the contractor's point of view were sought to aid in determining the benefits and problems associated with the use of any of the methods utilized.

This investigation by the final questionnaire was quite necessary to assure that the structured questionnaire covered the full range of information and the dimensions of the assigned objective of this study and the research subject.

The survey Questionnaire is divided into three sections. The first section (Part A) inquires about FIRM INFORMATION, which seeks general information related to the firm, such as the company's name, nationality, location of main and branch offices, total number of employees, and the size of the company in terms of Saudi riyals. The needed information in this section provides general information about the respondents in order to assist classification and other statistical analysis purposes. The second part (Part B) examines the implementation of the Systematic Examination Techniques (SET). It is entitled the SET IMPLEMENTATION and includes the type of methods used by the respondent organization, the frequency of use of the method, the main function or aspect of using the methods, and at which level the respondent utilizes the information from implementation of the SET. The main purpose of this section was to seek information relevant to the procedure of how respondents applied the methods in order to give researchers complete knowledge about the scope and nature of use of the Systematic Examination Techniques .

Finally, the third section (Part C) examines SET EVALUATION. It includes the type of benefits obtained from implementation of any one of the SET, and major concerns with regard to the operation and use of any one of the methods. It also seeks criteria to measure successful and the reasons related to successful use. It also seeks failures by users and the reasons for this failure. The SET Evaluation section function is to help any researcher, planner or any other concerned person in applying these methods and to give them complete knowledge about the scope and nature of use of the Systematic Examination Techniques for effective cost reduction. It also obtains the top manager's views on the benefits and problems associated with the use of these methods.

3.7 Sample Size Determination and Selection

This section explains the sample size determination from the population and the procedure for selecting the respondents in this study. These will be considered in turn.

3.7.1 Sample Size Determination

The structured questionnaire were distributed to construction contractor companies in Saudi Arabia, who are involved in industrial construction . This survey contains one population and covered by the stratum:

Stratum (1) .... Contractors

The following formula was used to determine the sample size :

$$n = (ts/d)^2 / [1 + (ts/d)^2 / N] \quad (3.1)$$

where:

n : Sample size

N : Sample population

t : $t\alpha/2$ is the abscissa of the normal curve that cuts off an area of σ at the tails. $t\alpha/2 = 1.960$ from Table.

d : the amount of accuracy $(1 - \sigma)\ \% = 0.05$

S : P_q, $P = 0.5$ and $q = 1\text{-}p = 0.5$; Maximum standard deviation in proportion of estimation.

For the only stratum concerning the survey study, the list of contractors available contains contractors mixed with building and other contractors. There are 1,000 construction contractors in different regions in Saudi Arabia as published in the directory of construction contractors.

Therefore, the calculation of the sample is as follows: (14, 22)

$n_1 = (1.96 * 0.5/0.05)^2 / [\ 1 + (1.96 * 0.5/0.05)^2/1000\ ] = 277.54$

$n_2 = 277.54 / [\ 1 + (277.54/1000)\ ] = 217.25$

$n_3 = 217.25 / [\ 1 + (217.25/1000)\ ] = 178.48$

$n_4 = 178.48 / [\ 1 + (178.48/1000)\ ] = 151.45$

$n_5 = 151.45/[1 + (151.45/1000)] = 131.53$

$n_6 = 131.53/[1 + (131.53/1000)] = 116.24$

$n_7 = 116.24/[1 + (116.24/1000)] = 104.13$

$n_8 = 104.13/[1 + (104.13/1000)] = 94.30$

$n_9 = 94.30/[1 + (94.30/1000)] = 86.17$

$n_{10} = 86.17/[1 + (86.17/1000)] = 79.33$

$n_{11} = 79.33/[1 + (79.33/1000)] = 73.51$

$n_{12} = 73.51/[1 + (73.51/1000)] = 68.10$

$n_{13} = 68.10/[1 + (68.10/1000)] = 63.75$

Beyond this, the difference becomes smaller. So, the total sample is 63 out of all contractors. This represents the actual sample size for this survey study. Questionnaires were distributed to one type of organization containing 63 respondents.

3.7.2 Sample Size Selection

The method of selection of these companies in the sample from different regions in Saudi Arabia was done by applying the generation of random digit procedure which is performed by numbering the whole population of the 1000 companies and each individual randomly. These selected construction companies are listed in Appendix C. The sample of construction firms in this study comprise 63, as calculated in the sample size determination section, out of the 1,000 construction firms in Saudi Arabia as published in both Al-Egtisad Magazine which is published by the Chamber of Commerce and Industry, Eastern Province, Dammam, Saudi

Arabia, and in the Directory of Construction Contractors in Saudi Arabia.(56)

3.8 Statistical Data Analysis and Measures

One of the important statistics is used to make inferences about larger groups on the basis of information obtained from smaller groups or samples. The analyzer or researcher can make statements and generalizations about the population on the basis of information gathered with any accuracy depending on the representative nature of the sample utilized. The analytical procedure is employed to represent the various different views and nature of using the SET. It also gives top management's views on the benefits and problems associated with implementation of these methods. Indeed, the most important parts included in the questionnaire are (Part B) SET IMPLEMENTATION and (Part C) SET EVALUATION. The information gathered from the questionnaire was analyzed statistically. The data was tabulated and summarized in a compact format in order to be studied and analyzed by descriptive statistical analysis. Also, statistical analysis through applying the cross tabulation procedure for calculating the percentage associated with the findings. Other statistical techniques were incurred and utilized in this study including ranking, scoring and correlation. These statistics are used for calculating and presenting the survey results. Analyses were conducted using the SAS Program. The analysis of the data finally represented by tables, diagrams, monographs and other figures.

3.8.1 Scores for Ranking of Factor Categories

The questionnaire contains three sections. For the first section, Part A "Firm's s Information" seeks general information related to the respondent and his company. For this reason, no such scorings or rankings were calculated. For Part B, "SET Implementation", which investigates the level of utilization, each question consists of factor or reason related to the subject and has some categories were listed under each one of them, namely, aspect of utilization of the SET by the firms and level of utilization the implementation obtaining through SET implementation by the firms. The analytical procedure employed aims to establish the Relative Importance Index. The Importance Index is figured through a combination of two questions, one of them related to the factor or reasons and the other related to the degree of importance (top management view) for each grouped category under each factor. For each SET cited, respondents were asked, "How important do they view the technique used in their firm". This question contains three opportunities which include, "very important" to the current success of their firm, "moderately important" to the current success and "relative unimportant" The categories were "very important" (3 credits), "Moderately important" (2 credits) and relative unimportant (1 credit). The answering of these items consisted of figures and means that could be established for the total answer of each question by using this formula :

$$X = [\sum_{i=1}^{n} X_i] / n \qquad (3.2)$$

Where:

X = The average

X_i = The value given by response (i)

n = Number of grouped responses

Scores obtained were reversed for analysis of the survey results. In other words, this calculation procedure of the importance index represents a transferring process from qualitative (nonnumerical values) into quantitative (numerical values) by grouping the non-numerical to numerical scores and a higher score meant a higher degree of importance index or the relative success index.

The main part in the questionnaire is Part C "SET Evaluation". The level of importance for each category under each factor is ranked depending on their frequencies. In this part, a combination of the top management views with the criteria for measuring the successful utilization of the technique used, the reasons for success in realizing the various benefits and reasons for failure in using the SET. The same results were computed in the same manner as the previous questions. It shows the frequentcy of each category under each factor by the three classifications of respondents, large firms, medium firms and small firms. The relative important index was obtained by multiplying the individual degrees of importance by the scores assigned to each degree by each respondent for each category under each factor for the three groups. Each category has an importance index as follows:

Relative Importance Index (IM IND) =

$$\Sigma [\, a_i * X_i \,] * \; 100/3 \qquad (3.3)$$

Where:

a_i = Constant expressing the scores assigned to each level of importance

X_i = The variables expressing the weights or the frequency of factor categories

X_1 = The frequency of "Very Important" response(s)

X_2 = The frequency of "Modest Important" response(s)

X_3 = The frequency of "Relatively Unimportant" response(s)

Some of the respondents added other comments for question 4 (Part - C) (top management views) which examines the level of importance. Some of the comments were:

(1) If the firm handles a small job, it is relatively unimportant.

(2) If the firm handles a large job, it is important.

On the other hand, as indicated in the questionnaire , there are three opportunities for methods used by the respondents that need to be considered as contributing to the successful contribution of each category listed under each factor. The firms were asked how successful their company has been in realizing the various advantages attributed to the use of each SET. The three options listed were very successful, modestly successful and unsuccessful. Scores obtained were reversed for analyses. Very successful corresponded to 3 credits, modestly successful corresponded to 2 credits, and unsuccessful to 1 credit. A higher score means a higher degree of success, and a lower score means a lower degree of success. The same procedure employed for calculating the relative importance index will be employed for the calculation of the relative success index. This analysis uses the same factors analyzed previously consisting of the aspect of utilization, level of implementation, criteria of successful users of the SET, reasons of success and reasons of failure among all the techniques used by the respondents.

Scores for ranking made this study very important and it may be possible to cross-compare the relative importance index and the relative success index of the different variables as seen in the different groups (large, medium and small firms). The relative success index was obtained by multiplying individual frequency for each group's methods by the scores assigned to each level of success of factor categories. The following formula is used for the calculation of this index.

Relative Success Index (SUC IND) =

$$\Sigma [a_i * X_i] * 100/3 \tag{3.4}$$

Where:

a_i = Constant expressing the scores assigned to each level of success

X_i = The variables expressing the weights or the frequency of factor categories

X_1 = The frequency of "Very Successful" response(s)

X_2 = The frequency of "Modestly Successful" response(s)

X_2 = The frequency of "Unsuccessful" response(s)

The other reasons listed in the questions which is related to the 'unsuccessful' include required extra cost, too complex to deal with any one of the methods, need for specialists and difficulty of dividing the job into phases. Some of the respondents added other reasons such as : 1) lower levels of personnel are not well trained for using the technique in their firms, 2) operations people are not familiar with the critical aspects of using the SET in their firms.

3.8.2. Statistical Techniques: Reliability and Validity

Statistical techniques are used in this thesis to aid in the interpretation of the existing information. Table 3.1 presents the results of statistical techniques for all of the questions about the SET. The statistics include the weighted mean, standard deviation, standard error of the mean, the confidence interval and the coefficient of variation. The two most important measures for this analysis are the confidence interval and the coefficient of variation. The confidence interval consists of the sample value of a point estimate with a calculated range on either side. Samples are not representing the perfect reflections of the total population from which they are drawn. We are not guaranteed how close the sample's values to popu-

Table 3.1 : **Statistical Techniques used in the analysis of data.**

Variable Q # Ind.	Mean	Standard Deviation	Std. error of Mean	95% Confidence interval	Variance	Coefficient of Variance (C.V.)
QA1	1.80	1.03	0.13	1.80 ± 0.25	1.06	57.11
QA2	5.48	2.47	0.32	5.40 ∓ 0.63	6.09	45.06
QA3	1.46	0.74	0.10	1.46 ∓ 0.19	0.55	50.94
QA4	4.98	1.95	0.25	4.92 ∓ 0.49	3.78	39.03
QA5	4.30	1.76	0.23	4.30 ∓ 0.45	3.11	41.07
QA1F	8.93	2.77	0.36	8.93 ∓ 0.71	7.70	31.05
QA2S	3.93	2.25	0.29	3.93 ∓ 0.57	5.06	57.19
QA3N	7.39	2.85	0.36	7.39 ∓ 0.71	8.11	38.52
QA5CPM	2.52	1.30	0.18	2.52 ∓ 0.35	1.68	51.48
QA5PND	2.46	1.27	0.35	2/46 ∓ 0.69	1.60	51.43
QA5PERT	2.74	1.24	0.28	2.74 ∓ 0.55	1.54	45.31
QA5GBC	1.55	0.95	0.13	1.55 ∓ 0.25	0.91	61.53
QA6CPM	5.42	3.33	0.48	5.42 ∓ 0.94	11.06	61.39
QA6PND	5.08	3.23	0.89	5.08 ∓ 1.74	10.41	63.55
QA6PERT	3.73	3.08	0.80	3.73 ∓ 1.57	9.50	82.54
QA6GBC	5.40	3.23	0.45	5.40 ∓ 0.88	10.40	59.68
QA7CPM	5.51	3.01	0.44	5.51 ∓ 0.86	9.08	54.69
QA7PND	4.46	3.07	0.85	4.46 ∓ 1.67	9.44	68.85
QA7PERT	2.65	2.23	0.54	2.65 ∓ 1.10	4.99	84.41
QA7GBC	5.53	2,60	0.36	5,53 ∓ 0,70	6.75	47.01
QB1CPM	15.10	8.53	1.23	15.10 ∓ 2.44	72.69	56.45
QB1PND	15.17	5.75	1.66	15.17 ∓ 3.25	33.06	37.91
QB1PERT	15.44	8.23	1.94	15.44 ∓ 3.80	67.79	53.31
QB1GBC	14.25	8.25	1.13	14.25 ∓ 2.21	68.07	57.92
QB2CPM	3.70	1.64	0.26	3.70 ∓ 0.51	2.68	44.22
QB2PND	4.18	1.40	0.42	4.18 ∓ 0.82	1.96	33.51
QB2PERT	3.77	1.96	0.54	3.77 ∓ 1.10	3.86	52.12
QB2GBC	4.27	1.63	0.25	4.27 ∓ 0.49	2.67	38.23
QB3CPM	3.52	2.59	0.38	3.52 ∓ 0.74	6.70	73.50
QB3PND	4.25	2.67	0.77	4.25 ∓ 1.51	7.11	62.76
QB3PERT	4.38	2.63	0.66	4.38 ∓ 1.29	6.92	60.11
QB3GBC	3.43	2.55	0.43	3.43 ∓ 0.84	6.49	74.29
QB4CPM	1.33	0.56	0.08	1.33 ∓ 0.16	0.31	41.90
QB4PND	1.33	0.49	0.14	1.33 ∓ 0.27	0.24	36.93
QB4PERT	1.47	0.51	0.12	1.47 ∓ 0.24	0.26	34.99
QB4GBC	1.30	0.51	0.07	1.30 ∓ 0.14	0.26	38.85
QB5CPM	1.60	0.57	0.08	1.60 ∓ 0.16	0.33	35.71
QB5PND	1.45	0.52	0.16	1.45 ∓ 0.31	0.27	35.90
QB5PERT	1.47	0.51	0.12	1.47 ∓ 0.24	0.26	34.99
QB5GBC	1.37	0.49	0.07	1.37 ∓ 0.14	0.24	35.58
QB6CPM	4.36	2.64	0.39	4.35 ∓ 0.76	6.98	60.55
QB6PND	5.00	2.68	0.81	5.00 ∓ 1.59	7.20	53.67
QB6PERT	3.81	2.86	0.71	3.81 ∓ 1.39	8.16	74.94
QB6GBC	4.51	2.71	0.38	4.51 ∓ 0.74	7.33	60.05
QB7CPM	4.80	3.04	0.43	4.80 ∓ 0.84	9.25	63.41
QB7PND	6.33	2.19	0.63	6.33 ∓ 1.23	4.79	34.55
QB7PERT	4.53	3.06	0.74	4.53 ∓ 1.45	9.39	67.65
QB7GBC	4.60	2.86	0.40	4.60 ∓ 6.78	8.16	62.11
QB8CPM	4.16	2.85	0.44	4.16 ∓ 0.86	8.14	68.54
QB8PND	5.80	2.30	0.73	5.80 ∓ 1.43	5.29	39.65
QB8PERT	4.25	2.57	0.64	4.25 ∓ 1.25	6.60	60.45
QB8GBC	4.44	2.73	0.43	4.44 ∓ 0.84	7.45	61.50

lation's value. This confidence interval size depends on the degree of confidence desired in the sample results. The confidence coefficient used here is 95% unless otherwise mentioned. 95% of a large number of the probability sample will be as follows :

$$\text{Upper Confidence Limit} = \overline{X} + 1.96\, S_x\, (\overline{X}) \text{ or}$$

$$95\%\ \text{Confidence Interval} = \overline{X} \pm 1.96\, S_x\, (\overline{X}) \qquad (3.5)$$

Where:

$\overline{X}$ = The weighted mean

X_x = Standard deviation.

For this study, the upper and lower confidence levels at 95% are calculated as :

$$\text{(UL) Upper Limit} = 1.8 + 1.96\ (0.13) = 2.055$$

$$\text{(LL) Lower Limit} = 1.8 - 1.96\ (0.13) = 1.545$$

Secondly, the coefficient of variation measures the precision of the estimator. It represents the variability with respect to the mean. The equation for calculating this variation is as follows :

$$\text{C.V.} = (S_x/\overline{X}) * 100\% \qquad (3.6)$$

Where:

$\overline{X}$ = Weighted mean

X_x = Standard deviation

The coefficient of variance values of this study are shown in Table 3.1. The variance presented considering the responses, is somewhat large. The reason for this variation is that responses to the SET might differ from one place to another due to the size and work activity of the firm involved. Another reason is that the respondents answering the questions usually consider all their experiences in the construction industry, so that the variation comes directly from their different knowledge and backgrounds as related to the methods used. Every level of respondents (large, medium and small) has their own background and experience, so that differences in attitudes lead to high values of coefficient variation. There is the probability of respondents who misunderstand, misinterpret and/or any unfamiliar with some questions. This could lead to high coefficient variance due to the fluctuation of experience background and technology used in construction industry.

3.8.3 Correlation

The correlation coefficient (r) is used to figure out the relationship existing among different categories or parties (small, medium and large) and the degree of this relationship. Spearman Correlation Coefficient is a statistical method which describes the goodness of fit between two variables. The Spearman rank correlation coefficient is used in this thesis to provide a numerical index of the relation between two ranks for each case or two scores for each case from which ranks can be determined. The Spearman "rho" ranges in value from -1 to +1. The value R = -1.0 indicates a unlinear relationship between two variables and the value R = +1.0 indicates a perfect linear relationship. The clear the value of R to zero, the weaker the relationship between the two variables being tested. The statistical formulas used to determine the three types of correlations will be considered in turn.

The formula for calculating the Spearman rank correlation is :

$$r_{LM} = 1 - \frac{6\,(\Sigma\, d^2_{LM})}{N\,(\,N^2 - 1\,)} \tag{3.7}$$

Where:

r_{LM} = Spearman rank correlation coefficient (the agreement between large and medium firms)

d_{LM} = Difference between ranks on one variable and ranks on the other variable.

N = Number of cases.

By substituting into the formula from data on Table 4.26, the result is given below :

$$r_{LM} = 1 - \frac{6 * 427}{27\,(27^2 - 1)} = 0.86$$

$$r_{LS} = 1 - \frac{6 * 376}{27\,(27^2 - 1)} = 0.88$$

$$r_{MS} = 1 - \frac{6 * 123}{27\,(27^2 - 1)} = 0.96$$

Where:

r_{LM} = The agreement between large Firms group (L) and medium firms group (M)

r_{LS} = The agreement between large Firms group (L) and small firms group (S)

r_{MS} = The agreement between medium Firms group (M) and small firms group (S)

A partial correlation is frequently used to find out and compare how well any two groups agree upon their ranking while holding the third party constant. It measures the relationship between two variables which are usually influenced by a third party. The formula for calculating the partial correlation is given below :

$$r_{LM.S} = \frac{r_{LM} - (r_{LS} * r_{MS})}{\sqrt{(1 - r_{LS}^2\,(1 - r_{MS}^2)}} = \frac{0.86 - (0.88 * 0.96}{\sqrt{(1 - 0.88^2)\,(1 - 0.96^2)}} = 0.12$$

$$r_{LS.M} = \frac{r_{LS} - (r_{LM} * r_{MS})}{\sqrt{(1 - r_{LM}^2\,(1 - r_{MS}^2)}} = \frac{0.88 - (0.86 * 0.96}{\sqrt{(1 - 0.86^2)\,(1 - 0.96^2)}} = 0.39$$

$$r_{MS.L} = \frac{r_{MS} - (r_{LM} * r_{LS})}{\sqrt{(1 - r_{LM}^2\,(1 - r_{LS}^2)}} = \frac{0.96 - (0.86 * 0.88}{\sqrt{(1 - 0.86^2)\,(1 - 0.88^2)}} = 0.83$$

Where:

$r_{LM.S}$ = The agreement between the large firm group and the medium firm group with the small firm group's rank held constant.

$r_{LS.M}$ = The agreement between the large firm group and the small firm group with the medium firm group's rank held constant.

$r_{MS.L}$ = The agreement between the medium firm group and the small firm group where the large firm group's rank held constant.

A multiple correlation is the simplest form of coefficient which indicates the relationship between one variable and a combination of two other variables (Lord, 1955). It describes the extent of association between the groups when considering one main group with the others. The following formulas are used in computing this correlation.

$$\text{Let } R = r_{LM} * r_{LS} * r_{MS} = 0.86 * 0.88 * 0.96 = 0.7265$$

$$r_{L.MS} = \frac{\sqrt{r_{LM}^2 + r_{LS}^2 - 2R}}{1 - V_{MS}^2} = \frac{\sqrt{(0.86)^2 + (0.88)^2 - 2(0.7265)}}{1 - 0.96^2} = 0.89$$

$$r_{M.LS} = \frac{\sqrt{r_{LM}^2 + r_{MS}^2 - 2R}}{1 - V_{LS}^2} = \frac{\sqrt{(0.86)^2 + (0.96)^2 - 2(0.7265)}}{1 - 0.86^2} = 0.96$$

$$r_{S.LM} = \frac{\sqrt{r_{LS}^2 + r_{MS}^2 - 2R}}{1 - V_{LM}^2} = \frac{\sqrt{(0.88)^2 + (0.96)^2 - 2(0.7265)}}{1 - 0.86^2} = 0.97$$

Where:

$r_{L.MS}$ = The agreement between the large firm group and the other groups.

$r_{M.LS}$ = The agreement between the medium firm group and the other groups.

$r_{S.LM}$ = The agreement between the small firm group and the other groups.

3.8.4 Correlation Matrix

A conventional display of a set of correlation coefficients in a compact format could be formed by a correlation matrix. By using the SAS computer package at King Fahd University of Petroleum and Minerals to treat each questionnaire item as a variable, a correlation matrix table was produced on all pairs of variables related to each factor. The information gathered from each entry shows Pearson's correlation coefficient (r), the probability of dependency and the number of observations related to the two variables analyzed. All the values of possible relations or the agreement between pairs of questions are calculated and illustrated in Appendix B.

CHAPTER 4

SET IMPLEMENTATION AND UTILIZATION IN SAUDI ARABIA

This chapter presents and explains how the survey data was analyzed. It also discusses the results obtained from the data for each factor category related to each technique included in the SET.

4.1 Characteristics of Respondents' Firms

A total of 61 construction contractors participated in this study. These firms are located in three regions of Saudi Arabia, namely, the Eastern, Central, and Western Provinces. They represent a response rate of 96.80% from the total number of firms comprised in the survey. A listing of construction contractors' names and locations are illustrated in Appendix C. The number of participating firms in each region is shown in Table 4.1. The observations of the variables of interest involved in the questionnaire set which are related to firm information represents a collection of data consists of one or more characteristics of participant contractors. The contractors are classified into large, medium and small size categories on the basis of the annual volume of construction . The categorization is based on the classification of construction firms suggested by the Chamber of Commerce and Industry in Saudi Arabia. These classifications are published in both Al-Egtisad Magazine and in the Directory of Construction Contractors in Saudi Arabia.(56)

Table 4.1 : Number of Questionnaires distributed and collected at various locations

Location	Number Distributed	Number of Respondents	% of Total No. Distributed	% of Total Final Number
Eastern	42	41	66	65
Central	13	13	21	21
Western	8	7	13	11
Total	63	61	100	97

Note: Total percentage response $= \frac{61}{63} * 100 = 96.8\%$

Firms with an annual business volume of 5-24 million riyals are classified as small, those sizing of 25-55 million riyals are classified as medium, while those larger than 55 million riyals are classified as large. There are six small, twenty-two medium and thirty-three large firms according to this classification scheme.

Table 4.2 breaks out the variables by which the participants contractors are characterized. These variables are: 1) the type of work activity, 2) the average amount of work subcontracted on each job, 3) average job size of each project, 4) average job duration of each project, 5) the

Table 4.2 : Firms Characteristics

VARIABLES (n/%)	SMALL FIRMS (0 - 14 ,000,000) (n=6/%)	MEDIUM FIRMS (15 ,000,000- 55 ,000,000) (n=22/%)	LARGE FIRMS (56 ,000,000- PLUS) (n=33/%)	TOTAL (n/%)	RANK ORDER
4.2.A. <u>Work Activity</u>					
Building of Contr.	6/9.8	7/11.5	9/14.8	22/36.1	1
Heavy	0/0.0	2/3.3	9/14.8	11/18.0	3
Building, Heavy and Structure	0/0.0	1/1.6	2/3.3	3/4.9	6
Building plus structure	0/0.0	9/14.8	5/8.2	14/23.0	2
Structure	0/0.0	2/3.3	3/4.9	5/8.2	5
Building plus Heavy	0/0.0	1/1.6	5/8.2	6/9.8	4
TOTAL	6/9.84	22/36.1	33/54.1		
4.2.B. Average Work <u>Subcontracted</u>					
(in % of one job)					
19% or less	6/9.8	17/27.9	17/27.9	40/65.6	1
20%-49%	0/0.0	3/4.9	13/21.3	16/26.2	2
50-99%	0/0.0	0/0.0	3/4.9	3/4.9	3
100%	0/0.0	2/3.3	0/0.0	2/3.3	4
TOTAL	6/9.8	22/36.1	33/54.1		

(Contd.)

Table 4.2 : Firms Characteristics (Contd.)

VARIABLES (n/%)	SMALL FIRMS (0 - 14 ,000,000) (n=6/%)	MEDIUM FIRMS (15 ,000,000- 55 ,000,000) (n=22/%)	LARGE FIRMS (56 ,000,000- PLUS) (n=33/%)	TOTAL (n/%)	RANK ORDER
4.2.C.					
Average Job Size					
(Million SR)					
0.5 or less	2/3.3	1/1.6	0/0.0	3/4.9	5
1 - 2	0/0.0	1/1.6	0/0.0	1/1.6	6
2 - 4	1/1.6	1/1.6	2/3.3	4/6.6	4
5 - 20	2/3.3	13/21.3	9/14.8	24/39.3	1
20 - 35	1/1.6	4/6.6	4/6.6	9/14.8	2
35 - 50	0/0.0	1/1.6	4/6.6	5/8.2	3
65 - 130	0/0.0	1/1.6	8/13.1	9/14.8	2
130 - 195	0/0.0	0/0.0	1/1.6	1/1.6	6
Over 195	0/0.0	0/0.0	5/8.2	5/8.2	3
TOTAL:	6/9.8	22/36.1	33/54.1		
4.2.D. Average Job Duration (In Years of one Job)					
0.5 or less	2/3.3	3/4.9	0/0.0	5/8.2	4
0.5 - 1	0/0.0	1/1.6	0/0.0	1/1.6	6
1 - 1.5	1/1.6	7/11.5	8/13.1	16/26.2	1
1.5 - 2.0	1/1.6	4/6.6	6/9.8	11/18.0	2
2.0 - 2.5	2/3.3	5/8.2	9/14.8	16/26.2	1
2.5 - 3.0	0/0.0	1/1.6	3/4.9	4/6.6	5
3.0 - 3.5	0/0.0	1/1.6	5/8.2	6/9.8	3
3.5 - 4.0	0/0.0	0/0.0	1/1.6	1/1.6	6
4.5 - 5.0	0/0.0	0/0.0	1/1.6	1/1.6	6
TOTAL:	6/9.8	22/36.1	33/54.1		

(Contd.)

Table 4.2 : Firms Characteristics (Contd.)

VARIABLES (n/%)	SMALL FIRMS (0 - 14 ,000,000) (n=6/%)	MEDIUM FIRMS (15 ,000,000-55 ,000,000) (n=22/%)	LARGE FIRMS (56 ,000,000-PLUS) (n=33/%)	TOTAL (n/%)	RANK ORDER
4.2.E. Type of Principal and Activity (a)					
- 1 Type	6/100	11/50	21/64	38/62.2	1
- 2 Type	-	10/45	10 /30	20/32.8	2
- 3 Type	-	1/5	2 /6	3/5	3
4.2.F. Nationality of the Company's Onwership					
- Saudi	6 /100	19/86	19 /58	44/72	1
- Non-Saudi	-	1/5	6 /18	7/11.5	3
- 50% Saudi & 50% Non-Saudi	-	2/9	8 /24	10/16.5	2
4.3.I. Location of Main Offices:					
Eastern Region	5/83	21/84	16 /34	42/53.8	1
Central Region	-	1/4	12 /25.5	13/16.7	3
Western Region	1/17	-	5 /10.6	6/7.7	4
Foreign Country (b)	-	3/12	14 /29.9	17/21.8	2
4.2.J. Number of Branches Existing (c)					
0 - 1	6/100	7/31	13 /39.5	26/42.6	1
2 - 3	-	14/64	12 /36.5	26/42.6	1
4 - 5	-	1/5	4 /12	5 /8.2	2
More than 5	-	-	4 /12	4/6.6	5

(Contd.)

Table 4.2 : Firms Characteristics (Contd.)

VARIABLES (n/%)	SMALL FIRMS (0 - 14 ,000,000) (n=6/%)	MEDIUM FIRMS (15 ,000,000-55 ,000,000) (n=22/%)	LARGE FIRMS (56 ,000,000-PLUS) (n=33/%)	TOTAL (n/%)	RANK ORDER
4.2.K. Region of Operation by Firm					
Central	-	1/ 5	6/18.2	7 /11.5	3
Eastern	1/16.7	10/45	-	11 /18	2
Western	-	-	-	-	
Central+Eastern	2/33.3	-	-	2 /3.3	5
Eastern+Western	1/16.7	-	4/12	5 /8.2	4
Kingdom of Saudi Arabia-wide	2/33.3	11 /50	16/48.5	29 /47.5	1
Middle East-wide	-	-	2/6.1	2 /3.3	5
World- wide	-	-	5/15.2	5 /8.2	4
4.2.L. Key Personnel Respondents					
General Manager	3/50	6/27	7/21.2	16/26.2	2
Project Manager	1 /16.7	4/18	12/36.4	17/27.9	1
Construction Manager	1 /16.7	2/9	1/3.05	4/6.6	5
Operation Manager	-	3/14	1/3.05	4/6.6	5
Engineers (d)	-	4/18	4/12.1	8/13.1	4
Others (e)	1/16.6	3/14	8/24.2	12/19.6	3

(Contd.)

Table 4.2 : Firms Characteristics (Contd.)

VARIABLES (n/%)	SMALL FIRMS (0 - 14 ,000,000) (n=6%)	MEDIUM FIRMS (15 ,000,000- 55 ,000,000) (n=22/%)	LARGE FIRMS (56 ,000,000- PLUS) (n=33/%)	TOTAL (n/%)	RANK ORDER
4.2.M. Total Number of Employees (n/%)					
0 - 200	2/3.3	8/13.1	4/6.6	14/23.0	2
200 - 1200	4/6.6	13/21.3	15/24.6	32/52.5	1
1200 - 2200	0/0.0	1/1.6	7/11.5	8/13.1	3
2200 - 2700	0/0.0	0/0.0	3/4.9	3/4.9	4
3200 - 3700	0/0.0	0/0.0	1/1.6	1/1.6	6
5200 - 5700	0/0.0	0/0.0	1/1.6	1/1.6	6
6200 - 6700	0/0.0	0/0.0	2/3.3	2/3.3	5
TOTAL:	6/9.8	22/36.1	33/54.1		

(a) Choices given: Building = (Educational, Commercial, etc.); Heavy Construction = (Highway, bridges, dams, harbours, roads, etc.); Structure = (Construction plants, foundation, engineering construction, etc.)

(b) Generally, all of the (non-Saudi and 50% Saudi and 50% non-Saudis) have two offices - one in Saudi Arabia and the other in their country.

(c) The company does not have branches regarded as owned one branch which is their main office.

(d) Choices given by respondents: Engineer = Civil, Senior, Chief, Estimating, etc.

(e) Choices given by Respondents: Technical Managers, Contract Administrators, Administration Manager, Quality Controller, Sales Manager, Chief Communication, Business, etc.

firm's nationality, 6) the locations of main offices, 7) the number of branches owned by each firm, 8) the region of operation, and 9) title or position of the respondents.

Table 4.2-A shows the distribution of types of firms. About 36% of the companies are in building-type construction , about 23% are in building plus structure-type construction , about 18% are in heavy-type construction , about 9% are in building plus heavy-type construction and about 8% are in structure-type construction . The rest of the firms are combinations of these three principal activity types.

The distribution of the average amount of work subcontracted on the average job is expressed in percentage as shown in Table 4.2-B. About 90% of the respondents subcontract 19%-49% of the average job and the rest of the firms subcontract 50% to 100% of one job.

Table 4.2-C breaks out the average job size of each project as expressed in millions of Saudi riyals. About half of the contractors have capabilities for construction projects with average contract size ranges between 5 and 35 million riyals.

The distribution of average job duration in years of each project, found that about 87% of the respondents deal with projects that last for an average duration between one and three and a half years. The remaining responding firms construct projects with durations either below or above that range as shown in Table 4.2-D.

Table 4.2-E contains the distribution of type of principal activity of

firms on the basis of one type, two types and three types of activities. About 62% are in single type - construction, about 33% are in double type - construction , and about 5% are in the combination of three activity types of construction .

Table 4.2-F shows the distribution of nationality of the company's ownership. This indicates that 72.10% of respondent firms are Saudi and the remaining firms are non-Saudi or 5% Saudi and non-Saudi in the form of joint venture.

Table 4.2-I breaks out the distribution of the locations of main offices of the participants. About 54% of the companies have their main offices located in the Eastern region, about 17% have offices located in the Central region, and about 8% have offices located in the Western region. The rest of the firms about 21% have their main offices located in the foreign countries. Usually, non-Saudi or 50% Saudi and non-Saudi firms have two main offices, one in Saudi Arabia and the other in their country.

Table 4.2-J contains the distribution of the total number of branches existing owned by respondents. About 85.25% of the respondents owned total number of branches ranging between one and three branch offices.

The distribution of regions of operation by firms as classified by region, Saudi Arabia, Middle East and world. It was found that about 41% of the contractors have their operations located in region, about 48% of the firms have operations in the Kingdom of Saudi Arabia, about 3%

have operations in the Middle East and the remaining responding firms have operations all over the world as shown in Table 4.2-K.

Table 4.2-M shows the distribution of the total number of employees in each organization. The majority of respondents frequently have the total number of employees ranged from 200 to 1200 employees in their firms. The remaining responding firms are distributed unevenly either below or above that range.

4.2 SET Application

The cross tabulation method is used herein to study the various aspects of SET applications in Saudi Arabia. The methods involved in the SET which are being used by contractors in the planning and scheduling of project processes are crossed by the three size categories in order to find the most frequently used technique within each class. This section discusses the assigned subjects related to SET application in Saudi Arabia such as the contractor's familiarity with SET, SET utilization, SET function and major concern claimed by respondents. These will be considered in turn.

4.2.1 Contractor's Familiarity with SET

The results indicate that all Saudi contractors are familiar with CPM and GBC Techniques. Only one third of the contractors, mainly large sized firms are familiar with CPM, PERT, PND and GBC techniques as one subset. It seems that the contractors are well known with the methods tested. The PND technique is known by one third of the contractors involved. The PERT technique is known by 64%, 45%, and 17% of large, medium, and small contractors, respectively. The GERT technique is the least known method among Saudi contractors. Only 23% of the contractors, mostly large sized firms, are familiar with GERT. The combination of SET techniques known by different sized contractors are shown in Table 4.3. In addition, the results indicate that about 16% of the firms have full knowledge about "CPM, PERT, PND and GBC" as one subset. About 11% of the firms know "CPM, PERT and GBC" as one combination. The rest of the methods known by respondents fall within a range of 4.92% to 1.64% of contractors. About 50% of those who know CPM is a medium contractors and the remaining 50% of them are in the small class.

There are several interesting observations such as all contractors who know "CPM plus PERT" or this combinations plus GBC together are large contractors, 45% of those who know "CPM and GBC", are in the large class, 57% of the contractors who know "CPM plus PERT and GBC" as one subset are medium contractors, 70% of them who know all the five methods together which represent the whole SET are in the large class, 70% of firms who know "CPM, PND, PERT, and GBC" as one combination are in the large class and all contractors who only know "CPM plus PERT" and "CPM plus GERT and GBC" as two combinations systems are large contractors. CPM and PND as one combination is being known only by medium sized firms. Half of the contractors who know "CPM plus PND and GBC" as one subset are medium sized firms and the other remaining half are in the small class. One single method and three

Table (4.3): Cross tabulation of the SET known by respondents and each of the test groups.

FREQUENCY PERCENT ROW PCT COL PCT	SET known by Respondents										TOTAL
	Critical Path Me	CPM & GBC	CPM.PERT & GBC	All techni- ques	CPM & PERT	CPM.PERT. GERT & GBC	CPM.PND. PERT & GBC	CPM & PND	CPM.GERT & GBC	CPM.PND & GBC	
LARGE FIRMS	0 0.00 0.00 0.00	10 16.39 30.30 45.45	3 4.92 9.09 42.86	7 11.48 21.21 70.00	3 4.92 9.09 100.00	1 1.64 3.03 50.00	7 11.48 21.21 70.00	0 0.00 0.00 0.00	2 3.28 6.06 100.00	0 0.00 0.00 0.00	33 54.10
MEDIUM FIRMS	1 1.46 4.55 50.00	9 14.75 40.91 40.91	4 6.56 18.18 57.14	2 3.28 9.09 20.00	0 0.00 0.00 0.00	1 1.64 4.55 50.00	3 4.92 13.64 30.00	1 1.64 4.55 100.00	0 0.00 0.00 0.00	1 1.64 4.55 50.00	22 36.07
SMALL FIRMS	1 1.64 16.67 50.00	3 4.92 50.00 13.64	0 0.00 0.00 0.00	1 1.64 16.67 10.00	0 0.00 0.00 0.00	0 0.00 0.00 0.00	0 0.00 0.00 0.00	0 0.00 0.00 0.00	0 0.00 0.00 0.00	1 1.64 16.67 50.00	6 9.84
TOTAL	2 3.28	22 36.07	7 11.48	10 16.39	3 4.92	2 3.28	10 16.39	1 1.64	2 3.28	2 3.28	61 100.00

CPM = Critical Path Method
PND = Precedence Network
GBC = Gantt Bar Chart
PERT= Program Evaluation & Review Technique

Row PCT = The percentage of the number of firms know each method over the total number of firms in each class.
Col PCT = The percentage of the number of firms know each method, in each class over the total number of firms know each method.
All techniques = CPM, PND, PERT, GERT, and GBC.

combinations of these techniques were known by small contractors as illustrated in Table 4.3.

The main sources of familiarity with these techniques are the educational institutes, experience from the construction industry and/or the research agencies. Additional sources mentioned by the contractors are: 1) seminar presentations, 2) industry associations, 3) software houses, 4) reading journals, magazines and books, etc., 5) other trade publications, and 6) U.S. Corps of Engineers' Training Center for professional development.

4.2.2 SET Utilization

The most popular techniques used by different sized contractors for planning and scheduling are the CPM and GBC. The former is used by 84% of the contractors and the latter is utilized by 92% of the contractors. The GERT technique is not used by all firms in the three sized classes. However, it is very rare to find a contractor who is using only one single technique for planning and scheduling projects. Contractors tend to use a combination of two or more techniques. The most widely used combination is the CPM and GBC, which is regarded as a unified system. It appears that contractors attempt to make use of the benefit of such a system at different organizational levels. The CPM may be used in high and middle management levels while the GBC technique is used in the lower level of personnel because of its ease and simplicity.

PERT and PND techniques are not widely utilized by small contractors. Some large and medium contractors use PERT and PND techniques in planning and scheduling processes of some projects. However, these contractors usually use the PERT more than PND for planning their projects. The distribution of the utilization of the SET techniques in Saudi construction firms are shown in Table 4.4.

It seems that very few contractors, those mostly being large, use all SET techniques in their organizations. In addition, the results indicate that about 43% of the contractors frequently use the CPM plus GBS as one subset. This represents the highest use rate. The second highest use rate corresponds to the contractors (13.11%) who used CPM plus PERT and GBC techniques as one subset system. The lowest use rate is the firms (1.64%) who used CPM and PND together as one combination. About 67% of the contractors who use CPM only are medium contractors. Large firms are not restricted only to use the CPM technique. The large contractors usually use other different subsets of the SET techniques. CPM is the most dominant element in all subsets. A subset may either involve "CPM and GBC", "CPM and PERT", or "CPM, PND, and GBC". There are other subsets as shown in Table 4.4. The most frequent subset that is commonly used by medium contractors are "CPM and GBC", and "CPM, PERT and GBC".

About 50% of contractors who use GBC alone are medium firms and 33% who use the same technique are large contractors. The rest of them are in the small category. The use rate of contractors who use CPM plus GBC are large sized firms (61%), medium sized firms (27%) and 12% of them are in the small class.

Table 4.4 : Cross Tabulation of the SET Utilization and Each of the Test Group

FREQUENCY PERCENT ROW PCT COL PCT	SET IMPLEMENTATION										TOTAL
	CPM	GANTT BAR CHART	CPM AND GBC	PERT & GBC	ALL TECH-NIQUES	PND AND GBC	CPM AND PERT	CPM, PERT & GBC	CPM AND PND	CPM, PND & GBC	
LARGE FIRMS	0 0.00 0.00 0.00	2 3.28 6.06 33.33	16 26.23 48.48 61.54	2 3.28 6.06 100.00	4 6.56 12.12 66.67	0 0.00 0.00 0.00	3 4.92 9.09 100.00	2 3.28 6.06 25.00	0 0.00 0.00 0.00	4 6.56 12.12 100.00	33 54.10
MEDIUM FIRMS	2 3.28 9.09 66.67	3 4.92 13.64 50.00	7 11.48 31.82 26.92	0 0.00 0.00 0.00	2 3.28 9.09 33.33	1 1.64 4.55 50.00	0 0.00 0.00 0.00	6 9.84 27.27 75.00	1 1.64 4.55 100.00	0 0.00 0.00 0.00	22 36.07
SMALL FIRMS	1 1.64 16.67 33.33	1 1.64 16.67 16.67	3 4.92 50.00 11.54	0 0.00 0.00 0.00	0 0.00 0.00 0.00	1 1.64 16.67 50.00	0 0.00 0.00 0.00	0 0.00 0.00 0.00	0 0.00 0.00 0.00	0 0.00 0.00 0.00	6 9.84
TOTAL	3 4.92	6 9.84	26 42.62	2 3.28	6 9.84	2 3.28	3 4.92	8 13.11	1 1.64	4 6.56	61 100.00

CPM = Critical Path Method
PND = Precedence Network Diagramming
GBC = Gantt Bar Chart
PERT = Program Evaluation & Review Technique
All techniques = CPM, PND, PERT and GBC.

Row PCT = The percentage of number of users over the total number of firms in each class.

Col PCT = The percentage of the number of users in each class over the total number of each Method users.

There are various observations such as, 66.67% of the contractors who use all of the four methods together are large contractors, 75% of users who use "CPM plus PERT and GBC" are medium firms, and half of contractors who use "PND and GBC" are in the medium class. The remaining half who use the same subset are small contractors. None of the large sized firms use both "PND and GBC" or "CPM and PND" as two subsets. Small sized firms do not use the PERT technique and most of them do not know what the PERT and GERT techniques mean. These are very interesting findings due to the scope and nature of SET utilization in Saudi construction organizations.

The SET techniques are crossed with principal work activity, the value of the average job size, the value of the average job duration, and the SET frequency of implementation, are shown in Tables 4.5, 4.6, 4.7 and 4.8, respectively. The results indicate that CPM and GBC techniques are the most common technique that are used in planning and scheduling projects in Saudi Arabia, regardless of the type of work activity, the project size, and the project duration. It seems that contactors treat those two techniques as one system. However, the CPM technique is used solely by very few building contractors only. The subset combining of CPM and PND techniques is used by building contractors only.

The GBC technique alone is used by building, building plus structure, and heavy contractors. PERT plus GBC are used by both building and heavy contractors. Heavy contractors are the most frequent users of the PERT technique. This intensive implementation could be attributed to

Table 4.5 : Cross Tabulation of the SET Utilization and Each of the Respondent's Principal Work Activity

WORK ACTIVITY (n/%)	SYSTEMATIC TECHNIQUE-1		SYSTEMATIC TECHNIQUE-2					SYSTEMATIC TECHNIQUE-3		SYST. TECH-NIQUE-4	TOTAL
	CPM	GBC	CPM & GBC	PERT & GBC	PND & GBC	CPM & PERT	CPM & PND	CPM, PERT & GBC	CPM/ PND & GBC	ALL OF THEM	
Building Contractor	3/4.9	4/5.6	8/13.1	1/1.6	1/1.6	1/1.6	1/1.6	0/0.0	3/4.9	0/0.0	22/36.1
Heavy Contractor	0/0.0	1/1.6	4/6.6	1/1.6	0/0.0	2/3.3	0/0.0	1/1.6	0/0.0	2/3.3	11/18.0
Structure Contractor	0/0.0	0/0.0	2/3.3	0/0.0	0/0.0	0/0.0	0/0.0	1/1.6	0/0.0	2/3.3	5/8.2
Building plus Structure	0/0.0	1/1.6	7/11.5	0/0.0	1/1.6	0/0.0	0/0.0	4/6.6	0/0.0	1/1.6	14/23.0
Building plus Heavy	0/0.0	0/0.0	4/6.6	0/0.0	0/0.0	0/0.0	0/0.0	0/0.0	1/1.6	1/1.6	6/9.8
Building, Heavy and Structure	0/0.0	0/0.0	1/1.6	0/0.0	0/0.0	0/0.0	0/0.0	2/3.3	0/0.0	0/0.0	3/4.9
TOTAL	3/4.9	6/9.8	26/42.6	2/3.3	2/3.3	3/4.9	1/1.6	8/13.1	4/6.6	6/9.8	

CPM = Critical Path Method
PND = Precedence Network Diagramming
GBC = Gantt Bar Chart
PERT = Program Evaluation and Review Technique

Table 4.6 : Cross Tabulation of the Value of Average Job Size and Each of the SET used by Respondents

Technique \ Average Job Size (million SR)	0-0.5 (n=3)	1.0-2.0 (n=1)	2.0-4.0 (n=4)	5.0-20.0 (n=24)	20.0-35.0 (n=9)	35.0-50.0 (n=5)	65.0-130.0 (n=9)	130.0-195.0 (n=1)	195.0-260.0 (n=5)	Total (n=61)
CPM	0/0.0	0/0.0	0/0.0	2/3.3	1/1.6	0/0.0	0/0.0	0/0.0	0/0.0	3/4.9
GBC	0/0.0	0/0.0	1/1.6	3/4.9	1/1.6	0/0.0	0/0.0	0/0.0	1/1.6	6/9.8
CPM/GBC	1/1.6	0/0.0	2/3.3	12/19.7	5/8.2	2/3.3	2/3.3	0/0.0	2/3.3	26/42.6
PERT/GBC	1/1.6	0/0.0	0/0.0	0/0.0	0/0.0	1/1.6	1/1.6	0/0.0	0/0.0	2/3.3
PND/GBC	1/1.6	0/0.0	0/0.0	0/0.0	1/1.6	0/0.0	0/0.0	0/0.0	0/0.0	2/3.3
CPM/PERT	0/0.0	0/0.0	0/0.0	1/1.6	0/0.0	1/1.6	1/1.6	0/0.0	0/0.0	3/4.9
CPM/PND	0/0.0	0/0.0	0/0.0	1/1.6	0/0.0	0/0.0	0/0.0	0/0.0	0/0.0	1/1.6
CPM/PERT/GBC	1/1.6	1/1.6	0/0.0	3/4.92	1/1.6	1/1.6	1/1.6	0/0.0	0/0.0	8/13.1
CPM/PND/GBC	0/0.0	0/0.0	0/0.0	1/1.6	0/0.0	0/0.0	1/1.6	1/1.6	1/1.6	4/6.6
ALL OF ABOVE	0/0.0	0/0.0	0/0.0	0/0.0	0/0.0	1/1.6	1/1.6	0/0.0	0/0.0	6/9.8
TOTAL	3/4.9	1/1.6	4/6.6	24/39.3	9/14.7	5/8.2	9/14.7	1/1.6	5/8.2	

CPM = Critical Path Method
PND = Precedence Network Diagramming
GBC = Gantt Bar Chart
PERT = Program Evaluation and Review Technique

the nature of work involved in heavy construction . Such jobs usually embody high uncertainty which can be analyzed by the PERT technique.

The SET techniques are crossed with all utilization criteria which include: 1) on all projects, 2) 50% or more of all projects, 3) 50% or less of all projects, and 4) when required by contract. The results indicated that about 44% of the respondents used the SET on all projects they handled, while 21.48% of them use SET at 50% or more of the contracts. 7.4% of them use SET on 50% of their contracts or fewer, and 26.67% of them implement these SET only when required by the contract agreement. The other results are illustrated in Table 4.8.

The results also indicate that about 65% of the contractors claim that they obtain definite cost savings contributing of 4% to 14% of the contract by implementing these techniques. The popularity of CPM and GBC combination is not surprising. The users claim that such a combination contributes 13% in the average to cost savings on projects. Other percentages of cost savings for other techniques are illustrated in Table 4.9.

About 36% of the contractors (22 firms) do not use any computer system(s) in their firms to assess for formalizing project planning and scheduling. About 15% (9 firms) of large firms, 16.39% (10 firms) of medium firms, and 4.9% (3 firms) of small firms do not use any computer system(s).

In addition, more than half of the contractors who use computer system(s) in their firms to assess for the planning and scheduling are using

Table 4.7 : Cross Tabulation of the Value of Average Job Duration and each of the SET Used by Respondents

Technique (n/%) \ Duration (Year)	0.5 or Less (n=5)	0.51-0.99 (n=1)	1.00-1.40 (n=16)	1.50-1.90 (n=11)	2.00-2.40 (n=16)	2.50-2.90 (n=4)	3.00-3.40 (n=6)	4.00-4.40 (n=1)	4.50-5.00 (n=1)	TOTAL
CPM	0/0.0	0/0.0	1/1.6	0/0.0	2/3.3	0/0.0	0/0.0	0/0.0	0/0.0	3/4.9
GBC	0/0.0	1/1.6	0/0.0	1/1.6	2/3.3	1/1.6	0/0.0	0/0.0	1/1.6	6/9.8
CPM/GBC	2/3.3	0/0.0	9/14.8	5/8.2	6/9.8	1/1.6	2/3.3	1/1.6	0/0.0	26/42.6
PERT/GBC	0/0.0	0/0.0	0/0.0	1/1.6	0/0.0	0/0.0	1/1.6	0/0.0	0/0.0	2/3.3
PND/GBC	1/1.6	0/0.0	0/0.0	1/1.6	0/0.0	0/0.0	0/0.0	0/0.0	0/0.0	2/3.3
CPM/PERT	0/0.0	0/0.0	0/0.0	1/1.6	1/1.6	0/0.0	1/1.6	0/0.0	0/0.0	3/4.9
CPM/PND	0/0.0	0/0.0	1/1.6	0/0.0	0/0.0	0/0.0	0/0.0	0/0.0	0/0.0	1/1.6
CPM/PERT/GBC	2/3.3	0/0.0	1/1.6	2/3.3	1/1.6	1/1.6	1/1.6	0/0.0	0/0.0	8/13.1
CPM/PND/GBC	0/0.0	0/0.0	2/3.3	0/0.0	1/1.6	1/1.6	0/0.0	0/0.0	0/0.0	4/6.6
ALL OF THE ABOVE	0/0.0	0/0.0	2/3.3	0/0.0	3/4.9	0/0.0	1/1.6	0/0.0	0/0.0	6/9.8
TOTAL	5/8.2	1/1.6	16/26.2	11/18.0	16/26.2	4/6.6	6/9.8	1/1.6	1/1.6	

CPM = Critical Path Method
PND = Precedence Network Diagramming
GBC = Gantt Bar Chart
PERT = Program Evaluation and Review Technique

Table 4.8 : Cross Tabulation of the Frequent Utilization Criteria and Each of the SET Implemented

TECHNIQUE	FREQUENCY OF IMPLEMENTATION				TOTAL
	On all Contracts	50% or more	50% or less	When Required	
CPM	0/0.0	2/6.9	0/0.0	1/2.8	3/2.2
GBC	3/5.0	2/6.9	1/10.0	0/0.0	6/4.4
CPM/GBC	26/43.3	10/34.5	2/20.0	12/33.3	50/37.0
PERT/GBC	1/1.7	2/6.9	0/0.0	1/2.8	4/3.0
PND/GBC	2/3.3	0/0.0	1/10.0	1/2.8	4/3.0
CPM/PERT	3/5.0	1/3.5	0/0.0	2/5.7	6/4.4
CPM/PERT/GBC	9/15.0	6/20.7	1/10.0	8/22.2	24/17.7
CPM/PND/GBC	4/6.7	2/6.9	2/20.0	4/13.8	12/8.9
ALL OF THE ABOVE	10/16.7	4/13.8	3/30.0	7/24.1	24/17.7
TOTAL	60/44.4	29/21.5	10/7.4	36/26.7	

CPM = Critical Path Method
PND = Precedence Network Diagramming
GBC = Gantt Bar Chart
PERT = Program Evaluation & Review Technique

Table 4.9 : Cross Tabulation of the Percentage of Cost Saving and Each of the SET Implemented

TECHNIQUE (n/%)	APPROXIMATE PERCENTAGE OF COST SAVING						TOTAL	The Mean ($\bar{X}$) (%)
	26%-30%	20%-25%	15%-19%	10%-14%	5%-9%	4% or less		
CPM	1/7.69	0/0.00	1/9.0	0/0.00	1/4.35	0/0.00	3/2.8	17.3
GBC	0/0.00	1/7.69	0/0.00	2/8.0	2/8.69	0/0.00	5/4.67	20.3
CPM/GBC	6/46.15	4/30.76	5/45.45	14/56	7/30.43	8/36.36	44/41.12	13.1
PERT/GBC	0/0.00	0/0.00	0/0.00	0/0.00	0/0.00	2/9.09	2/1.86	2.0
PND/GBC	0/0.00	0/0.00	0/0.00	2/8.0	0/0.00	2/9.09	4/3.73	7.0
CPM/PERT	0/0.00	0/0.00	0/0.00	4/16.00	0/0.00	0/0.00	4/3.73	12.0
CPM/PND	0/0.00	2/15.38	0/0.00	0/0.00	0/0.00	0/0.00	2/1.86	22.5
CPM/PERT/GBC	5/38.46	2/15.38	1/9.0	1/4.0	6/26.08	4/18.18	19/17.75	13.9
CPM/PND/GBC	0/0.00	1/7.69	0/0.00	1/4.0	1/4.35	2/9.09	5/4.67	9.1
All of the above	1/7.69	3/23.07	4/36.36	1/4.0	6/26.08	4/18.18	19/17.75	11.8
TOTAL	13/12.15	13/12.15	11/10.28	25/23.36	23/21.48	22/20.56		

CPM = Critical Path Method PERT = Program Evaluation & Review Technique
PND = Precedence Network Diagramming
GBC = Gantt Bar Chart

"IBM, Lotus, Monitor with database and primavision" computer device. Other contractors have other computer devices such as: 1) HPM3-computer device with time-line, viewpoint and production programs, 2) Premis and Cresta computers with materials status management, 3) Harvard Project Management Computers with Primavera project management, 4) Super, Wang and Atlas computers and 5) Artimes and Quicknet with software package. An additional comment mentioned by one respondent is that the computer device is often very important and usually defines the amount of cost savings in the long run among the utilization of the Systematic Examination Techniques . Some other contractors indicated that the successful implementation of computer program depends on:

1. Top Management support
2. Using field proven program
3. Reasonably low cost to implement
4. Experienced planners to make the main CPM network or others
5. Importance of accurate data updating.
6. Importance of program follow up by construction management team.

The results indicate that 38% of the CPM users apply it only when specified by contracts. Another 32% of CPM users implement it frequently on all contracts. For large firms, CPM is mostly used when required by contract, but for medium firms, it is used frequently on 50% or more of all projects. Small firms also use CPM when required by

Table 4.10: Distribution (Percentage) By Size of Firm with Frequent Utilization of the SET Based on Using Criteria

SIZE (n/%)	ON ALL CONTRACTS				50% OR MORE OF A CONTRACT				LESS THAN 50% OF CONTRACT				WHEN REQUIRED				Total Respondents	RANK ORDER
	(a) CPM (n/%)	(b) PND (n/%)	(c) PERT (/%)	(d) GBC (n/%)	(a) CPM (n/%)	(b) PND (n/%	(c) PERT (n/%)	(d) GBC (n/%)	(a) CPM (n/%)	(b) PND (n/%	(c) PERT (n/%)	(d) GBC (n/%	(a) CPM (n/%	(b) PND (n/%	(c) PERT (n/%)	(d) GBC (n/%)		
LARGE FIRMS	10/20.0	2/15.9	2/10.5	22/41.5	4/8.0	3/23.1	4/21.1	5/9.4	2/4.0	2/15.8	1/5.3	0/0.0	13/26.0	1/7.7	4/21.1	3/5.7	78/57.8	1
MEDIUM FIRMS	5/10.0	2/15.4	2/10.5	13/24.5	7/14.0	0/0.0	1/5.26	4/7.6	2/4.0	0/0.0	1/5.3	1/1.9	4/8.0	2/15.4	4/21.1	0/0.0	48/35.6	2
SMALL FIRMS	1/2.0	0/0.0	0/0.0	1/1.9	0/0.0	0/0.0	0/0.0	1/1.9	0/0.0	0/0.0	0/0.0	1/1.9	2/4.0	1/7.7	0/0.0	2/3.8	9/6.7	3
TOTAL	16/32.0	4/30.8	4/21.1	36/67.9	11/22.0	3/23.1	5/26.3	10/18.9	4/8.0	2/15.8	2/10.5	2/3.8	19/38.0	4/30.8	8/42.1	5/9.43		

(a) Total Frequency is 50 Respondents for CPM
(b) Total Frequency is 13 Respondents for PND
(c) Total Frequency is 19 Respondents for PERT
(d) Total Frequency is 53 Respondents for GBC

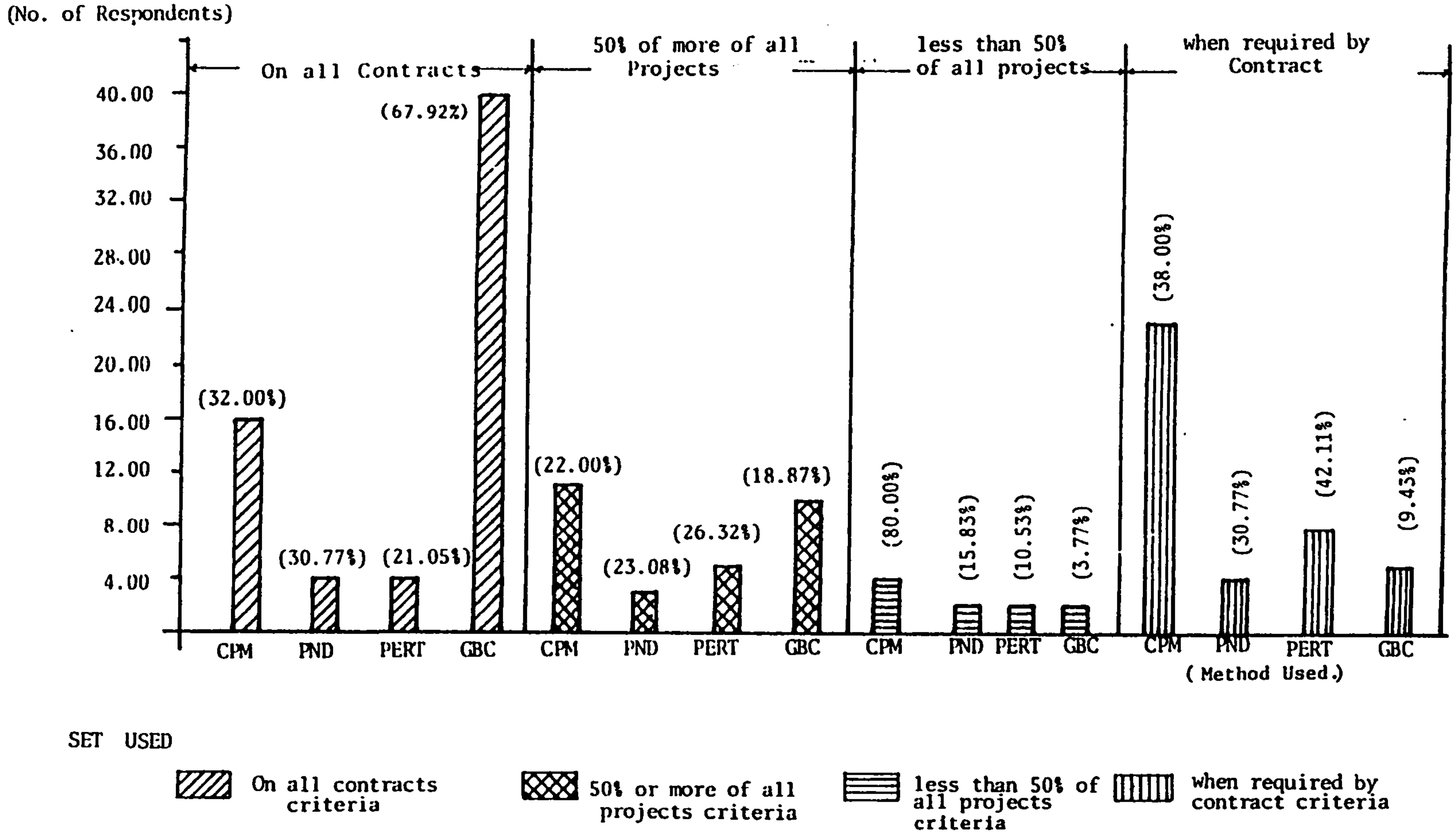


Fig. 4.1: Frequent Utilization of the (SET) By Respondents (Construction Firms)

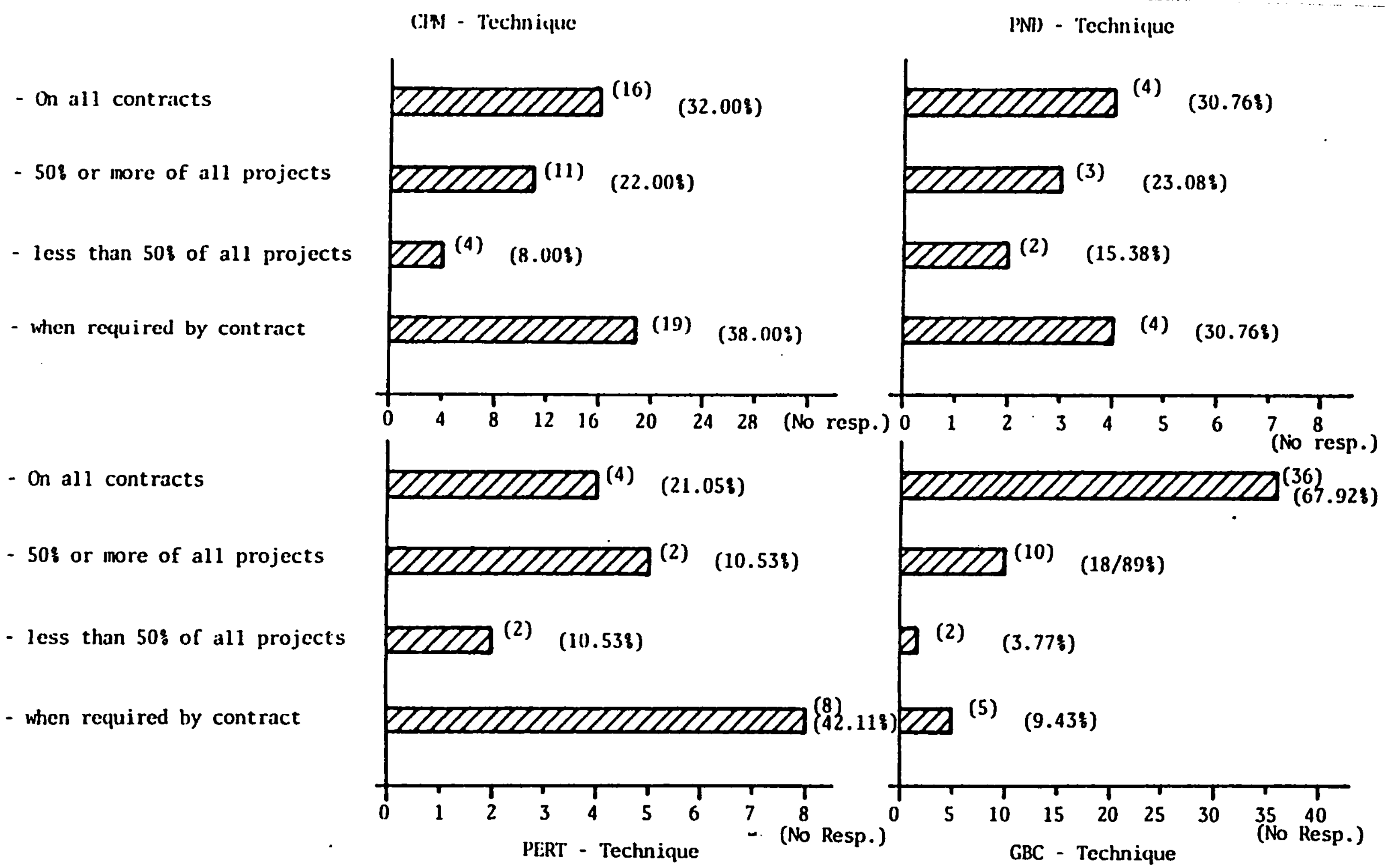


Fig. 4.2: Frequent Utilization Criteria of Each Technique included in the Systematic Examination Technique (SET).

contracts, so that large and small firms agreed about the frequency criteria of using CPM when required by contracts. In the United States of America, 25% of the top contractors use the CPM technique when required by contract.(20) It is interesting to note that both the PND and PERT techniques are always used when required by contract. The GBC technique is frequently used on all contracts for both large and medium firms, and it is used frequently when required by contracts by small firms. The PERT technique is usually used on 50% or more of all projects by large firms, and it is usually used when required by contracts by medium firms. Rarely, large and medium sized firms use PERT on less than 50% of all projects handled. It is used on all contracts and when required by contracts by medium firms. For small firms, PND is used when required by contracts. The GBC technique is the most common method used by respondents. It is usually used on small contracts by large and medium firms. It is used when required by contract only by small firms. The other methods used by respondents among the frequency criteria are illustrated in Table 4.10. The actual representation of the results of user criteria is shown in Figs. 4.1 and 4.2.

4.2.3 SET Function

Aspects of SET Implementation represent the actual function for application of these set by the contractors. The results indicate that 78.68% of the contractors (48 firms) use CPM in their projects and 56.30% of firms who use CPM are large firms, 37.50% of them are medium contractors and the remaining users who employ CPM are in the small class, as shown in Table 4.11.

About 69% of the contractors (39 firms) employ CPM as detailed planning for controlling construction works, whereas only 4.20% (2 firms) used CPM as a control tool only and 4.20% (2 firms) used it for planning cash flow only. No contractor uses it as a control tool and for planning cash needs purposes.

CPM is the most popular technique used by all contractors as a detailed planning, controlling material and control tool rather than using it for planning cash needs and material purchases and delivery. Small contractors claim that the main function of CPM technique is utilized as a planning and controlling material purchases and delivery, while medium firms used CPM as detailed planning of construction.

Large and medium firms who use CPM gave the first rank to (as detailed planning, planning cash needs and control materials) whereas it is (as detailed planning of construction) which ranked by small firms. The other ranks according to importance index for the other categories per CPM method are illustrated in Table 4.12.

Large and medium firms who used CPM gave first success rank to as detailed planning, planning cash flow and controlling material purchases and delivery, but small contractors who used the same technique gives the first priority to as detailed planning of construction . The success ranks of aspects of utilization categories of major functions of SET application by the three categoried groups are shown in Table 4.13.

Table 4.11 : Distribution (Percentage) by Size of Firm with Aspect of SET Implementation with Each of the Test Groups

ASPECT OF UTILIZATION (APPLICATION) (n/%)	LARGE FIRMS				MEDIUM FIRMS				SMALL FIRMS				TO-TAL	RANK ORDER
	CPM	PND	PERT	GBC	CPM	PND	PERT	GBC	CPM	PND	PERT	GBC		
As a detailed planning of construction	5/10.4	2/15.4	3/20.0	7/13.7	6/12.5	0/0.0	0/0.0	1/9.2	1/2.1	0/0.0	0/0.0	1/1.9	26/20.4	3
As a control tool	1/2.1	2/15.4	4/26.7	4/7.7	1/2.1	0/0.0	2/13.3	2/3.9	0/0.0	1/7.7	0/0.0	2/3.9	19/14.8	4
As a planning and controlling material purchases & delivery	3/6.3	1/7.7	0/0.0	1/1.9	0/0.0	0/0.0	1/6.8	0/0.0	2/4.2	0/0.0	0/0.0	2/3.9	10/7.8	5
As planning cash needs	2/4.2	-	1/6.8	0/0.0	0/0.0	-	0/0.0	1/1.9	0/0.0	-	0/0.0	0/0.0	4/3.1	6
As control tool and planning cash needs	-	-	-	2/3.9	-	-	-	2/3.9	-	-	-	0/0.0	4/3.1	6
As detailed planning, planning & controlling materials & control tools	10/20.8	2/15.4	1/6.8	9/17.3	4/8.3	4/30.8	1/6.7	3/5.8	0/0.0	0/0.0	0/0.0	0/0.0	34/26.6	1
All of the above	6/12.5	1/7.7	0/0.0	6/11.5	7/14.6	0/0.0	2/13.3	9/17.3	0/0.0	0/0.0	0/0.0	0/0.0	31/24.0	2
TOTAL	27/56.3	8/61.5	9/60.0	29/55.8	18/37.5	4/30.8	6/40.0	18/34.6	3/6.3	1/7.7	0/0.0	5/9.6		

Total Responses of CPM = 48
Total Responses of PND = 13
Total Responses of PERT = 15
Total Responses of GBC = 52

The PND technique was employed by 61.6% of firms (8 firms) as a detailed planning and control tool while the rest used it as for planning cash needs and for controlling material purchases and delivery. In addition, PERT is usually used as a control tool only whereas GBC is used by all firms for detailed planning and controlling purposes. Also it is used for planning cash needs and for managing material purchases and delivery as shown in Table 4.11.

Small firms use PND as a control tool only, while this method is usually used for detailed planning and control of material purchases and delivery by both large and medium firms. PERT is frequently used as a control tool by large and medium firms. Small firms use GBC usually as a control tool material purchases and delivery where it used as detailed planning, control tool, planning cash needs and controlling materials by the other two groups. The responses for each technique individually are illustrated in Figure 4.3.

Table 4.12 shows the importance ranks of aspects of utilization categories of major areas of Systematic Examination Techniques application. Large firms who used GBC, PERT, and PND gave first priority to detailed planning of construction . The users of GBC from the medium size category used it as a control tool and for planning cash needs. PERT and PND's users gave the first rank to detailed planning and control. Small firms rated "all categories for planning and controlling purposes" as the first important rank for all three methods are being used by them which are CPM, GBC and PND. The other rank according to

Table 4.12: Mean Rank for Aspect of Utilization of the SET for the Three Test-groups according to Importance Index.

Rank	SET	Categories under Aspect of Utilization	Relative Importance Index(%)
(Large Firms Rank)			
1	CPM	As a planning and controlling material	99.952
2	"	As detailed planning & plan cash & control mtl.	93.333
3	"	As detailed planning & control tool	91.667
4	"	All categories listed under the factor	88.889
5	"	As a detailed planning of constrution	83.333
6	"	As a control tool	66.667
7	"	As planning cash need	66.653
8	"	As detailed planning,control and plan cash needs	66.633
1	GBC	As a detailed planning of construction	99.989
2	"	As a planning & controlling material	99.952
3	"	As control tool & planning cash needs	99.889
4	"	As detailed planning,control & plan cash	99.778
5	"	As detailed planning & control tool	99.667
6	"	As detailed planning & plan cash & control mtl.	91.667
7	"	All categories listed under the factor	86.667
8	"	As a control tool	83.333
1	PERT	As a detailed planning of construction	99.889
2	"	As detailed planning & control tool	99.553
3	"	As a control tool	83.333
1	PND	As a detailed planning of construction	99.667
2	"	As a control tool	99.563
3	"	As a planning & controlling material	99.553
4	"	All categories listed under the factor	99.500
5	"	As detailed planning, control & plan cash	66.667
6	"	As detailed planning & control tool	66.633
(Medium Firms Rank)			
1	CPM	As a detailed planning of construction	99.889
2	"	As detailed planning & plan cash & control mtl.	99.778
3	"	As detailed planning & control tool	99.667
4	"	All categories listed under the factor	88.889
1	GBC	As control tool & planning cash needs	99.952
2	"	As detailed planning & plan cash & control mtl.	99.889
3	"	All categories listed under the factor	53.333
4	"	As a detailed planning of construction	66.667
5	"	As planning cash need	33.333
1	PERT	As a planning & controlling material	99.889
2	"	As detailed planning & control tool	99.953
3	"	As a control tool	66.667
1	PND	As detailed planning & control tool	91.557
(Small Firms Rank)			
1	CPM	All categories listed under the factor	91.667
2	"	As a detailed planning of construction	66.667
3	"	As a control tool	66.557
1	GBC	All categories listed under the factor	99.952
2	"	As detailed planning & control tool	83.333
3	"	As a control tool	66.667
4	"	As control tool & planning cash needs	66.633
1	PND	All categories listed under the factor	83.333
2	"	As a control tool	66.667

Table 4.13: Mean Rank for Aspect of Utilization of the SET for the Three Test-groups according to Success Index.

Rank	SET	Categories under Aspect of Utilization	Relative Success Index(%)
		(Large Firms Rank)	
1	CPM	As detailed plng.& plan cash needs & control mtl.	93.333
2	"	As a detailed planning of construction	83.333
3	"	As detailed planning & control tool	83.300
4	"	As a planning & controlling material	77.778
5	"	All categories listed under the factor	72.222
6	"	As a control tool	66.667
7	"	As planning cash need	66.683
8	"	As detailed planning,control & plan cash needs	33.333
1	GBC	As control tool & planning cash needs	99.952
2	"	As detailed planning,control & plan cash needs	99.988
3	"	As detailed planning & control tool	99.776
4	"	As a detailed planning of construction	90.476
5	"	All categories listed under the factor	86.667
6	"	As a control tool	83.333
7	"	As detailed plng. & plan cash needs & control mtl.	75.000
8	"	As a planning & controlling material	66.667
1	PERT	As detailed planning & control tool	99.500
2	"	As a detailed planning of construction	88.889
3	"	As a control tool	83.333
1	PND	As a detailed planning of construction	99.663
2	"	As a control tool	99.653
3	"	As a planning & controlling material	66.667
4	"	As detailed planning & control tool	66.665
5	"	All categories listed under the factor	66.553
		(Medium Firms Rank)	
1	CPM	As detailed planning & plan cash & control mtl.	99.988
2	"	As detailed planning & control tool	99.776
3	"	All categories listed under the factor	99.667
4	"	As a detailed planning of construction	83.333
1	GBC	As a detailed planning of construction	99.989
2	"	As planning cash need	99.952
3	"	As control tool & planning cash needs	99.776
4	"	As detailed planning & plan cash & control mtl.	99.667
5	"	All categories listed under the factor	86.667
1	PERT	As detailed planning & control tool	99.958
2	"	As a control tool	66.667
3	"	As a planning & controlling material	66.638
1	PND	As detailed planning & control tool	91.667
		(Small Firms Rank)	
1	CPM	As a detailed planning of construction	83.333
2	"	All categories listed under the factor	75.000
3	"	As a control tool	66.667
1	GBC	All categories listed under the factor	91.667
2	"	As detailed planning & control tool	83.333
3	"	As a control tool	66.667
4	"	As control tool & planning cash needs	66.633
1	PND	All categories listed under the factor	83.333
2	"	As a control tool	66.667

importance index for the other categories per method are illustrated in Table 4.12.

The contractors in the large class who use GBC ranks to the first place of utilization for this method as control tool and planning cash needs. Large and medium firms who used PERT gave first rank to as detailed planning and control tool. Small firms rated that "all categories for all functions of utilization" as occupied the first success rank for using both GBC and PND. The other ranks according to the relative success index for the three sized groups are illustrated in Table 4.13.

Table 4.14 shows the importance and the success ranks of aspects of utilization categories ranked by all contractors for all major functions per technique. The results indicate that all contractors give the highest rank to as detailed planning and control tool function in using CPM and the first rank to as detailed planning, control tool and planning cash flow in using GBC technique. The contractors agree on the priority of the highest rank to as detailed planning of construction of aspects in using both PERT and PND according to the importance index.

As detailed planning, planning cash needs and control material category occupied the highest rank by all contractors who used CPM. This rank is obtained by the relative success index. Detailed planning and control tool category got the second place of rank by all of CPM's users and as detailed planning of construction was ranked the third. However, there seem to be differences between the two types of rank which are importance rank and relative success rank as to the four techniques for planning and

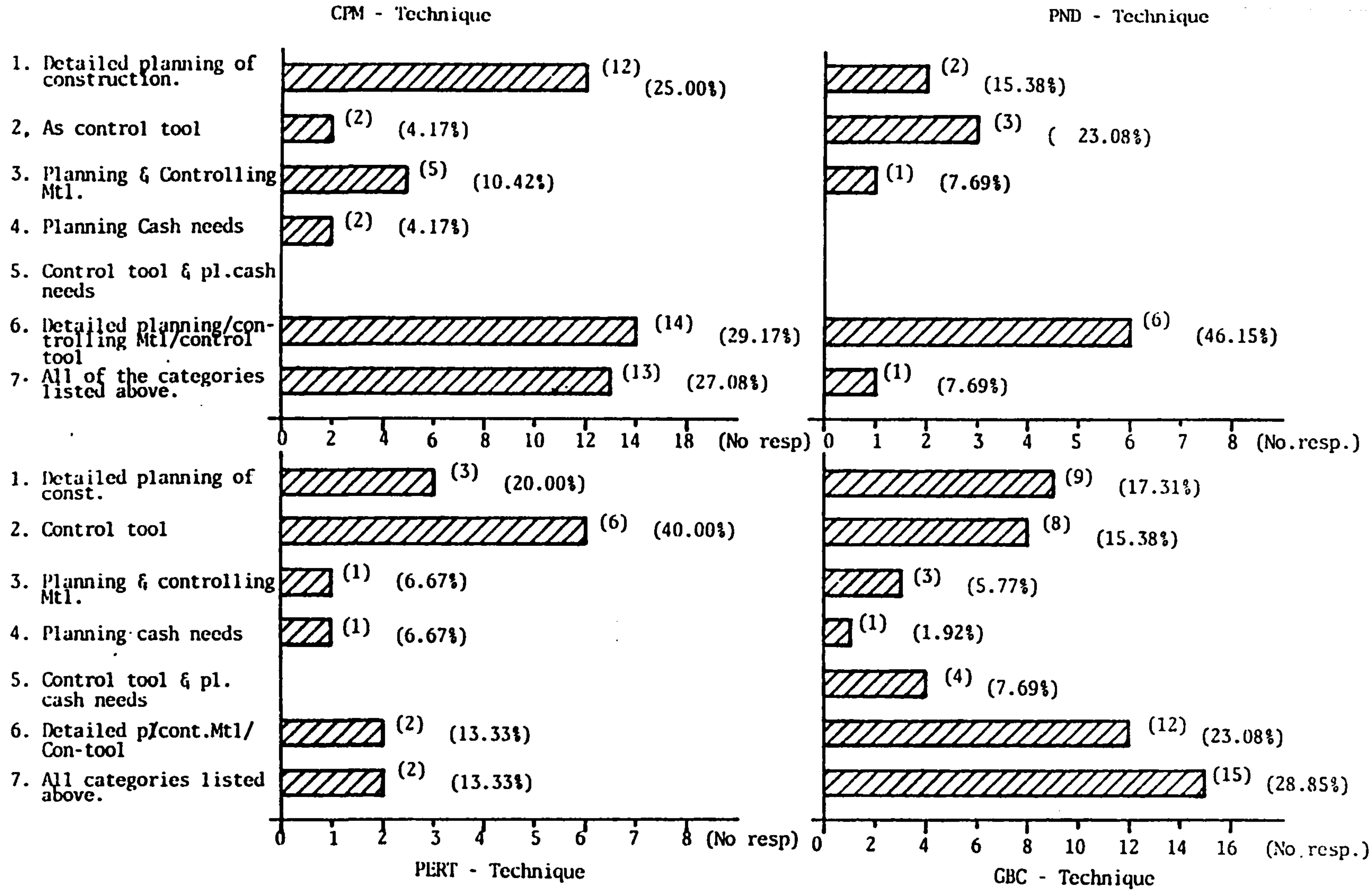


Fig. 4.3 : Major Aspects of Utilization of Each Technique in the SET based on using Criteria

Table 4.14: Mean Rank for Aspect of Utilizing the SET for the Total Surveyed Population according to Both (IM IND) & (SUC IND)

Rank	SET	Categories under Aspect of Utilization	Relative IM IND (%)
1	CPM	As detailed planning & control tool	95.238
2	"	As detailed planning & plan cash & control mtl.	94.444
3	"	As a planning & controlling material	93.333
4	"	All categories listed under the factor	89.744
5	"	As a detailed planning of construction	87.879
6	"	As a control tool	66.667
7	"	As a planning cash need	66.533
8	"	As detailed planning,control & plan cash	66.333
1	GBC	As detailed planning,control & plan cash	99.988
2	"	As a detailed planning of construction	96.296
3	"	As detailed planning & plan cash & control mtl.	93.333
4	"	As detailed planning & control tool	93.300
5	"	All categories listed under the factor	92.857
6	"	As control tool & planning cash needs	91.667
7	"	As a planning & controlling material	88.889
8	"	As a control tool	80.952
9	"	As planning cash need	33.333
1	PERT	As a detailed planning of construction	99.889
2	"	As a planning & controlling material	99.857
3	"	As detailed planning & control tool	99.778
4	"	All categories listed under the factor	83.333
5	"	As a control tool	77.778
1	PND	As a detailed planning of construction	99.952
2	"	As a planning & controlling material	99.889
3	"	All categories listed under the factor	99.779
4	"	As detailed planning & control tool	86.667
5	"	As a control tool	83.333
6	"	As detailed planning,control & plan cash	66.667
			SUC IND (%)
1	CPM	As detailed planning & plan cash & control mtl.	94.444
2	"	As detailed planning & control tool	90.476
3	"	As a detailed planning of construction	81.818
4	"	All categories listed under the factor	79.487
5	"	As a control tool	66.667
6	"	As a planning & controlling material	66.553
7	"	As planning cash need	66.333
8	"	As detailed planning,control & plan cash	33.333
1	GBC	As planning cash need	99.985
2	"	As detailed planning,control & plan cash	99.889
3	"	As detailed planning & control tool	93.333
4	"	As a detailed planning of construction	92.593
5	"	As control tool & planning cash needs	91.667
6	"	All categories listed under the factor	88.095
7	"	As detailed planning & plan cash control mtl.	80.000
8	"	As a planning & controlling material	77.778
9	"	As a control tool	76.190
1	PERT	As detailed planning & control tool	99.952
2	"	As a detailed planning of construction	88.889
3	"	All categories listed under the factor	83.333
4	"	As a control tool	77.778
5	"	As a planning & controlling material	66.667
1	PND	As a detailed planning of construction	99.889
2	"	As detailed planning & control tool	86.667
3	"	As a control tool	83.333
4	"	As a planning & controlling material	66.667
5	"	All categories listed under the factor	66.533

scheduling. These differences come from the various contractors' views and from their experiences. The other ranks according to both indices for each technique by all firms are illustrated in Table 4.14.

The agreement between the three sized contractors have been measured by correlation ratios for the aspects of SET utilization factor. The correlation results were obtained by using Spearman, partial and multiple correlations, so that the average agreement between all parties are, $r_s\overline{X}$ (aspects of utilization) = 90.00%, $r_p\overline{X}$ = 45%, and $r_m\overline{X}$ = 94%. The first highest average of corrleation is the multiple correlation which indicates the agreement between the one sized group and the other combined groups. The second highest average of correlation is the Spearman correlation which shows the agreement between one sized group with the other sized group. This high average percentage means that the responses of all groups reflect the existing situation concerning aspects of SET utilization by all sized contractors. The computation of Spearman ranks correlations of aspects of SET utilization (SET function) are illustrated in Appendix B - Table B-1. The schematic representation of the results of the three types of correlation ratios associated with aspects of SET utilization factor are shown in Appendix B - Figures B-1, 2, and 3.

4.2.4 Contractor's Major Concerns of SET

The companies were asked about their major concerns with regard to the operation and use of their present technique used for planning and scheduling. The responses for each method are illustrated in Table 4.15.

Table 4.15 : Distribution of Major Concerns of Top Management Regarding the SET Utilization

Concern to the SET operation (n/%)	LARGE FIRMS				MEDIUM FIRMS				SMALL FIRMS				TOTAL	RANK ORDER
	CPM	PND	PERT	GBC	CPM	PND	PERT	GBC	CPM	PND	PERT	GBC		
Consulting personnel (not using the method)	8/17.4	2/16.7	2/12.5	3/8.6	3/6.5	1/8.3	0/0.0	5/14.3	1/2.2	1/8.3	0/0.0	3/8.6	29/26.6	1
Implementation of them on 'excessive' work	5/10.9	1/8.3	1/6.3	3/8.6	6/13.0	0/0.0	2/12.5	1/2.9	2/4.4	0/0.0	0/0.0	2/5.7	23/21.1	2
Complexity of input and output	2/4.4	-	1/6.3	4/11.4	3/6.5	-	2/12.5	2/5.7	0/0.0	-	0/0.0	0/0.0	14/12.8	4
Other major concerns	-	-	-	1/2.9	-	-	-	0/0.0	-	-	-	0/0.0	1/0.1	8
Personnel are not using and implementation of them on excessive work	1/2.2	1/8.3	1/6.3	1/2.9	1/2.2	1/8.3	1/6.3	0/0.0	0/0.0	0/0.0	0/0.0	0/0.0	7/6.4	6
Implementation of them on excessive work and complexity of input and output	3/6.5	1/8.3	2/12.5	3/8.6	0/0.0	0/0.0	1/6.3	1/2.9	1/2.2	0/0.0	0/0.0	0/0.0	12/11.0	5
Personnel are not using/excessive work and complexity of input and output	6/13.0	2/16.7	1/6.3	3/8.6	2/4.4	2/16.7	0/0.0	1/2.9	0/0.0	0/0.0	0/0.0	0/0.0	17/15.6	3
Complexity of input and output and other major concerns	0/0.0	-	0/0.0	0/0.0	2/4.4	-	2/12.5	2/5.7	0/0.0	-	0/0.0	0/0.0	6/5.5	7
TOTAL	25/54.4	7/58.3	8/50	18/51.4	17/37.0	4/33.3	8/50	12/34.3	4/8.7	1/8.3	0/0.0	5/14.3		

The total response of CPM = 46 The total response of PERT = 16
The total response of PND = 12 The total response of GBC = 35

It can be noted that, the most frequently voiced concern is that construction personnel who must do the work or who supervise it are "not using the method". The second most frequently voiced concern is that implementation of all methods require an "excessive" amount of work. The latter concern was elaborated upon by many respondents who stated the concern of "complexity of input and output" and the other major concerns mentioned by the firms. Among the major concerns indicated by the contractors include: complexity of the actual recording of data updating with reasonable accuracy; construction field personnel not following work schedule; long delays in the approvals from client; permits not granted on time; insufficient time given from authorities; the CPM requires a special staff and set up to follow up; CPM cannot be justified for project less than SR15 million and the difficulty of the difference between CPM and PERT used for above SR15 million. Large sized contracators who use CPM, claim that the major concerns of SET utilization include, consulting personnel are not using the method, implementation of this technique required excessive work, and the complexity of input and output. It seems that medium and small sized firms state that the major concerns regarding the CPM utilization are the implementation of it required excessive work, and consulting personnel are not using the method. Indeed, the top American construction contractors share the same major concerns related to the application of the CPM technique. They believe that CPM technique is not responsive to the needs of top management.(20) All sized contracators claim that the major concerns regarding the PND technique utilization include, personnel are not using the system, required excessive work and

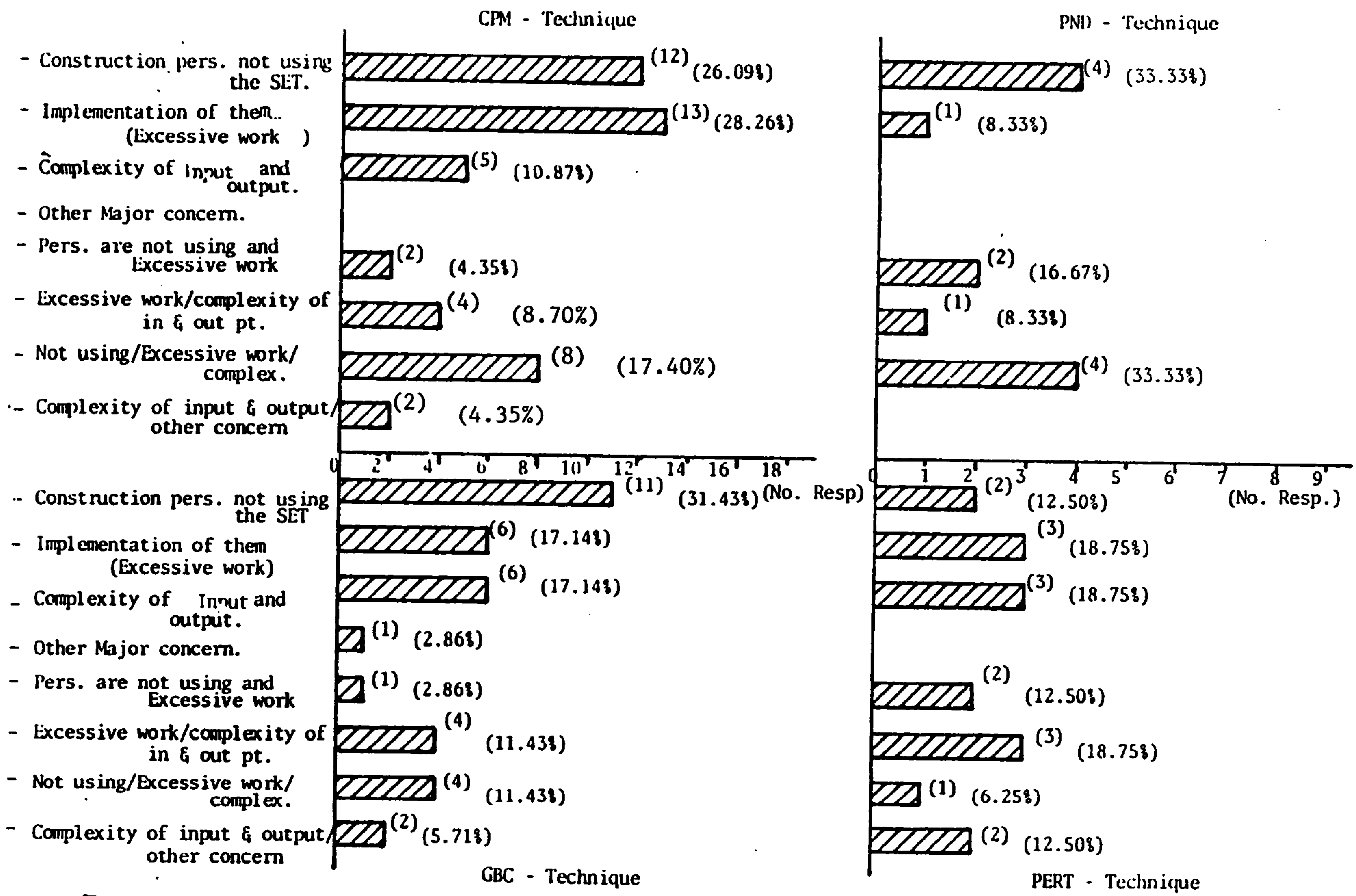


Fig. 4.4: Major Concerns of Top Management Regarding the SET Implementation

complexity of input and output.

Large and medium sized firms agree about the major concerns of PERT technique utilization which includes implementation of it required excessive work, personnel are not using the system and complexity of computer utilization for input and output. Large sized contractors who use GBC indicate that the major concern of utilization of this technique is the complexity of input and output in implementation of the system. This is a surprising observation due to the simplicity of the GBC technique application. Medium and small contractors claim that the major concerns of GBC technique utilization is that personnel are not using the method. Graphical representation of these major concerns for each technique are shown in Figure 4.4.

4.3 SET Advantages: A Contractor's View

The participating contractors indicated the major benefits they have obtained through the application of the SET. The frequent benefits gained associated with all of the techniques involved in the SET with respect to the three sized contractors are shown in Table 4.16. The most frequent benefits are defining cost saving, improving the planning of project activities, controlling project process and responding quickly to management crisis. The second most frequently claimed benefits are improvement of bidding and estimating, improvement in the planning of projects prior to start of construction , and improvement of communication among the work forces. Some contractors claim only one benefit obtained in applying one SET on project. The benefit of improvement of project control after work starts is the most frequent among the other and this is not surprising, because of updating and monitoring of scheduled plan to the actual progress.

It seems that only 21% of the contractors identified a definite cost savings attributed as a result of using the SET and most of them have stated that these SET were mostly used for planning rather than for control purposes.

In addition, 17.18% of the SET users indicated that the bidding and estimating activities have been improved because of the SET techniques. About 14% stated that the improvement of communication among work force benefit as a result gained from SET utilization. Only 26.46% of the

Table 4.16 : Distribution by Size of Firms with Benefits obtained through SET Implementation Among the Three Groups

BENEFITS OBTAINED (n/%)	LARGE FIRMS				MEDIUM FIRMS				SMALL FIRMS				TOTAL	RANK ORDER
	CPM	PND	PERT	GBC	CPM	PND	PERT	GBC	CPM	PND	PERT	GBC		
Defining Cost Saving	-	1/8.3	-	1/1.9	-	0/0.0	-	0/0.0	-	0/0.0	-	0/0.0	2/1.5	10
Improved Bidding and Estimating	-	-	1/5.7	0/0.0	-	-	0/0.0	1/1.9	-	-	0/0.0	0/0.0	2/1.5	10
Improved Planning before work starts	1/2.1	-	-	-	0/0.0	-	-	-	0/0.0	-	-	-	1/0.8	11
Improved project control after work starts	2/4.2	-	1/5.7	1/1.9	2/4.2	-	0/0.0	1/1.9	2/4.2	-	0/0.0	2/3.8	11/8.6	3
Faster response to management	2/4.2	-	-	1/1.9	0/0.0	-	-	0/0.0	0/0.0	-	-	0/0.0	3/2.3	9
Improved communication among work forces	-	-	-	1/1.9	-	-	-	0/0.0	-	-	-	0/0.0	1/0.8	11
Improved bid/estimate and faster response	-	-	0/0.0	-	-	-	1/5.6	-	-	-	0/0.0	-	1/0.8	11
Improved bid/Estimate & planning before work/project control	0/0.0	-	0/0.0	1/1.9	2/4.2	-	1/5.6	4/7.6	0/0.0	-	0/0.0	0/0.0	8/6.3	5
Cost saving and improved bid/estimate & planning before work	3/6.3	1/8.3	-	2/3.8	1/2.1	0/0.0	-	0/0.0	0/0.0	0/0.0	-	0/0.0	7/5.5	6
Improved planning/ project control/ Faster response	1/2.1	0/0.0	1/5.7	3/5.1	1/2.1	0/0.0	0/0.0	1/1.9	0/0.0	1/8.3	0/0.0	1/1.9	9/7	4

Table 4.16 : (Continued)

BENEFITS OBTAINED (n/%)	LARGE FIRMS				MEDIUM FIRMS				SMALL FIRMS				TOTAL	RANK ORDER
	CPM	PND	PERT	GBC	CPM	PND	PERT	GBC	CPM	PND	PERT	GBC		
Improved planning/project control/faster response/comm.	1/2.1	-	-	1/1.9	1/2.1	-	-	1/1.9	1/2.1	-	-	1/1.9	6/4.6	3
Cost saving/Imp.Bid/Est/Planning after work/faster response/communication	1/2.1	1/8.3	2/5.6	1/1.9	2/4.2	0/0.0	1/5.6	1/1.9	0/0.0	0/0.0	0/0.0	1/1.9	9/7.0	4
Improved bid/Est/Planning after work starts	-	1/8.3	0/0.0	1/1.9	-	0/0.0	0/0.0	0/0.0	-	0/0.0	0/0.0	0/0.0	4/3.1	8
Cost saving & project control after work	2/4.2	-	0/0.0	1/1.9	1/2.1	-	1/5.6	0/0.0	0/0.0	-	0/0.0	0/0.0	5/3.9	7
Cost saving and imp. project control before & after work	3/6.3	2/16.8	2/11.1	-	0/0.0	0/0.0	0/0.0	-	1/2.1	0/0.0	0/0.0	-	8/6.3	5
Imp. Bid/Est/Planning Faster Response/Communication	4/8.3	1/8.3	1/5.6	2/3.7	2/4.2	1/8.3	2/11.1	3/5.7	0/0.0	0/0.0	0/0.0	0/0.0	16/12.5	2
Cost saving, Imp.Bid/Est/Planning/Faster Response/Communication	1/2.1	-	-	3/7.7	0/0.0	-	-	0/0.0	0/0.0	-	-	0/0.0	3/2.3	9
Cost Saving/Imp.Plg. Project Control & Faster Communication	1/2.1	0/0.0	-	8/15.1	1/2.1	2/25	-	5/9.4	0/0.0	0/0.0	-	0/0.0	18/14.2	1
Cost saving/Imp.Plan/Control/Faster Res. to Mgt. & Communication	0/0.0	-	1/5.6	0/0.0	1/2.1	-	1/5.6	1/1.9	0/0.0	-	0/0.0	0/0.0	4/3.1	8
Faster Response to Management & Communication	-	-	0/0.0	1/7.9	-	-	1/5.6	0/0.0	-	-	0/0.0	0/0.0	2/1.5	10
All of the above	3/6.3	-	-	-	4/8.3	-	-	-	0/0.0	-	-	-	7/5.5	6
TOTAL	26/54.2	7/58.3	10/55.6	29/54.7	18/37.5	4/33.3	8/44.4	19/35.9	4/8.3	1/8.3	0/0.0	5/9.4		

The Total Response of CPM = 48　　The Total Response of PERT = 18
The Total Response of PND = 12　　The Total Response of GBC = 53

respondents listed the benefits obtained from SET utilization is the improvement of planning before work starts and 21.31% of the users stated the benefit of improvement of project control after work starts as obtained from SET utilization.

CPM users claim that improved planning before work starts and improved project control after work starts are the most frequent benefits obtained. The second frequent benefits is defining cost saving and faster response to managements. The lowest frequent benefits is improved communication among work forces.

Large and medium contractors claim that the prime benefits of CPM include, improving of bidding and estimating activities, improving the planning process before work starts, responding quickly to management crisis and improving communication among work-forces. Small contractors who use CPM indicated that the major benefits obtained in using this technique are improving the project control after work starts, and improving the planning before the work starts.

The most frequent benefits obtained from application of the CPM technique by top American contractors are in the form of improvements in the planning of project activities prior to the start of construction.(20) Also, some CPM users in the United States of America indicated that no benefits were obtained as a result of using CPM and sometimes added "only higher costs", while in Saudi Arabia, none of the respondents claimed this category of "no benefits, only higher costs".

The PND technique users reported that the first highest weight of benefits related to PND application is improved planning before work starts. The second highest benefits are define cost saving, improved project control after work starts and faster response to management. The lowest benefits are improved bidding and estimating, and improved communication among work forces.

Large and medium sized firms stated that the main benefits of using PND technique are defining cost savings, improving planning before work starts, improving project control after work starts and improving both communication and the responding character to management crisis. Small contractors who use the PND technique claim that the benefits obtained include improving planning and project control before and after work starts and faster response to management crisis.

For the PERT technique, the results indicated that the contractors who use this method claim its use leads to improved project control after work starts, quick response to management crisis, define cost saving and improved communication among work-forces. The second frequent benefits is improving planning before work starts and the third frequent benefits are improving bidding and estimating of project activities. In addition, all large and medium firms who use PERT generally agree on the above benefits obtained when implementing this technique on their projects.

GBC users indicate that the highest rated benefits are improved project control after work starts and the quick response to management crisis. The second rated benefits are improving bidding or estimating, and improving communication. The lowest rated benefits are defining cost savings and improving planning before work starts.

Large and medium sized contractors claim that the prime benefits of GBC include, defining cost saving, improving planning before work starts, improving project control after work starts, responding quickly to management crisis and improving communication among work forces. Small sized contractors claim that the major benefits of GBC involve, improving project control after work starts, responding quickly to management crisis and improving of communication among work forces.

Additional benefits are mentioned by respondents include improvements of delivery dates for material, presenting all needed information to the manager or planner, make effective schedule of equipment and effective sales presentation to customers. Many respondents feel that the greatest benefit obtained from the use of the SET in their firm is the planning before work starts because it assists the manager or any other concerned person or site manager to know the full plan of the project in a detailed manner before the work starts.

4.3.1. User's Levels of SET Information

Information generated by SET techniques are used at different management levels. CPM information are used at all levels of a contracator's organization. The majority of the contractors who use the CPM technique make extensive use of its information at the project management level, site manager level and trade superintendent level. The results also indicate that only 4.3% of firms gained information when using the CPM technique at the division or group manager levels. About 19% of the firms use CPM at all categories of levels and departments under the user's levels category and also 19% of contractors use it at project management level, department managers level and bidding or estimating levels. It seems that CPM information is used by all levels for controlling purposes. In the U.S., the overwhelming majority of contractors generate CPM information at the project or site manager's level and division manager's levels.(20)

The majority of PERT and PND users use the generated information at project management level and trade superintendent level. About 80.5% of firms used information from PERT at the same level as for PND technique. The GBC technique is one of the SET could be applicable to gain information from it at all categories listed under the factor (percentage is a total of 100 per each technique individually). The other distribution of the user's levels among the three sized groups are illustrated in Table 4.17.

Large contractors who implement CPM and/or GBC use the generated information as input for decision making at the project management and site management levels. Medium firms agreed upon using information from SET implementation at project management and site manager, division (department) or group and bidding or estimating levels through the utilization of all techniques included in the SET. It is interesting to note that small firms used the information from CPM and GBC at project man-

Table 4.17 : Distribution of Major Users' Levels of SET Implementation with each of the test group

USERS LEVEL (n/%)	LARGE FIRMS				MEDIUM FIRMS				SMALL FIRMS				TOTAL	RANK ORDER
	CPM	PND	PERT	GBC	CPM	PND	PERT	GBC	CPM	PND	PERT	GBC		
At Project Management Level (Project Manager & Site Manager	5/10.6	4/30.8	7/41.2	4/7.6	4/8.5	1/7.7	2/11.8	4/7.6	2/4.3	0/0.0	0/0.0	2/3.8	35/26.9	5
At the Division or Group Manager's Level	2/4.3	-	1/5.9	1/1.9	0/0.0	-	1/5.9	0/0.0	0/0.0	-	0/0.0	0/0.0	5/3.9	2
At the Trade Superintendent Level	-	-	0/0.0	-	-	-	1/5.9	-	-	-	0/0.0	-	1/0.1	7
At the bidding or estimating level	-	-	-	0/0.0	-	-	-	1/1.9	-	-	-	1/1.9	2/1.5	6
At Project Management Division or Group & Bidding or Estimating Level	7/14.9	1/7.7	1/5.9	9/17.0	8/17.0	2/15.4	2/11.8	5/9.4	1/2.1	1/7.7	0/0.0	2/3.8	39/30.0	1
At Project Management Level & Division or Group Level	8/17.0	1/7.7	-	4/7.6	1/2.1	0/0.0	-	1/1.9	0/0.0	0/0.0	-	0/0.0	15/11.5	4
All of the above	4/8.5	2/15.4	0/0.0	12/22.6	5/10.7	1/7.7	2/11.8	7/13.2	0/0.0	0/0.0	0/0.0	0/0.0	33/25.4	3
TOTAL	26/55.3	8/61.5	9/52.9	30/56.6	18/38.3	4/30.8	8/47.1	18/34.0	3/6.4	1/7.7	0/0.0	5/13.2		

Total Responses of CPM = 47
Total Responses of PERT = 17
Total Responses of PND = 13
Total Responses of GBC = 53

agement and site manager's levels because the information of these methods usually utilized at project management level by the top management. Also small firms use the information of PND as the same as for CPM by large firms.

It is interesting to observe that the information of CPM and PERT are utilized at project management , departments, bidding and estimating levels because it seems to be an important category especially for large contractors. The generated information from GBC is utilized only at project management and site manager's levels. The PND technique information is utilized at project management and division or groups levels, the priority was given to this categories by large firms.

Medium and small firms agreed on generated information from the PND technique at project management , department or group manager's levels, bidding and estimating, according to importance index. Medium firms were considered that GBC information could be gained at all levels included under the user's levels factor. The information of the PERT technique is gained at trade superintendents level only by medium firms and it occupied the highest importance rank by them. CPM information is utilized by medium firms at project management and site manager's levels.

GBC information is utilized at the same level as the PND technique by small firms which is due to the fact that the easiest to be used and more understandable than the other methods. CPM users in small class utilized information gathered from them at all levels of categories under the user's level tested and this has the highest rank by small firms. The other categories ranks are illustrated in Table 4.18 through all SET implemented.

The information of CPM is utilized at project management, department or group levels and bidding or estimating levels and it has the first degree of rank by large firm. Large and medium firms utilized the information from GBC and CPM respectively at project management level and site manager levels, they agreed to the priority of these levels. Large firms who use PERT gave the first priority of users level at project management and site managers levels according to importance indices.

Table 4.19 shows the rank of user's levels of information gained from SET implementation per each technique according to the relative success index. Large firms who use GBC and PND gave the highest rank for gaining information from them at project management and site managers levels. Medium firms and small firms agreed on utilizing the information of CPM at project management department or group managers levels, and bidding or estimating levels. Large firms and medium firms agreed on utilizing the information of PERT at division (department) or group managers levels and it occupied the highest priority of rank by them.

Medium and large firms do not regard that "all categories of levels listed under user's levels factor" as the highest rank among the method, where it is the first degree levels for small firms based on their successful utilization of the methods. The ranks of other categories according to success indices shown in Table 4.19. Table 4.20 shows the rank of user's levels by all contractors for both importance and success indices. the results indicate that, The users of CPM obtained information at project

Table 4.18: **Mean Rank for User's levels of Utilization of the SET by the three test groups according to Importance Index.**

Pank	SET	Categories under User's Levels	Pelative Importance Index(%)
		(Large Firms Rank)	
1	CPM	At project management, division & bidding	99.952
2	"	At project management & trade superintendents	99.789
3	"	At project management & bidding or estimating	99.667
4	"	All categories listed under the factor	88.889
5	"	At project & division managers	87.500
6	"	At project & site managers (PM-level)	80.000
7	"	At division or group manager level	66.667
1	GBC	At project & site managers (PM-level)	99.989
2	"	At division or group manager level	99.563
3	"	At project management & bidding or estimating	99.553
4	"	All categories listed under the factor	93.333
5	"	At project & division managers	91.667
6	"	At project management, division & bidding	88.889
7	"	At project management & trade superintendents	83.333
1	PERT	At project management, division & bidding	99.667
2	"	At project & site managers (PM-level)	90.676
3	"	At division or group manager level	66.667
1	PND	At project & division managers	99.952
2	"	At project & site managers (PM-level)	91.667
3	"	All categories listed under the factor	83.333
		(Medium Firms Rank)	
1	CPM	At project & site managers (PM-level)	99.932
2	"	At project management & trade superintendents	99.673
3	"	All categories listed under the factor	99.667
4	"	At project management & bidding or estimating	99.553
5	"	At project management, division & bidding	88.889
1	GBC	All categories listed under the factor	93.333
2	"	At project & site managers (PM-level)	83.333
3	"	At project management, division & bidding	66.667
1	PERT	At trade superintendent level	99.563
2	"	All categories listed under the factor	99.553
3	"	At project & site managers (PM-level)	66.667
4	"	At division or group manager level	66.683
1	PND	At project management, division & bidding	99.776
2	"	All categories listed under the factor	99.667
3	"	At project & site managers (PM-level)	66.667
		(Small Firms Rank)	
1	CPM	All categories listed under the factor	99.952
2	"	At project & division managers	99.889
3	"	At project management, division & bidding	83.333
4	"	At project & site managers (PM-level)	50.000
1	GBC	At project management, division & bidding	99.667
2	"	All categories listed under the factor	99.553
3	"	At project & site managers (PM-level)	66.667
4	"	At project & division managers	66.633
1	PND	At project management, division & bidding	83.333
2	"	At project & site managers (PM-level)	66.667
3	"	All categories listed under the factor	66.633

Table 4.19: Mean Rank for User's levels of Utilization of the SET by the three test groups according to Success Index.

Rank	SET	Categories under User's Levels	Relative Success Index(%)
(Large Firms Rank)			
1	CPM	At project management & trade superintendent	99.452
2	"	At project management & bidding or estimating	88.889
3	"	At project & division managers	87.500
4	"	At project management, division & bidding	77.778
5	"	At project & site managers (PM-level)	73.333
6	"	At division or group manager level	66.667
7	"	All categories listed under the factor	55.556
1	GBC	At project & site managers (PM-level)	91.667
2	"	At project & division managers	91.337
3	"	At project management, division & bidding	88.989
4	"	At project management & bidding or estimating	88.889
5	"	All categories listed under the factor	86.667
6	"	At project mana ement & trade superintendent	83.333
7	"	At division or group manager level	66.667
1	PERT	At division or group manager level	99.668
2	"	At project anagement, division & bidding	99.553
3	"	At project & site managers (PM-level)	80.952
1	PND	At project & site managers (PM-level)	91.667
2	"	All categories listed under the factor	66.667
3	"	At project & division anagers	66.337
(Medium Firms Rank)			
1	CPM	At project management, division & bidding	99.889
2	"	All categories listed under the factor	99.773
3	"	At project management & bidding or estimating	99.667
4	"	At project & site managers (PM-level)	83.333
5	"	At project management & trade superintendent	66.667
1	GBC	At project & site managers (PM-level)	99.983
2	"	At project management, division 'idding	99.889
3	"	All categories listed under the factor	86.667
1	PERT	At division or group manager level	99.952
2	"	All categories listed under the factor	99.552
3	"	At project & site managers (PM-level)	66.667
4	"	At trade superintendent level	66.337
1	PND	At project management, division & bidding	99.285
2	"	All categories listed under the factor	99.553
3	"	At project & site managers (PM-level)	66.667
(Small Firms Rank)			
1	CPM	At project management, division & bidding	83.667
2	"	All categories listed under the factor	83.333
3	"	At project & site managers (PM-level)	66.667
4	"	At project & division managers	66.337
1	GBC	At project management, division & bidding	99.992
2	"	All categories listed under the factor	83.333
3	"	At project & site managers (PM-level)	66.667
4	"	At project & division managers	66.337
1	PND	All categories listed under the factor	99.952
2	"	At project management, division & bidding	83.333
3	"	At project & site managers (PM-level)	66.667

management and trade superintendent's levels. These levels are rated as the first degree of important category level for all firms. The users of PERT obtained information at trade superintendent's level. GBC users gathered information at division (department) or group manager's level. This category occupied the highest rank by all firms. PND information is utilized at project management level and division or (department) groups or managers levels and bidding or estimating levels. This priority was given by all sized contractors for both importance and success indices.

However, there seem to be difference between all firms of two different ranks according to both importance and success indices. The GBC and PND users agreed upon utilizing the information of SET at project management, division (department) or groups and bidding or estimating levels. CPM information is utilized at project management and bidding or estimating, but the information of PERT is utilized at division or group manager's level. These ranks are based on success indices. Table 4.20 shows the breakdown of the ranks of user's level by all firms who utilize information from SET for project planning and scheduling through the four methods have been tested. The schematic representation of the results obtained from these SET user's levels are shown in Fig. 4.5.

The correlation results have been obtained by using Spearman, partial and multiple correlations. The average agreement between all sized contractors for user's level of SET information are, $r_s\overline{X}$ (user's level) = 91%, $r_p\overline{X}$ = 46% and $r_m\overline{X}$ = 94%. Both the multiple and Spearman

Table 4.20: Mean Rank for User's levels of Utilization of the SET for the Total Surveyed Population according to both (IM IND) & (SUC IND)

Rank	SET	Categories under User's Levels	Relative IM IND (%)
1	CPM	At project management & trade superintendent	99.998
2	"	At project management & bidding or estimating	99.952
3	"	All categories listed under the factor	95.833
4	"	At project management, division & bidding	91.667
5	"	At project & division managers	88.889
6	"	At project & site managers (PM-level)	78.788
7	"	At division or group manager level	66.667
1	GBC	At division or group manager level	99.776
2	"	At bidding & estimating phase	99.667
3	"	All categories listed under the factor	94.118
4	"	At project management & bidding or estimating	91.667
5	"	At project management & trade superintendent	88.889
6	"	At project management, division & bidding	87.500
7	"	At project & site managers (PM-level)	86.667
8	"	At project & division managers	86.336
1	PERT	At trade superintendent level	99.889
2	"	At project management, division & bidding	88.889
3	"	At project & site managers (PM-level)	85.185
4	"	All categories listed under the factor	83.333
5	"	At division or group manager level	66.667
1	PND	At project mana ment, division & bidding	99.889
2	"	At project & division anagers	99.776
3	"	All categories listed under the factor	88.889
4	"	At project & site managers (PM-level)	86.667
5	"	At project management & bidding or estimating	66.667
			SUC IND (%)
1	CPM	At project management & bidding or estimating	88.889
2	"	At project management, division& bidding	87.500
3	"	At project & division anageers	85.185
4	"	At project management & trade superintendent	83.333
5	"	All categories listed under the factor	79.167
6	"	At project & site managers (PM-level)	69.697
7	"	At division or group manager level	66.667
1	GBC	At project management, division & bidding	95.833
2	"	At project management & trade superintendent	88.889
3	"	At project & site managers (PM-level)	86.667
4	"	At project & division managers	86.336
5	"	All categories listed under the factor	86.275
6	"	At project management & bidding or estimating	83.333
7	"	At division or roup manager level	66.667
8	"	At bidding & estimating phase	66.337
1	PERT	At division or group manager level	99.952
2	"	All categories listed under the factor	99.889
3	"	At project management, division & bidding	88.889
4	"	At project & site managers (PM-level)	77.778
5	"	At trade superintendent level	66.667
1	PND	At project management, division & bidding	99.952
2	"	At project & site managers (PM-level)	86.667
3	"	All categories listed under the factor	83.333
4	"	At project management & bidding or estimating	66.667
5	"	At project & division managers	66.336

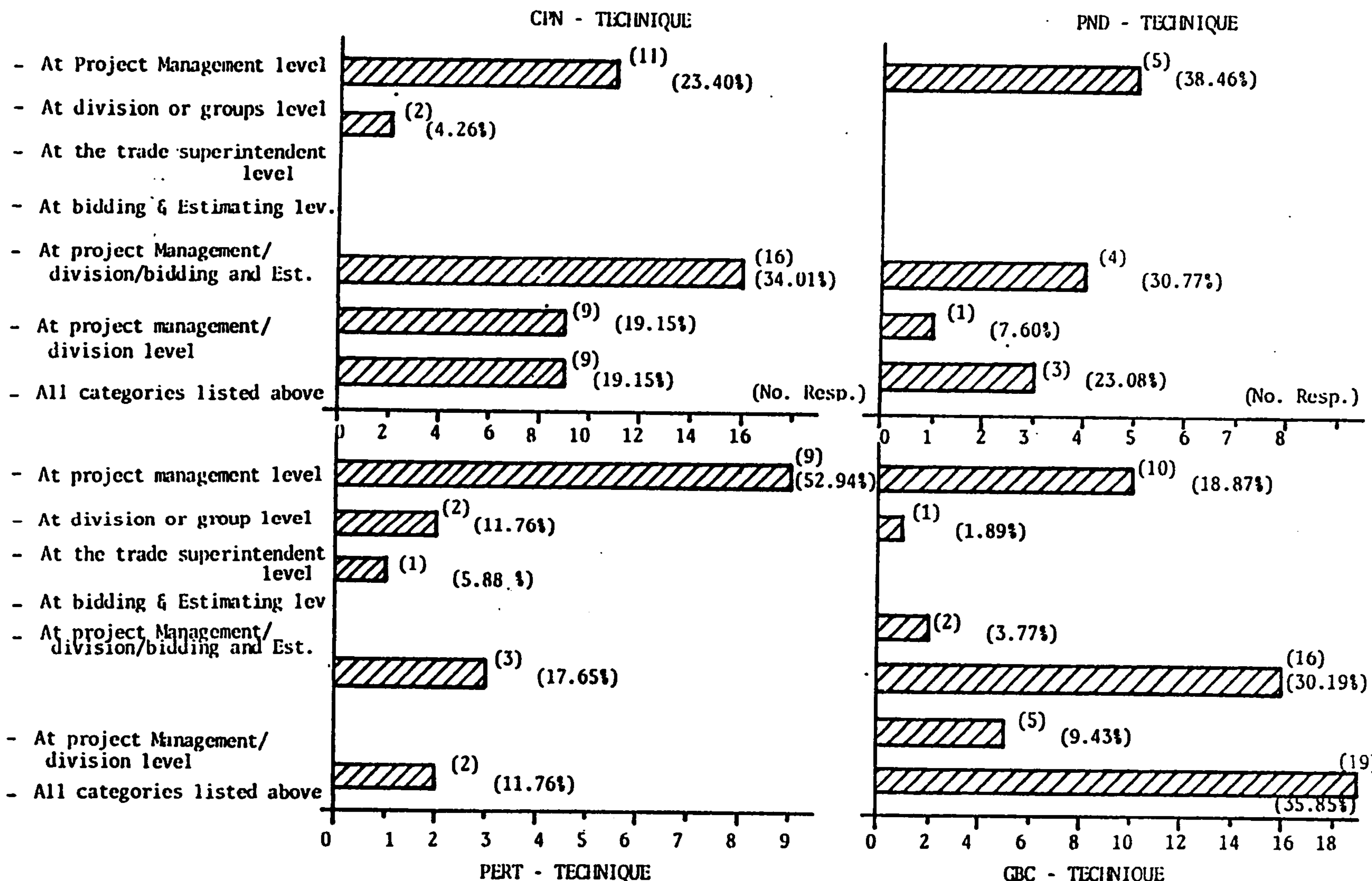


Fig. 4.5: User's Levels of Information gained from SET Implementation

correlation coefficients have occupied the first and the second highest average of agreements. These results indicated that a clearer agreement between parties and a sensible agreement between one party with the other two sized groups exist.

The lowest value of the correlation coefficient represents a weaker relationship among parties and this is usually for the agreement of partial correlation which represents the agreement between two parties with the third party who kept constant. The computation of Spearman ranks correlations of user's levels of SET information are demonstrated in Appendix B - Table B-2. The graphical representation of three correlation coefficients associated with user's level of SET information factor are shown in Appendix B - Figures B-4, 5, and 6.

4.3.2 Cost Saving

Contractors can assure themselves many benefits by using a SET technique. Cost saving is one benefit that is immediately realized. Table 4.21 shows the percentage of cost saving that can be gained from the implementation of SET technique by different sized contractors. The largest range in percentage of cost saving, that is indicated by a large number of firms is the (10-14%) of the total contract cost amount and 4% or less of the total contract cost amount. The overall mean of these percentage ranges of cost saving by using the midpoint is 12.22% of the total contract cost amount. For large firms, the highest percentage mean of cost saving when using CPM is about $\overline{X}$ = 13.20% of the total contract cost, and

Table 4.21 : Distribution of approximate (%) of cost saving obtaining through SET implementation

Approximate (%) Range of Cost Saving (n/%)	LARGE FIRMS				MEDIUM FIRMS				SMALL FIRMS				TOTAL	RANK ORDER
	CPM	PND	PERT	GBC	CPM	PND	PERT	GBC	CPM	PND	PERT	GBC		
26% - 30% of contract cost amount	3/7.5	-	0/0.0	3/6.8	2/5.0	-	3/23.1	1/2.3	0/0.0	-	0/0.0	0/0.0	12/11.1	4
20%-25% of contract cost amount	2/5.0	0/0.0	0/0.0	1/2.3	3/7.5	2/18.2	1/7.7	1/2.3	2/5.0	0/0.0	0/0.0	1/2.3	13/12.0	3
15%-19% of contract cost amount	2/5.0	1/9.1	1/7.7	3/9.8	1/2.5	0/0.0	0/0.0	1/2.3	0/0.0	0/0.0	0/0.0	2/4.6	11/10.2	5
10%-14% of contract cost amount	5/12.5	2/18.2	2/15.4	4/9.1	4/10.0	1/9.1	0/0.0	4/9.1	2/5.0	0/0.0	0/0.0	1/2.3	25/23.2	1
5%-9% of contract cost amount	5/12.5	2/18.2	2/15.4	5/11.4	3/7.5	1/9.1	1/7.7	3/6.8	0/0.0	0/0.0	0/0.0	0/0.0	22/20.4	2
4% or less of contract cost amount	3/7.5	1/9.1	2/15.4	8/18.2	3/7.5	0/0.0	1/7.7	5/11.4	0/0.0	1/9.1	0/0.0	1/2.3	25/23.2	1
TOTAL	20/50	6/54.6	7/53.9	24/54.6	16/40	4/36.4	6/46.2	15/34.1	4/10.0	1/9.1	0/0.0	5/11.4		
THE MEAN ($\bar{X}$)	13.2%	9.5%	8.4%	9.4%	13.5%	16.0%	19.3%	9.8%	17.2%	2.0%	0.0%	14.1%		

The total of CPM = 40 Respondents The total of PND = 11 Respondents
The total of PERT = 13 Respondents The total of GBC = 44 Respondents

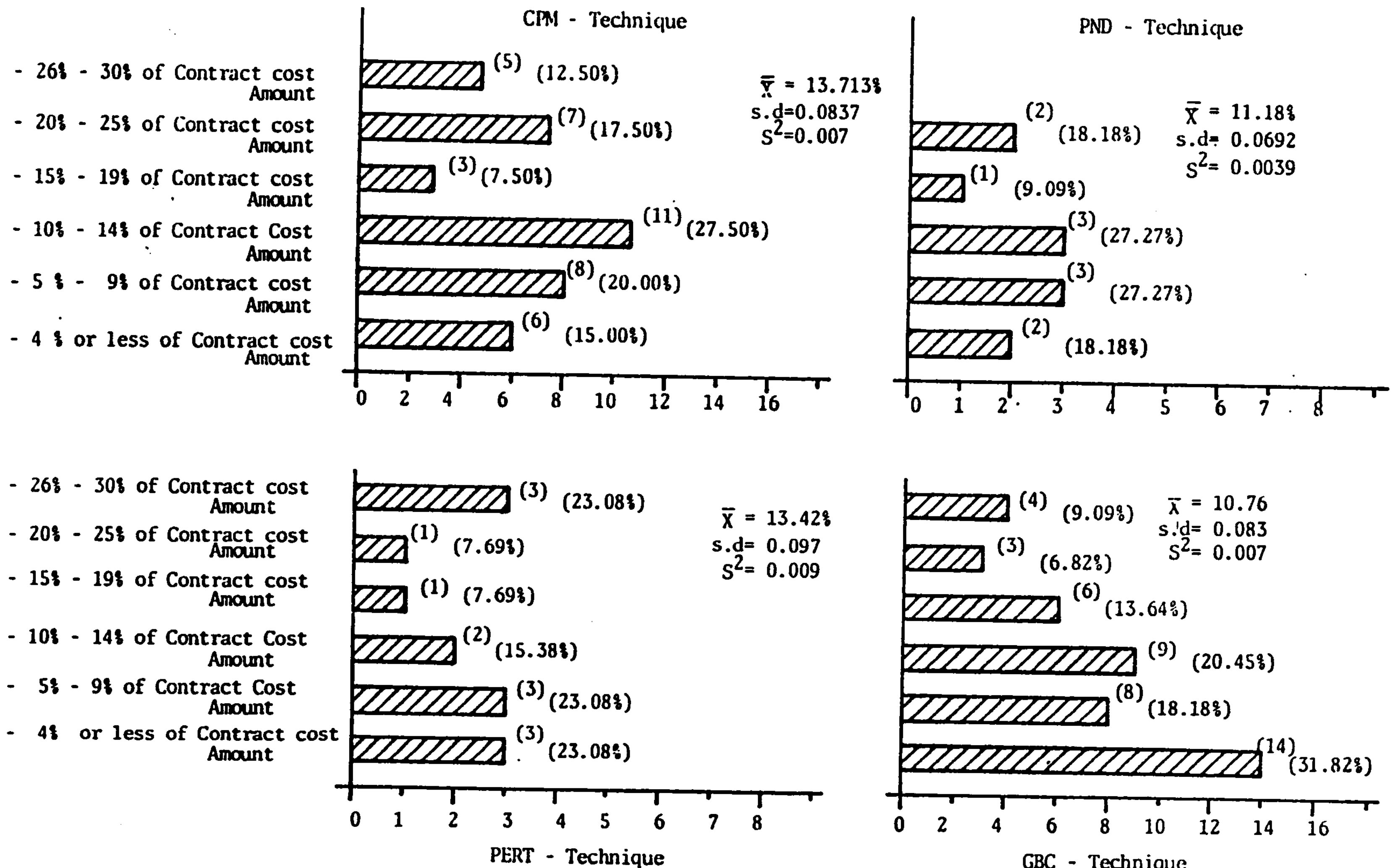


Fig. 4.6: Approximate Percentage of Cost Saving from SET Implementation

$\overline{X}$ = 9.5% when using both PND plus GBC, and $\overline{X}$ = 8.42% of the total contract cost when using PERT. As far as cost saving gained when using the methods are concerned, it may be noted that the highest mean of the percentage of cost saving by medium sized firms is equal to 19.25% when implementing PERT in their organization, 16.0% when using PND, 13.47% when using CPM and 9.76% when using GBC. For small firms, the highest percentage of cost saving when using CPM is equal to 17.24% and secondly, it is equal to 14.1% when using GBC and the lower mean of cost saving occurred when using PND. The response for each method individually are illustrated in Figure 4.6 where it can be seen that the most highest percentage for cost saving based on the method, is the one for CPM which is equal to 13.713% of the total contract cost amount. The lower percentage of cost saving when using GBC is equal to 10.76% of the contract amount.

Figure 4.7 shows a graphical representation of both the frequent users and the approximate percentage of cost saving per each method in the SET. It is interesting to observe that the GBC with lower percentage of cost saving has the highest percentage of users and CPM with the largest percentage of cost saving has the majority of users, but fewer than the users of GBC. Additionally, for both PND and PERT have the lower percentage of users among contractors and they vary from one response to other. It was noted, however, the results of cost saving is approximately relevant because it was figured from the participants' viewpoints and from their experience and, in fact, is not based on mathematical calculation of

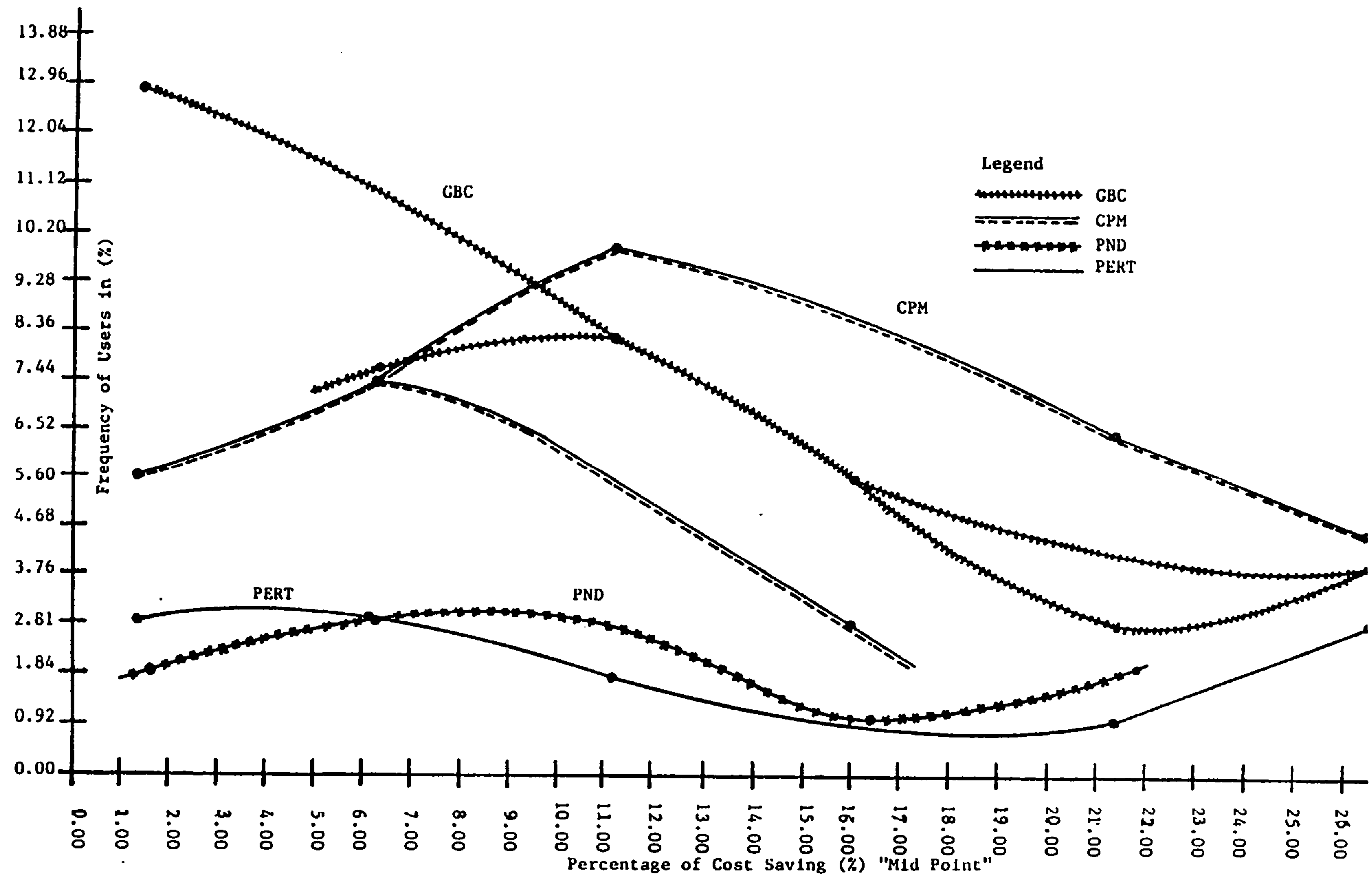


Fig. 4.7: : Frequent Users & The Approximate Percentage of Cost Saving Per Contract Cost Amount

various construction projects. This information gathered attempted to figure out the approximate percentage of cost saving gained for SET in formalizing project planning and scheduling.

4.3.3 Levels of SET Importance to Firm's Success: A Contractor's View

The levels of importance associated to each technique included in the SET have been assessed by the contractors views on utilization of these techniques. The determination of level of importance is dependent on the firm's success in implementing the SET for project planning and scheduling. The results indicate that about 71% of the CPM users regard this technique as a very important contributor to their firm's current success. This is indicated that about 56% of all contractors regarded this technique as very important to the current success. Large firm contractors view CPM as very important, moderately important and relatively unimportant by 51.5%, 24.24% and 3% of them, respectively. Medium sized firms regard the CPM technique as very important, moderately important, and relatively unimportant by 63.6%, 13.6%, and 4.5% of them respectively. About 50% of those who use the CPM technique and view it as very important, are a small sized contractors and 17% of small firms view the CPM technique as moderately important.

The other findings are illustrated in Table 4.22 and the percentage presented there is calculated per users of each technique and the sum of the total is out of 100. The results indicated that the contractors who view the SET as very important are as follows: about 55.73% of contractors using CPM, 13.11% of contractors who use PND, 14.75% of contractors

Table 4.22 : Distribution of Top Management Views as Important Technique to Firm's Success

Levels of Importance (n/%)	LARGE FIRMS				MEDIUM FIRMS				SMALL FIRMS				TOTAL	RANK ORDER
	CPM	PND	PERT	GBC	CPM	PND	PERT	GBC	CPM	PND	PERT	GBC		
Very important to the current success	17/35.4	5/41.7	6/35.3	22/44	14/29.2	3/25	3/17.7	11/22	3/6.3	0/0.0	0/0.0	3/6	87/68.5	1
Modest important for the current success	8/16.7	2/16.7	3/17.7	5/10	3/6.3	1/8.3	5/29.4	6/12.0	1/2.1	1/8.3	0/0.0	2/4	37/29.1	2
Relatively unimportant	1/2.1	0/0.0	0/0.0	0/0.0	1/2.1	0/0.0	0/0.0	1/2.0	0/0.0	0/0.0	0/0.0	0/0.0	3/2.3	3
TOTAL	26/54.2	7/58.3	9/52.9	27/54	18/37.5	4/33.3	8/47.1	18/36.0	4/8.3	1/8.3	0/0.0	5/10		

Table 4.23 : Degree of Success in Achieving Advantages Attributed to SET Utilization

Degree of Success (n/%)	LARGE FIRMS				MEDIUM FIRMS				SMALL FIRMS				TOTAL	RANK ORDER
	CPM	PND	PERT	GBC	CPM	PND	PERT	GBC	CPM	PND	PERT	GBC		
Very successful	11/22	3/27.3	5/29.5	18/35.3	11/22	3/27.3	4/23.5	12/23.5	0/0.0	0/0.0	0/0.0	2/3.9	69/53.9	1
Modest successful	16/32	3/27.3	4/23.5	10/19.6	7/14	1/9.1	4/23.5	6/11.8	3/6.0	1/9.1	0/0.0	3/5.9	58/44.9	2
Unsuccessful	1/2	0/0	0/0.0	0/0.0	0/0	0/0	0/0.0	0/0.0	1/2.0	0/0.0	0/0.0	0/0.0	2/1.6	3
TOTAL	28/56	6/54.5	9/52.9	28/54.9	18/36	4/36.4	8/47	18/35.3	4/8.0	1/9.1	0/0.0	5/9.8		

who use PERT and 59% of contractors using GBC. The contractors who view the SET as modestly important, the results show that about 20% of contractors use CPM, 6.55% of firms use PND, 13.11% of contractors use PERT, and 21.32% of contractors use GBC. The last level of relatively unimportant indicated only by two contractors (3.3%) who use CPM technique and one contractor (1.6%) who uses GBC. No one of the contractors who use PND or PERT feel it is a relatively unimportant contributor to their firm's success.

Among the executives who view the SET as very important are generally in the large and small sized class. The GBC technique regarded as very important and it has occupied the highest percentage weight of users among the other methods, while the CPM technique has the second peracentage weights of users among the methods which viewed as very important to the current success. The CPM and GBC techniques regarded as very important by medium sized firms and this occupied the first and the second percentage weights of users among the other method. For large firms, CPM has the highest weight among the remaining method when regarded as moderately important, while the users who view GBC as moderately important are in the medium class and it has occupied the highest weights of users. Levels of importance of the SET's evaluation to firm's success by all participating contractaors are shown in Figure 4.8.

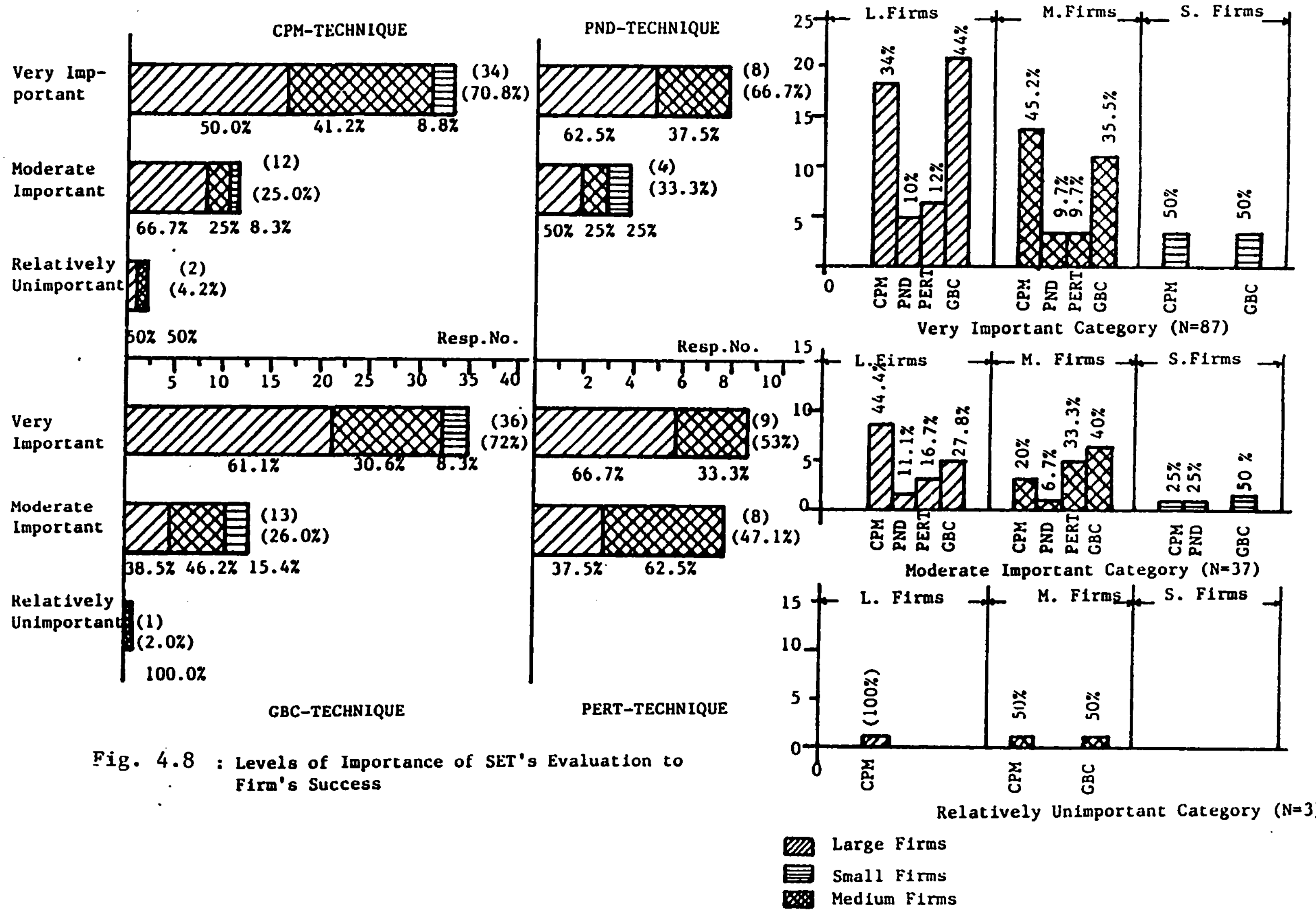


Fig. 4.8 : Levels of Importance of SET's Evaluation to Firm's Success

4.3.4 Degree of Success in Achieving SET Benefits: A Contractor's View

The degree of success in achieving advantages attributed to SET utilization have been assessed by the contractors views. The identification of degree of success is dependent on the firm's view in realizing the various advantages attributed to SET implementation and level of importance associated to SET for project planning and scheduling. More than half of the contractors feel they are very successful, about 45% of the contractors feel moderately successful, and the remaining contracators feel unsuccessful in achieving the advantages attributed to SET utiliztion. At a modestly successful degree, all firms - large, medium and small - agree that CPM is the highest weight of users among the methods and it is surprising to observe that for small firms because CPM applications required advanced technology by the users. Both CPM and GBC techniques have the highest weight of users among the techniques in respect of the three degrees of success. In contrast, the majority of construction firms in the United States who use the CPM technique in their firms feel only moderately successful in realizing the various advantages attributed to CPM application.(20)

The other findings are illustrated in Table 4.23. The peracentages presented there are calculated per users of individual technique and the sum of the total is out of 100. The results among the contractors who feel very successful in realizing the benefits from SET application include that, about 36% of the contractors use CPM, 9.8% of the contractors use PND, 18% of the contractors use PERT and 52.5% of firms use GBC which

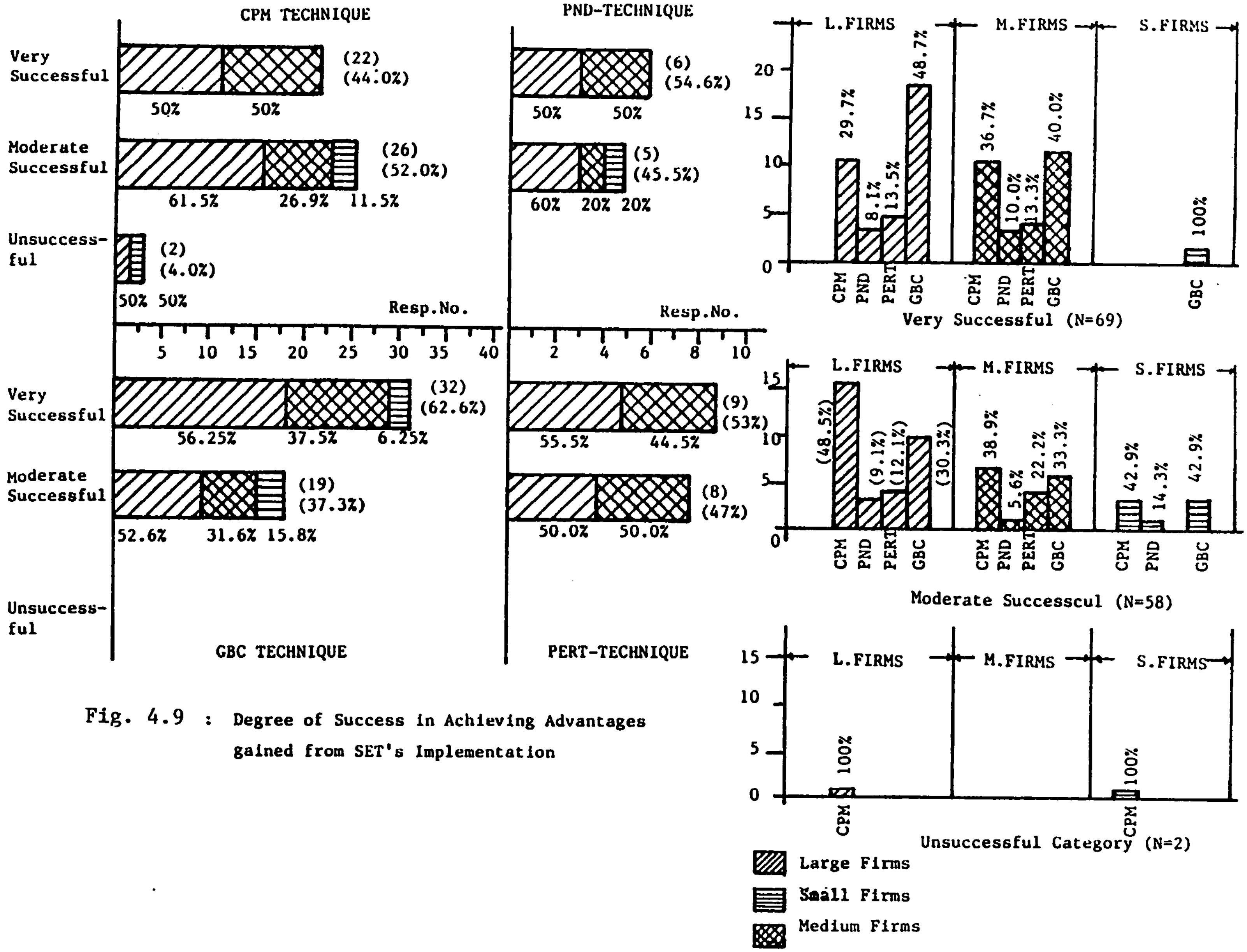


Fig. 4.9 : Degree of Success in Achieving Advantages gained from SET's Implementation

contributes the highest weight. The contractors who feel modestly successful in realizing the various benefits to SET utilization, about 43% of the firms use CPM, 8.2% of the contractors use PND, 13.11% of contractors use PERT, and 31.15% of contractors use GBC.

The last degree which felt unsuccessful in achieving the benefits from SET utilization by contractor was only indicated by two contractors who use CPM only and one contractor in the large class and the other is in the small class. None of the medium contractors feel unsuccessful in realizing the benefits obtained from SET application. Only the users of CPM feel they are unsuccessful in achieving advantages attributed to SET utilization. The graphical representation of the degree of success in achieving advantages from SET implementation are demonstrated in Fig. 4.9.

4.4 Criteria for Successful SET Implementation

The contractors were asked to indicate the criteria by which they measure successful implementation. Distribution of major criteria findings are illustrated in Table 4.24. Some firms cited the whole list of criteria (categories under this factor) to measure the successful use of these methods. Other respondents stated that there are other or "selected" criteria for measuring the success such as defining responsibility and authority, identifying and examining the reality of the project cost, controlling change order, improving communication with client, assuring the client of things happening and narrowing the gap between the estimated and actual execution and vice versa. Adjustment of the planned schedule to actual accomplishment and vice versa and evaluating the alternatives by users is

Table 4.24 : Distribution of Different Criteria for Measuring the Successful Implementation of the SET

SUCCESS CRITERIA (n/%)	LARGE FIRMS				MEDIUM FIRMS				SMALL FIRMS				TOTAL	RANK ORDER
	CPM	PND	PERT	GBC	CPM	PND	PERT	GBC	CPM	PND	PERT	GBC		
Improvement of Planning and Control	8/17.0	1/9.1	3/18.8	8/15.7	4/8.5	1/9.1	3/18.8	5/9.8	3/6.4	0/0.0	0/0.0	3/5.9	39/31.2	1
Defining Cost Saving	0/0.0	1/9.1	1/6.3	0/0.0	1/2.1	0/0.0	1/6.3	2/3.9	0/0.0	0/0.0	0/0.0	0/0.0	6/4.8	6
Improvement of Communication among work force (AWF)	0/0.0	-	-	1/2.0	1/2.1	-	-	0/0.0	0/0.0	-	-	0/0.0	2/1.6	7
Achieving other Benefits	-	-	-	1/2.0	-	-	-	0/0.0	-	-	-	0/0.0	1/0.1	8
Improving planning/ control/define cost saving	7/14.9	1/9.1	1/6.3	2/3.9	5/10.6	1/9.1	2/12.5	2/3.9	1/2.1	1/9.1	0/0.0	1/2.0	24/19.2	3
Define cost saving/ Improving communication (AWF)	3/6.4	1/9.1	2/12.5	5/9.8	2/4.3	1/9.1	0/0.0	1/2.0	0/0.0	0/0.0	0/0.0	1/2.0	16/12.8	4
Improving planning/ control Define cost saving/Improving Communication (AWF)	5/10.6	1/9.1	1/6.3	12/23.5	3/6.4	0/0.0	0/0.0	5/9.8	0/0.0	0/0.0	0/0.0	0/0.0	27/21.6	2
All of the above	2/4.3	1/9.1	0/0.0	0/0.0	2/4.3	1/9.1	2/12.5	2/3.9	0/0.0	0/0.0	0/0.0	0/0.0	10/8.0	5
TOTAL	25/53.2	6/54.6	8/50	29/56.9	18/38.3	4/36.4	8/50	17/33.3	4/8.5	1/9.1	0/0.0	5/9.8		

The Total Response of CPM = 47 The Total Response of PERT = 16
The Total Response of PND = 11 The Total Response of GBC = 51

regarded as a tool for helping in this purpose. About 31% (39 firms) have given improvement of planning and control criteria only. About 22% (27 firms) stated that to measure the successful implementation of the method used in form of improvement of planning and control plus define cost saving and improvement of communication among work forces together. It is surprising that the improvements of communication among work force have the lowest response of 23.11%, while cost saving category is 34.87% because the main important objective of applying these methods in construction is to improve communication among work staff more than cost saving. The majority of firms indicated that improvement of planning and scheduling as one factor for measuring the success of SET implementation (42.02% of respondents) and it carries the highest percentage of response. The second response is to define cost saving (34.87%) and the latter is improvement of communication category.

For measuring rank according to the importance index, all firms agree that defining cost saving is the highest rank, but small and large firms agree on both defining cost saving plus improvement of communication among the work force as the highest ranking. Medium firms gave priority to defining cost saving only in using the CPM technique only. For GBC, all three test groups regarded improvements for planning and control plus defining of cost saving as the highest ranking by all of them. It may be noted that for the PERT technique, defining of cost saving was considered as highly important by large and small firms. For the PND technique, medium and small firms regarded that the improvement of planning and scheduling plus defining of cost saving as the most important

Table 4.25: **Mean Rank of Criteria of Measuring the Successful Implementation of the SET for the three Test Groups according to (IM IND).**

Rank	SET	Categories under the Criteria of Successful	Relative Importance Index(%)
	(Large Firms Rank)		
1	CPM	Def. cost saving & Impr. of Comm. AWF	99.988
2	"	Imp. of Pl., Con., Def. C-S, and Comm.	99.776
3	"	All categories listed under the factor	99.667
4	"	Impr. of Pl. & Con. & Def. cost saving	90.476
5	"	Improvement of planning & control	75.000
1	GBC	Impr. of Pl. & Con. & Def. cost saving	99.952
2	"	Def. cost saving & Impr. of Commun.	99.900
3	"	Imp. of Pl., Con., Def. C-S, and Comm. AWF	99.653
4	"	Improvement of planning & control	87.500
5	"	Impr. of Comm. among work forces	66.667
6	"	Achieved other benefits (a)	66.653
1	PERT	Defining cost saving	99.985
2	"	Impr. of Pl. & Con. & Def. cost saving	99.952
3	"	Def. cost saving & Impr. of Commun.	99.889
4	"	Imp. of Pl., Con., Def. C-S and Comm. AWG	99.778
5	"	Improvement of planning & control	77.778
1	PND	Defining cost saving	99.778
2	"	Impr. of Pl. & Con. & Def. cost saving	99.663
3	"	Def. cost saving & Impr. of Commun.	99.553
4	"	Imp. of Pl., Con., Def. C-S, and Comm.,AWF	99.543
5	"	All categories listed under the factor	99.533
6	"	Improvement of Planning & control	66.667
	(Medium Firms Rank)		
1	CPM	Defining cost saving	99.988
2	"	Impr. of Pl. & Con. & Def. cost saving	99.889
3	"	Def. cost saving & Impr. of Comm. AWF	99.776
4	"	Imp. of Pl., Con., Def. C-S, and Comm. AWF	99.667
5	"	Improvement of planning & control	91.667
1	GBC	Impr. of Pl. & Con. & Def. cost saving	99.889
2	"	Def. cost saving & Impr. of Comm. AWF	99.776
3	"	Imp. of Pl., Con., Def. C-S, and Comm. AWF	99.889
4	"	Defining cost saving	83.333
5	"	Improvement of planning & control	66.667
1	PERT	Defining cost saving	99.952
2	"	Improvement of planning & control	77.778
1	PND	Impr. of Pl. & Con. & Def. cost saving	99.988
2	"	Def. cost saving & Impr. of Comm. AWF	99.776
3	"	All categories listed under the factor	99.667
4	"	Improvement of planning & control	66.667
	(Small Firms Rank)		
1	CPM	Impr. of Pl. & Con. & Def. cost saving	99.952
2	"	Imp. of Pl., Con., Def. C-S, and Comm.	99.552
3	"	All categories listed under the factor	66.667
4	"	Impr. of Comm. among work forces	33.333
1	GBC	Impr. of Pl. & Con. & Def. cost saving	99.988
2	"	Imp. of Pl., Con., Def. C-S, and Comm.	99.886
3	"	All categories listed under the factor	99.553
4	"	Improvement of planning & control	66.667
1	PND	Impr. of Pl. & Con. & cost saving	83.333
2	"	All categories listed under the factor	66.667

Table 4.26 : **Mean Rank of Criteria of Measuring the Successful Implementation of the SET for the three Test Groups according to (SUC IND).**

Rank	SET	Categories under the Criteria of Successful	Relative Success Index(%)
		(Large Firms Rank)	
1	CPM	Def. cost saving & Impr. of Comm. AWF	99.988
2	"	All categories listed under the factor	99.776
3	"	Impr. of Pl. & Con. & Def. cost saving	80.952
4	"	Improvement of planning & control	75.000
5	"	Imp. of Pl., Con., Def. C-S, and Comm. AWF	73.333
1	GBC	Achieved other benefits (a)	99.958
2	"	Def. cost saving & Impr. of Comm. AWF	99.776
3	"	Imp. of Pl., Con., Def. C-S, and Comm. AWF	87.879
4	"	Improvement of planning & control	83.333
5	"	Impr. of Pl. & Con. & cost saving	83.222
6	"	Impr. of Comm. among work forces	66.667
1	PFPT	Defining costr saving	99.879
2	"	Impr. of Pl. & Con. & Def. cost saving	99.885
3	"	Def. cost saving & Impr. of Comm. AWF	99.776
4	"	Improvement of planning & control	77.778
5	"	Imp. of Pl., Con., Def. C-S, and Comm.AWF	66.667
1	PND	Defining cost saving	99.988
2	"	Def. cost sa ing & Impr. of Comm. AWF	99.776
3	"	All categories liste under the factor	99.063
4	"	Improvement of planning & control	66.667
5	"	Impr. of Pl. & Con., Def. cost saving	66.556
6	"	Imp. of Pl., Con., Def. C-S, and Comm. AWF	66.333
		(Medium Firms Rank)	
1	CPM	Defining cost saving	99.988
2	"	Impr. of Pl. & Def. Cost saving	99.952
3	"	Def. cost saving & Impr. of commun.	99.776
4	"	Improvement of Plannin control	91.667
5	"	Imp. of Pl., Con., Def. C-S, and Comm. AWF	66.567
1	GBC	Improvement of planning & control	99.778
2	"	Impr. of Pl. & Con. & Def. cost saving	99.663
3	"	Def. cost saving & Impr. of Commun.	99.83
4	"	Imp. of Pl., Con., Def. C-S, and Comm. AWF	88.889
5	"	Defining cost saving	88.333
1	PFPT	Improvement of planning & control	88.889
2	"	Defining cost saving	66.667
1	PND	Impr. of Pl. & Def. cost saving	99.889
2	"	Def. cost sa ing & Impr. of Comm.AWF	99.776
3	"	All categories listed under the factor	99.665
4	"	Improvement of planning & control	66.667
		(Small Firms Rank)	
1	CPM	Impr. of Pl. & Con. & Def. cost saving	83.333
2	"	Imp. of Pl., Con., Def. C-S, and Comm. AWF	83.222
3	"	Impr. of Comm. among work forces	66.667
4	"	All categories listed under the factor	66.567
1	GBC	Impr. of Pl. & Con. & Def. cost saving	99.889
2	"	All categories listed under the factor	99.776
3	"	Imp. of Pl., Con., Def. C-S, and Comm.	83.333
4	"	Improvement of planning & control AWF	66.667
1	PND	Impr. of Pl. & Con. & Def. cost saving	99.985
2	"	All categories listed under the factor	66.667

among the other categories, but large firms regarded defining cost saving category as the highest. It is surprising that they did not regard the improvement of planning and control with it. The rest of the factor categories importance indices are shown in Table 4.25.

Success indices for measuring the same successful criteria are illustrated in Table 4.26. Only large firms regarded the improvement of communication among work forces as having the highest importance. All of the firms agreed on the primary importance of defining cost saving, but small firms added another factor which is the improvement of planning and scheduling; this latter is for the CPM technique. For the GBC technique, large firms are different from the other two groups and for small firm improvement of planning and control as important as defining cost saving. For the PERT method, defining of cost saving category reserved the highest rank by large firm, while improvement of planning and scheduling has the first important rank by medium groups. Small and medium firms agreed to the priority of improvement of planning and control plus cost saving and it carries the highest index, but large firms regarded defining cost saving as of the highest importance. By all firms (as shown in Table 4.27) for CPM, PERT and PND, the defining of cost saving categories have the first importance; for GBC all firms added another category which is improvement of communication among work force. The success indices of all firms are shown in Table 4.28. The results that follow in a later section are based on reasons of success should be viewed with these facts in mind.

Table 4.27: **Mean Rank of Criteria of Measuring the Successful Implementation of the SET for the Total Surveyed Population according to (IM IND).**

Rank	SET	Categories under the Criteria of Successful	Relative Importance Index(%)
1	CPM	Defining cost saving	99.985
2	"	Def. cost saving & Impr. of Commun. AWF	99.952
3	"	Imp. of Pl., Con., Def. C-S, and Comm.	99.889
4	"	Impr. of Pl. & Con. & Def. cost saving	94.872
5	"	All categories listed under the factor	83.333
6	"	Improvement of planning & control	82.222
7	"	Impr. of Comm. among work forces	33.333
1	GBC	Def. cost saving & Impr. of Commun.	99.778
2	"	All categories listed under the factor	99.667
3	"	Imp. of Pl., Con., Def. C-S, and Comm.	97.917
4	"	Imp. of Pl. & Con. & Def. cost saving	93.333
5	"	Defining cost saving	83.333
6	"	Improvement of planning & control	81.250
7	"	Impr. of Comm. among work forces	66.667
8	"	Achieved other benefits (a)	66.557
1	PERT	Defining cost saving	99.667
2	"	Def. cost saving & Impr. of Comm. AWF	99.563
3	"	Imp. of Pl., Con., Def. C-S, and Comm. AWF	99.553
4	"	Impr. of Pl. & Con. & Def. cost saving	88.889
5	"	Improvement of planning & control	77.778
6	"	All categories listed under the factor	66.667
1	PND	Defining cost ssaving	99.952
2	"	Def. cost saving & Impr. of Comm. AWF	99.889
3	"	Imp. of Pl., Con., Def. C-S, and Comm. AWF	99.776
4	"	All categories listed under the factor	99.553
5	"	Impr. of Pl. & Con. & Def. cost saving	88.889
6	"	Improvement of planning & control	66.667

Where:
- (Def) = Defining
- (Impr) = Improvement
- (Con) = Control
- (C-S) = Cost Saving
- (Comm) = Communication
- (A.W.F.) = Among Work Force

(a) Other benefits such as :
- define responsibility and authority
- Control over change order.
- Adjusted planned to actual.
- Tool of evaluation of the alternatives.
- Clear gap between the estimated to actual.
- Imp. Comm. with client...etc.

Table 4.28 : **Mean Rank of Criteria of Measuring the Successful Implementation of the SET for the Total Surveyed Population according to (SUC IND).**

Rank	SET	Categories under the Criteria of Successful	Relative Success Index(%)
1	CPM	Defining cost saving	99.985
2	"	Def. cost saving & Impr. of Comm. AWF	99.889
3	"	Impr. of Pl. & Def. cost saving	84.615
4	"	All categories listed under the factor	83.333
5	"	Improvement of planning & control	75.556
6	"	Imp. of Pl., Con., Def. C-S, and Comm. AWF	75.000
7	"	Impr. of Comm. among work forces	66.667
1	GBC	Achieved other benefits (a)	99.776
2	"	All categories listed under the fa^tor	99.665
3	"	Def. cost saving & Impr. of comm. AWF	94.444
4	"	Imp. of Pl., Con., Def. C-S,and Comm. AWF	87.500
5	"	Impr. of Pl. & Con. & Def. cost saving	86.667
6	"	Improvement of planning & control	85.417
7	"	Defining cost saving	83.333
8	"	Impr. of Comm. among work forces	66.667
1	PERT	Impr. of Pl. & Con. & Def. cost saving	99.667
2	"	Def. cost saving & Impr. of Comm. AWF	99.553
3	"	Improvement of planning & control	83.333
4	"	Defining cost saving	83.333
5	"	Imp. of Pl., Con., Def. C-S, an Comm. AWF	66.667
6	"	All categories listed under the factor	66.667
1	PND	Definin cost saving	99.889
2	"	Def. cost saving & Impr. of Comm. AWF	99.776
3	"	All categories listed under the factor	99.663
4	"	Impr. of Pl. & Con. &Def. cost saving	77.778
5	"	Improvement of Planning & control	66.667
6	"	Imp. of Pl., Con., Def. C-S, and Comm. AWF	66.553

Where:
(Def) = Defining
(Impr) = Improvement
(Con) = Control
(C-S) = Cost Saving
(Comm) = Communication
(A.W.F.) = Among Work Force

(a) Other benefits such as :
- define responsibility and authority
- Control over change order.
- Adjusted planned to actual.
- Tool of evaluation of the alternatives.
- Clear gap between the estimated to actual.
- Imp. Comm. with client...etc.

The agreement between all sized contractors have been measured by using the three correlation coefficients. The highest average correlation coefficient between groups for the Spearman correlation is "the criteria of success" which is $r_s\overline{X}$ (criteria) = 94.67%. For multiple correlations, the highest average is for the factor "measuring success", is $r_M\overline{X}$ (criteria) = 96.00%. For partial correlation the value is $r_p\overline{X}$ (criteria) = 48.00%. The highest average ratio among them indicate a high degree of agreement between different parties. The computation of Spearman ranks correlations of criteria of measuring successful SET application are shown in Appendix B - Table B-3. The graphical representation of the results related to the above factor are illustrated in Appendix - B Figures B-7, 8 and 9.

4.4.1 Success Factors of SET Implementation

One of the objectives of this study is to attempt to identify contractors which have "very successful" utilization of the methods and to pinpoint the reasons why. The respondents were asked to indicate the major reasons for success. In this case, the reason most often cited was "good top management plus good training of personnel plus good computer programs". Also, good top management support came in a close second. All of categories listed under the factor of causes of success was coming the third frequent category. The fourth is the good support for personnel using the system. Some respondents added under the "other" categories some reasons of success such as obtaining good support from a bank

Table 4.29 : Distribution by Size of Firms and Reasons of Success Through Implementation of the SET

REASONS OF SUCCESS (n/%)	LARGE FIRMS				MEDIUM FIRMS				SMALL FIRMS				TOTAL	RANK ORDER
	CPM	PND	PERT	GBC	CPM	PND	PERT	GBC	CPM	PND	PERT	GBC		
Good Top Management Support	7/14.3	1/8.3	3/17.7	5/10.0	6/12.2	0/0.0	2/11.8	5/10.0	2/4.1	0/0.0	0/0.0	3/6	34/26.6	2
Good Training of Personnel	1/2.0	1/8.3	1/5.9	3/6	0/0.0	0/0.0	0/0.0	0/0.0	0/0.0	0/0.0	0/0.0	0/0.0	6/9.7	6
Good support for personnel using the system	3/6.1	-	1/5.9	5/16	1/2.0	-	1/5.9	1/2.0	1/2.0	-	0/0.0	1/2	14/10.9	4
Good computer program	-	-	-	1/2.0	-	-	-	0/0.0	-	-	-	0/0.0	1/0.8	8
Other Reasons	0/0.0	-	1/5.9	1/2.0	1/2.0	-	0/0.0	0/0.0	0/0.0	-	0/0.0	0/0.0	3/2.3	7
Good top management/ training/computer	9/18.4	3/25	2/11.8	9/18	4/8.2	1/8.3	2/11.8	6/12.0	1/2.0	1/8.3	0/0.0	1/2.0	39/30.5	1
Good training and support for personnel	2/4.1	0/0.0	1/5.9	1/2	2/4.1	1/8.3	1/5.9	1/2.0	0/0.0	0/0.0	0/0.0	0/0.0	9/7	5
All of the above	5/10.2	2/16.7	0/0.0	2/4	4/8.2	2/16.7	2/11.8	5/10.0	0/0.0	0/0.0	0/0.0	0/0.0	22/17.2	3
TOTAL	27/55.1	7/58.3	9/52.9	27/54	18/36.7	4/33.3	8/47.1	18/36	4/8.2	1/8.3	0/0.0	5/10		

Total CPM Respondents = 49 Total PERT Respondents = 17
Total PND Respondents = 12 Total GBC Respondents = 50

(financial improvements), good support from suppliers, and using field proven program. The distribution of respondents associated with each category is illustrated in Table 4.29.

Clients and contractors should fully know the method which is to be used and have a deep understanding of what is required for such methods. Some respondents blamed the procedure of the techniques themselves. The results of this examination and opinions mentioned by the firms tend to support top management's views about what is actually happening with the other managers when applying SET in their firms. Large firms ranked "Good training of personnel" as the highest importance for both CPM and GBC, while ranking "good top management support" as the first importance for both PERT and PND. Medium firms regarded "good support for personnel" as the first degree for all methods except PND. All the three test groups differs from each other for reason of success per each method except only large and small firms agree only of the categories which occupied the first rank "good top management support" for PND method.

The presentation of both the mean rank for reasons of success according to importance and success indices are shown in Tables 4.30 and 4.31 respectively. All the respondents agreed on that "good training of personnel" has the first importance for CPM, PERT and GBC and it is not found significant for the PND technique. On the other hand, according to the success index analysis, all firms agreed on that "Good top management support" is the first degree for PERT and PND methods. The importance

Table 4.30: **Mean Rank for Reasons of Success of SET Implementation by the Three Test Groups according to Importance Index.**

Rank	SET	Categories under the Reasons of Success	Relative Importance Index (%)
	(Large Firms Rank)		
1	CPM	Good training of personnel	99.952
2	"	Good top Manag.,Tra. & support of Peer.	99.667
3	"	All categories listed under the factor	93.333
4	"	Good top management support	90.476
5	"	Good training & support of personnel	83.333
6	"	Good support for Pers. using system	77.778
7	"	Good top Manag., Tra. & Comp. program	75.000
1	GBC	Good training of personnel	99.889
2	"	Other reasons	99.776
3	"	All categories listed under the factor	99.558
4	"	Good training & support of personnel	99.536
5	"	Good top Manag., Tra. & support of Per.	95.238
6	"	Good top management support	93.663
7	"	Good support for Pers. using system	93.333
9	"	Good computer program	66.667
1	PEPT	Good top management support	99.667
2	"	Good support for pers. using system	99.665
3	"	Other reasons	99.555
4	"	Good training & support of personnel	99.500
5	"	Good topManag., Tra. & Comp. program	83.333
6	"	Good training of personnel	66.667
1	PND	Good top management support	99.952
2	"	All categories listed under the factor	99.889
3	"	Good top Manag.,Tra. & Com. Program	88.889
	(Medium Firms Rank)		
1	CPM	Good support for Pers. using system	99.952
2	"	Other reasons	99.888
3	"	Good top Manag., Tra. & Co p. program	99.776
4	"	Good top Manag., Tra. & support of Per.	99.667
5	"	All categories listed under the factor	99.556
6	"	Good training & support of personnel	99.535
7	"	Good top management support	88.889
1	GBC	Good support for Pers. using system	99.889
2	"	Good top Manag., Tra. & Comp. program	99.776
3	"	All categories listed under the factor	99.667
4	"	Good training & support of personnel	99.556
5	"	Good top management support	66.667
6	"	Good top Manag., Tra. & Support of Per.	50.000
1	PEPT	Good support for Pers. using system	99.950
2	"	All categories listed under the factor	99.555
3	"	Good top management support	66.667
4	"	Good top Manag., Tra. & Comp. program	66.333
1	PND	All categories listed under the factor	99.667
2	"	Good training & support of personnel	99.533
3	"	Good top Manag., Tra. & Comp. program	66.667
	(Small Firms Rank)		
1	CPM	Good top Manag., Tra. & support of Peer.	83.667
2	"	All categories listed under the factor	83.333
3	"	Good top management support	77.778
1	GBC	All categories listed under the factor	99.889
2	"	Good top management support	88.889
3	"	Good top Manag., Tra. & support of Per.	66.667
1	PND	Good top management support	99.889
2	"	Good top Manag., Tra. & support of Per.	66.667
3	"	All categories listed under the factor	66.657
4	"	Good Training & support of personnel	66.647

Table 4.31:Mean Rank for Reasons of Success of SET Implementation by the Three Test Groups according to Success Index.

Pank	SFT	Categories under the Peasons of Success	Pelative Succeess Index (%)
		(Large Firms Pank)	
1	CPM	Good top Manag., Tra. & supportk of Per.	99.889
2	"	Good top management support	90.476
3	"	Good top Manag., Tra. & Comp. program	75.000
4	"	All categories listed under the factor	73.333
5	"	Good training of personnel	66.667
6	"	Good support for Pers. using system	66.383
7	"	Good training & support of personnel	50.000
1	GBC	Other reasons	99.952
2	"	All categories listed under the factor	99.889
3	"	Good top management support	93.333
4	"	Good top Manag., Tra. & support of Per.	90.476
5	"	Good training of personnel	88.889
6	"	Good support for Pers. using system	86.667
7	"	Good top Manag., Tra. & Comp. program	83.333
8	"	Good computer program	66.667
9	"	Good training & support of personnel	66.333
1	PERT	Good top management support	99.667
2	"	Other reasons	99.553
3	"	Good top Manag., Tra. & Comp. program	99.500
4	"	Good training of personnel	66.667
5	"	Good support for Pers. using system	66.557
6	"	Good training & support of personnel	66.833
1	PND	Good top management support	49.952
2	"	Good top Manag., Tra. & Comp. Program	83.667
3	"	All categories listed under the factor	83.333
		(Medium Firms Rank)	
1	CPM	Good support for Pers. using system	99.952
2	"	Other reasons	99.889
3	"	Good top Manag., Tra. & Comp. program	99.776
4	"	Good top Manag.,Tra. & support of Per.	40.667
5	"	All categories listed under the factor	99.556
6	"	Good top management support	88.889
7	"	Good training & support of personnel	83.333
1	GPC	Good top management support	99.889
2	"	Good support for Pers. using system	99.776
3	"	All categories listed under the factor	99.667
4	"	Good training & support of personnel	99.553
5	"	Good top Manag., Tra. & Comp. program	83.667
6	"	Good top Manag., Tra. & support of Per.	83.333
1	PERT	Good top management support	99.889
2	"	All categories listed under the factor	99.667
3	"	Good support for Pers. using system	66.667
4	"	Good top Manag., Tra. & Comp. program	66.333
1	PND	All categories listed under the factor	99.889
2	"	Good training & support of personnel	99.776
3	"	Good top Manag., Tra. & Comp. program	66.667
		(Small Firms Fank)	
1	CPM	All categories listed under the factor	83.333
2	"	Good top management support	77.778
3	"	Good top Manag., Tra. & support of Per.	66.667
1	GPC	All categories listed under the factor	99.952
2	"	Good top management support	77.778
3	"	Good top Manag., Tra. & support of Per.	66.667
1	PND	Good top management support	99.667
2	"	Good training & support of personnel	99.556
3	"	Good top Manag., Tra. & support of Per.	66.667
4	"	All categories listed under the factor	66.333

Table 4.32: Mean Rank for Reasons of Successful of the SET Implementation of the Total Surveyed Population according to both (IM IND) & (SUC IND)

Rank	SET	Categories under the Reasons of Success	IM IND (%)
1	CPM	Good training of personnel	99.952
2	"	Other reasons	99.889
3	"	Good top Manag., Tra. & support of Per.	94.444
4	"	All categories listed under the factor	92.593
5	"	Good training & support of personnel	91.667
6	"	Good top management support	86.667
7	"	Good support for Pers. using system	86.553
8	"	Good top Manag., Tra. & Comp. program	83.333
1	GBC	Good training of personnel	99.889
2	"	Other reasons	99.818
3	"	All categories listed under the factor	99.776
4	"	Good training & support of personnel	99.667
5	"	Good support for Pers. using system	95.238
6	"	Good top Manag., Tra. & Comp. program	93.238
7	"	Good top management support	87.179
8	"	Good top Manag., Tra. & support of Per.	81.818
9	"	Good computer program	66.667
1	PERT	Good support for Pers. using system	99.952
2	"	Other reasons	99.889
3	"	Good top management support	91.667
4	"	All categories listed under the factor	83.667
5	"	Good training & support of personnel	83.333
6	"	Good top Manag., Tra. & Comp. program	77.778
7	"	Good training of personnel	66.667
8	"	Good top Manag., Tra. &support of Per.	66.333
1	PND	Good top management support	99.776
2	"	All categories listed under the factor	99.667
3	"	Good training & support of personnel	99.553
4	"	Good top Manag., Tra. & Comp. program	80.000
			SUC IND (%)
1	CPM	Other reasons	99.952
2	"	Good top Manag., Tra. & support of Per.	88.889
3	"	Good top management support	82.222
4	"	All categories listed under the factor	81.481
5	"	Good top Manag., Tra. & Comp. program	77.778
6	"	Good support for Pers. using system	73.333
7	"	Good training of personnel	66.667
8	"	Good training & support of personnel	66.333
1	GBC	Other reasons	99.889
2	"	All categories listed under the factor	99.776
3	"	Good top management support	89.744
4	"	Good training kof personnel	88.889
5	"	Good support for Pers. using system	85.714
6	"	Good top manag., Tra. & support of Per.	84.048
7	"	Good Training & support of personnel	83.333
8	"	Good top Manag., Tra. & Comp. program	80.000
9	"	Good computer program	66.667
1	PERT	Good top management support	99.952
2	"	Other reasons	99.889
3	"	Good top Manag., Tra. & Comp. program	88.889
4	"	All categories listed under the factor	83.667
5	"	Good training & support of personnel	83.333
6	"	Good training of personnel	66.667
7	"	Good support for Pers. using system	66.556
8	"	Good top Manag., Tra. & support of Per.	66.533
1	PND	Good top management support	99.776
2	"	Good training & support of personnel	99.535
3	"	All categories listed under the factor	91.667
4	"	Good top Manag., Tra. & Comp. program	75.000

and success indices of all categories associated with each method were illustrated in Table 4.32.

The correlation results have been obtained by using the Spearman, partial and multiple correlations. The average agreement between all sized firms for success factors of SET implementation are, $r_s \overline{X}$ (success factors) $= 92\%$, $r_p \overline{X} = 46\%$, and $r_m \overline{X} = 95\%$. The second highest average ratio of the partial correlation is the average of success factors of SET implementation among the other factors tested. The computation of Spearman ranks correlations of success factors are shown in Appendix B - Table B-4. The schematic representation of the results of the three types of correlation ratios associated with the above factor are demonstrated in Appendix B - Figures B-10, 11, and 12.

4.4.2 Factors for SET Spurious Application

The participating contractors assessed the reasons behind the poor utilization of the SET techniques for planning and scheduling. The results indicate that, about 24% thought that the reasons for failure is the "lack of top management support". About 20% of the respondents indicated "all of the factors". A small number of respondents regarded poor computer programs and poor training of personnel as the lowest responses and 20.90% of firms listed other reasons such as the need for specialized persons to use the system, using a complicated program which is not field proven, needing more complicated assumptions, and the difficulty of both parties to understand the technique and procedures. One of the key bits of

Table 4.33: Distribution by Size of Firms and Reasons of Failure through Implementation of the SET

REASON ON FAILURE (n/%)	LARGE FIRMS				MEDIUM FIRMS				SMALL FIRMS				TOTAL	RANK ORDER
	CPM	PND	PERT	GBC	CPM	PND	PERT	GBC	CPM	PND	PERT	GBC		
Lack of Top Management support	7/16.3	1/10.0	3/18.8	3/7.3	5/11.6	2/12.5	2/12.5	3/7.3	1/2.3	0/0.0	0/0.0	1/2.4	26/23.6	1
Lack of support from people	4/9.3	-	-	5/12.2	1/2.3	-	-	2/4.9	1/2.3	-	-	2/4.9	15/13.6	4
Poor training of personnel	1/2.3	-	0/0.0	2/4.9	0/0.0	1/6.3	1/6.3	0/0.0	1/2.3	-	0/0.0	2/4.9	7/6.4	6
Poor computer program and poor training of personnel	-	0/0.0	-	-	-	-	-	-	-	1/10.0	-	-	1/0.9	7
Other Reasons	4/9.3	3/30.0	3/18.8	3/7.3	3/7.0	2/12.5	2/12.5	3/7.3	0/0.0	0/0.0	0/0.0	0/0.0	23/20.9	2
Lack of support and poor training	1/2.3	-	1/6.3	3/7.3	0/0.0	1/6.3	1/6.3	2/4.9	0/0.0	-	0/0.0	0/0.0	8/7.3	5
Lack of top management/poor training	1/2.3	1/10.0	1/6.3	0/0.0	6/7.0	0/0.0	0/0.0	1/2.4	1/2.3	0/0.0	0/0.0	0/0.0	8/7.3	5
All of the above	5/11.6	0/0.0	0/0.0	4/9.8	4/9.3	2/20.0	2/12.5	5/12.2	0/0.0	0/0.0	0/0.0	0/0.0	22/20	3
TOTAL	23/53.5	5/50	8/50	20/48.8	16/37.2	4/40	8/50	16/39.0	4/9.3	1/10.0	0/0.0	5/12.2		

The Total Responses of CPM = 43 The Total Responses of PERT = 16
The Total Responses of PND = 10 The Total Responses of GBC = 41

information added one major reason of lack of success, being that operations people do not want to train for the use of these systems. The distribution of respondents associated with each category is illustrated in Table 4.33. It is interesting to observe that lack of support from people plus poor training of personnel seems to be an important factor for large and small firms who use the CPM method, yet it is not given much importance by medium firms. Also, large and small firms regarded lack of top management support as the first degree factor in the GBC method, where it is ranked in second place by medium firms. None of the firms agreed on the first rank for PERT or PND. The mean value rank of reasons of failure is shown in Tables 4.34 and 4.35. As for as the factor is concerned, it may be noted that there is agreement between the test groups when the ranking is done according to the success index.

For CPM and GBC techniques, "lack of support of personnel and poor training of personnel" category occupied the highest rank by all firms. Poor training of personnel only got the first rank by all the firms for PERT, while the first place rank for PND by all firms is the lack of top management support. Consequently, the results of the mean values of rank according to the success index shows that both CPM and GBC have the same factor on the important index, and PERT plus GBC stated that lack of top management support which has the primary reason for failure. The importance and success indices which are ranked by all firms are illustrated in Table 4.36.

The agreement between the three sized groups which have been

Table 4.34: Mean Rank for Reasons of Failure of the SET Implementation of the three Test Groups according to importance Index.

Rank	SET	Categories under the Reasons of Failure	Relative Importance Index (%)
(Large Firms Rank)			
1	CPM	Lack of Sup. F. Peo. & Po-Tr. of Per.	99.952
2	"	Lack of top Mgt. Sup. & Po-Tra. of Per.	99.889
3	"	Lack of top management support	95.238
4	"	All categories listed under the factor	93.333
5	"	Other reasons	91.667
6	"	Lack of Support from people	66.667
7	"	Poor training of personnel	66.333
1	GBC	Lack of Top management support	99.667
2	"	Lack of Sup. F. Peo. & PO-Tra. of Per.	99.553
3	"	All categories listed under the factor	99.533
4	"	Lack of support from people	93.333
5	"	Other reasons	88.889
6	"	Poor training of personnel	83.333
1	PERT	Lack of Sup. F. Peo. & PO-Tra. of Per.	99.889
2	"	Lack of Top Management support	88.889
3	"	Other reasons	88.667
4	"	Lack of top Mgt. Sup. & PO-Tra. of Per.	66.667
1	PND	Lack of top management support	99.889
2	"	Lack of top Mgt. Sup. & PO-Tra. of Per.	99.776
3	"	Other reasons	88.889
(Medium Firms Rank)			
1	CPM	Other reasons	99.889
2	"	Lack of top Mgt. Sup. & PO-Tra. of Per.	99.776
3	"	All categories listed under the factor	99.667
4	"	Lack of top management support	91.667
1	GBC	Lack of Sup. F. Peo. & PO-Tra. of Per.	99.952
2	"	Lack of top Mgt. Sup. & PO-Tra. of Per.	99.889
3	"	All categories listed under the factor	99.776
4	"	Lack of top management support	83.667
5	"	Othr reasons	83.333
6	"	Lack of support from people	50.000
1	PERT	Poor training of personnel	99.776
2	"	All categories listed under the factor	99.667
3	"	Lack of top mana ement support	66.667
4	"	Other reasons	66.333
1	PND	All categories listed under the factor	99.889
2	"	Other reasons	83.333
(Small Firms Rank)			
1	CPM	Lack of Sup. F. Peo. & PO-Tra. of Per.	99.532
2	"	Lack of top Mgt. Sup. & PO-Tra. of Per.	99 500
3	"	Lack of top management support	95.238
4	"	All categories listed under the factor	93.333
5	"	Other reasons	91.667
6	"	Lack of support from people	66.667
7	"	Poor training of personnel	66.333
1	GBC	Lack of top management support	99.889
2	"	Lack of Sup. F. Peo. & PO-Tra. of Per.	99.776
3	"	All categories listed under the factor	99.667
4	"	Lack of support from people	93.333
5	"	Other reasons	88.889
6	"	Poor training of personnel	83.333
1	PND	Lack of Sup. F. Peo. & PO-Trea. of Per.	99.776
2	"	Lack of top management support	88.889
3	"	Other reasons	88.667
4	"	Lack of top Mgt. Sup. & PO-Tra. of Per.	66.667

Table 4.35: Mean Rank for Reasons of Failure of the SET Implementation of the three Test Groups according to Success Index.

Rank	SET	Categories under the Reasons of Failure	Relative Success Index (%)
		(Large Firms Rank)	
1	CPM	Lack of top Mgt. Sup. & PO-Tra. of Per.	99.889
2	"	Lack of top management support	85.714
3	"	Lack of support from people	75.333
4	"	Other reasons	75.000
5	"	All categories listed under the factor	73.333
6	"	Poor training of personnel	66.667
7	"	Lack of Sup. F. Peo. & PO-Tra. of Peer.	66.333
1	GBC	All categories listed under the factor	91.667
2	"	Lack of top management support	88.889
3	"	Other reasons	88.667
4	"	Lack of support from people	86.667
5	"	Poor training of personnel	83.333
6	"	Lack of Sup. F. Peo. & PO-Tra. of Per.	77.778
1	PERT	lack of top management support	88.889
2	"	Other reasons	88.667
3	"	Lack of Sup. F. Peo. & PO-Tra. of Per.	66.667
4	"	Lack of top Mgt. Sup. & PO-Tra. of Per.	66.333
1	PND	Lack of top management support	99.952
2	"	Lack of top Mgt. Sup. & PO-Tra. of Per.	99.889
3	"	Other Reasons	83.333
		(Medium Firms Rank)	
1	CPM	Lack of top Mgt. Sup. & PO-Tra. of Per.	99.776
2	"	All categories listed under the factor	99.667
3	"	Lack of top management support	91.667
4	"	Other reasons	83.333
1	GBC	Lack of top management support	99.957
2	"	Lack of support from people	49.889
3	"	Lack of Sup. F. Peo. & PO-Tra. of Per.	99.776
4	"	Lack of top Mgt. Sup. & PO-Tra. of Per.	99.667
5	"	All categories listed under the factor	99.553
6	"	Other reasons	66.667
1	PERT	Lack of top management support	99.889
2	"	All categories listed under the factor	99.776
3	"	Poor training of personnel	66.667
4	"	Other reasons	66.833
1	PND	All categories listed under the factor	99.952
2	"	Other reasons	83.333
		(Small Firms Rank)	
1	CPM	Lack of top Mgt. Sup. & PO-Tra. of Per.	99.952
2	"	Lack of top management support	85.714
3	"	lack of support from people	75.333
4	"	Othewr reasons	75.000
5	"	All categories listed under the factor	73.333
6	"	Poor training of personnel	66.667
7	"	Lack of Sup. F. Peo.& PO-Tra. of Per.	66.333
1	GBC	All categories listed under the factor	91.667
2	"	Lack of top management support	88.889
3	"	Other reasons	88.667
4	"	Lack of support from people	86.667
5	"	Poor training of personnel	83.333
6	"	Lack of Sup. f. Peo. & PO-Tra. of Per.	77.778
1	PND	Lack of top management support	88.889
2	"	Other reasons	88.667
3	"	Lack of Sup. F. Peo. & PO-Tra. of Per.	66.667
4	"	Lack of top Mgt. Sup. & PO-Tra. of Per.	66.333

Table 4.36: Mean Rank for Reasons of Failure of the SET Implementation of the Total Surveyed Population according to both (IM IND) & (SUC IND)

Rank	SET	Categories under Reasons of Failure	IM IND (%)
1	CPM	Lack of Sup. F. Peo. &PO-Tra. of Per.	99.889
2	"	Lack of top management support	94.872
3	"	All categories listed under the factor	92.593
4	"	Other reasons	90.476
5	"	Lack of support from people	66.667
6	"	Poor training of personnel	66.333
1	GBC	Lack of top Mgt. Sup. & PO-Tra. of Per.	99.889
2	"	All categories listed under the factor	99.776
3	"	Lack of top management support	95.238
4	"	Lack of Sup. F. Peo. & PO-Tra. of Per.	93.333
5	"	Lack of support from people	85.185
6	"	Other reasons	83.333
7	"	Poor training of personnel	77.778
8	"	Poor training of Per. & Cop. program	66.667
1	PERT	Poor training of personnel	99.952
2	"	Lack of top management support	86.667
3	"	Lack of Sup. F. Peo. & PO-Tra. of Per.	83.667
4	"	All categories listed under the factor	83.333
5	"	Other reasons	80.000
6	"	Lack of top Mgt. Sup. & PO-Tra. of Per.	66.667
1	PND	Lack of top management support	99.776
2	"	Lack of top Mgt. Sup. & PO-Tra. of Per.	99.667
3	"	All categories listed under the factor	99.553
4	"	Other reasons	86.667
5	"	Poor training of Per. & Cop. program	66.667
			SUC IND (%)
1	CPM	Lack of top Mgt. Sup. & PO-Tra. of Per.	93.333
2	"	Lack of top management support	87.179
3	"	All categories listed under the factor	77.778
4	"	Other reasons	76.190
5	"	Lack of support from people	72.222
6	"	Lack of Sup. F. Peo. & PO-Tra. of Per.	66.667
7	"	Poor training of personnel	50.000
1	GBC	Lack of top Mgt. Sup. & PO-Tra. of Per.	99.952
2	"	All categories listed under the factor	92.593
3	"	Lack of Top management support	90.476
4	"	Lack of support from people	88.889
5	"	Poor training of personnel	88.667
6	"	Lack of Sup. F. Peo. & PO-Tra. of Per.	80.000
7	"	Other reasons	77.778
8	"	Poor training of Per. & Cop. program	66.667
1	PERT	Lack of top management support	93.333
2	"	Lack of Sup. F. Peo. & PO-Tra. of Per.	83.667
3	"	All categories listed under the factor	83.333
4	"	Other reasons	80.000
5	"	Poor training of personnel	66.667
6	"	Lack of top Mgt. Sup. & PO-Tra. of Per.	66.333
1	PND	Lack of top management support	99.889
2	"	Lack of top Mgt. Sup. & PO-Tra. of Per.	99.667
3	"	All categories listed under the factor	99.553
4	"	Other reasons	83.333
5	"	Poor training of Per. & Cop. program	66.667

measured by the three types of correlations which include Spearman, partial and multiple correlations. The average agreement between all sized contractors for factors spurious SET application are $r_s \overline{X}$ (factors of failure) = 93%, $r_p \overline{X}$ = 49%, and $r_m \overline{X}$ = 89%. The first highest average agreement among the other factors of the partial correlation is the one of the factors of spurious SET application. This indicates a clearer agreement between parties than the other. The computation of Spearman ranks correlation of factors of spurious SET application are illustrated in Appendix B - Table B-5. The graphical representation of the above factors results are shown in Appendix B - Figures B-13, 14 and 15.

4.5 Hypothesis Testing of the Significance of the Correlation Coefficient Ratio r

The correlation coefficients tested here includes Pearson, Spearman, partial and multiple correlations. The statistical test used here is the t-test through the three sized contractors indicating the significance of the relationship between two parties. It used to find out among the three groups who generally agree on the importance index of categories under each factor per technique, which have been analyzed earlier.

The hypothesis will be tested by comparing the calculated value of t with the critical test value. The obtained r is merely a chance deviation in the sampling distribution in which the population R is zero (H_o: R = 0). It is defined as the ratio of a deviation to a standard deviation. The standard error of the mean or the (r) which is obtained by using the following formula :

$$S_{ro} = \frac{\sqrt{1-r_s^2}}{\sqrt{N-2}} \tag{4.1}$$

$$t = \frac{r - \rho}{S_r} \tag{4.2}$$

Where:

S_{ro} = Standard error when R is assumed to be zero.

N = Number of pairs used in computing r.

ρ = The population correlation which has zero value as stated by the null hypothesis.

Thus,

$$S_r \frac{\sqrt{1 - (0.889)^2}}{\sqrt{23 - 2}} = 0.09994$$

$$t_{cal} \frac{0.884}{0.0999} = 8.845$$

t_{table} = 2.069 (from t table for α = 0.05,

d_f = N-2 = 23-2 = 21 and a two tailed test.

Hypothesis:

H_o = The test groups do not agree on the importance index rank of the categories per factor.

H_1 = The test groups agree on the importance index rank.

This test is most suitable when N is large. Generally, the hypothesis will be tested by comparing the calculated value of t with the critical test values. The null hypothesis states that the value of R is equal to zero. The degree of freedom is (N-2); significance is set at the 5 percent level. The null states that no correlation exists between the test groups, which means that they do not agree on the importance index rank of all categories under each factor and that they differ in their responses. The result of the calculation of the standard error of r are illustrated in Table 4.37.

The test used in this thesis is the t-test which is suitable for the sample size encountered in this analysis. The standard error for the value of t computed by the following formula :

$$t = \frac{r}{\sqrt{1-r^2}} \sqrt{n-2} \tag{4.3}$$

Where:

r = Correlation coefficient of all correlations

t = t-statistics.

N = Number of pairs used in computing r.

The r values present for all types of correlation either spearman, partial or multiple, for each method per each factor and the result of t-values are demonstrated in Table 4.37.

Table 4.37 : T-Values of the Hypothesis Test of Factors Categories (All Techniques)

CORRELATION COEFFICIENT				SPEARMAN			PARTIAL			MULTIPLE		
FACTOR	N	DF	S_{r0}	T_1	T_2	T_3	T_4	T_5	T_6	T_7	T_8	T_9
1. Aspects of Utilization	27	25	0.2	8.8	9.8	17.1	0.6	5.4	7.4	9.8	17.1	20.0
2. User's Level of Utilization	23	21	0.2	8.7	9.5	13.9	1.0	2.1	5.4	9.5	13.9	15.7
3. Criteria of Success	29	27	0.2	15.8	12.7	16.8	6.6	1.2	6.8	16.4	21.4	17.1
4. Reasons of Success	29	27	0.2	13.1	10.1	15.8	3.8	0.3	5.6	13.1	18.6	15.8
5. Reasons of Failure	25	23	0.2	12.1	12.1	13.2	2.4	2.4	3.2	9.4	10.5	8.9

Where:

N = No. of apirs computed for (r)
DF = Degree of Freedom
S_{ro} = Standard error at R=0
$t_{0.05}$= t-stastics at 0.05 level of significance
T_1 = t value at r_{LM}
T_2 = t value at r_{LS}
T_3 = t value at r_{MS}
T_4 = t value at $r_{(LM)S}$
T_5 = t value at $r_{(LS)M}$
T_6 = t value at $r_{(MS)L}$
T_7 = t value at $r_{(L)MS}$
T_8 = t value at $r_{(M)LS}$
T_9 = t value at $r_{(S)LM}$

Decision Rule

Since the critical test value t = 2.069 (from t-statistic distribution for $\alpha = 0.05$, Df = N-2 = 21), and the calculated values of t exceed the tabulated values, we can reject the null hypothesis at the 0.05 level of significance and conclude that the three firm groups agree on the relative importance index and the relative success index of factor categories related to the SET.

The analysis of variance among the three groups is conducted in this thesis. The general formula for determining the number of combination tests to be made by taking the groups two at a time, is $\frac{N(N-1)}{2}$ where N is the number of groups. In this study there are three groups and the possible number of tests would be 3 (3-1)/2 which is equal to 3. The variation of the group means of all groups is referred to as between groups variance. The average variability analysis is referred to as within-group variance. The test of significance of the difference of the abovementioned types is computed by using the F-test.

4.6 The Differences Among The Three Sized Groups by Variance Analysis

The single classification analysis of variance (referred to Bartlett (1937), Cochran (1947) and Edwards (1968, 1960)) represents the interaction for comparing subsamples and the statistical design estimates of variance due to the treatment of interaction. This analysis generally tests the null hypothesis of no difference among the mean of the various groups and their variation.

(a) The Total Sum-of-Squares:

The total sum of squares could be determined by finding the deviation and squaring and summing these variances. This is computed by the use of the following formula :

$$\Sigma X_t^2 = \Sigma X^2 - \frac{\Sigma X^2}{N} \tag{4.4}$$

Where:

ΣX_t^2 = The total sum-of-squares

$$\Sigma X_t^2 = \Sigma X_L^2 + \Sigma X_M^2 + \Sigma X_S^2$$

ΣX_L^2 = The sum squared of variances for large firm group

ΣX_M^2 = The sum squared of variances for medium firm group

ΣX_S^2 = The sum squared of variances for small firm group

N = The total number of cases for all groups.

By substituting the above equation by using the data in Table (4.38), thus,

$$\Sigma X_t^2 = (397.47 + 199.86 + 92.91) - \frac{171.84^2}{60}$$

$$= 690.24 - 492.15 = 198.09.$$

(b) The Variance Squares between sum-of-squares:

This step between various groups can be found by taking the mean of each group and squaring them and then multiplying each of these by the number of individual cases in each subsample (n). These can be obtained by using the following formula :

$$\Sigma X_b^2 = \Sigma(\overline{X} - \overline{X}_t)^2 n \tag{4.5}$$

Where:

ΣX_b^2 = The sum of squares between various groups.

$\overline{X}$ = The mean value of variance per group.

$\overline{X}_t$ = The mean value of all the three groups.

n = Total number of individual cases.

Thus,

$$\Sigma X_b^2 = (4.06\text{-}2.864)^2 (20) + (2.81\text{-}2.864)^2 (20) + (1.72\text{-}2.864)^2 (20)$$

$$= 28.60 + 0.05832 + 26.175$$

$$= 54.833$$

The abovementioned value of (ΣX_b^2) will be used in the following calculations.

(c) The Within Sum-of-Squares:

The sum-of-squares within groups is found by using the following equation with the data in Table 4.38.

For group L = (Large Firms)

$$\Sigma X^2_{WL} = \Sigma X^2_L - \frac{(\Sigma X_L)^2}{n_L}$$

$$= 397.470 - \frac{(81.20)^2}{20}$$

$$= 397.470 - 329.672 = 67.798$$

For group M = (Medium Firms)

$$\Sigma X^2_{WM} = \Sigma X^2_M - \frac{(\Sigma X_M)^2}{n_M}$$

$$= 199.860 - \frac{(56.16)^2}{20}$$

$$= 199.860 - 157.697 = 42.163$$

For group S = (Small Firms)

$$\Sigma X^2_{WS} = \Sigma X^2_S - \frac{(\Sigma X_S)^2}{n_S}$$

$$= 92.908 - \frac{(34.48)^2}{20}$$

$$= 92.908 - 59.444 = 33.465$$

Table 4.38 : Single Classification Analysis of Variance of the Test Groups

SEQUENCE	METHOD	FACTOR	L-FIRMS	M-FIRMS	S-FIRMS	(L^2)	(M^2)	(S^2)
1	1	CRITERIA	3.84	3.84	3.84	14.746	14.746	14.7456
2	2		5.25	3.75	3.75	27.563	14.063	14.0625
3	3		2.50	0.80	0.00	6.250	0.640	0.0000
4	4		4.67	2.62	1.48	21.809	6.864	2.1904
5	1	ASPECTS	6.00	2.50	1.36	36.000	6.250	1.8496
6	2		7.50	3.75	2.40	56.250	14.063	5.7600
7	3		1.67	1.67	0.00	2.789	2.789	0.0000
8	4		3.50	0.67	0.70	12.250	0.449	0.4900
9	1	USER'S	4.67	3.81	2.62	21.809	14.516	6.8644
10	2		4.67	1.48	2.62	21.809	2.190	6.8644
11	3		1.69	3.28	0.00	2.856	10.758	0.0000
12	4		1.67	1.67	1.67	2.789	2.789	2.7889
13	1	RE -S	6.00	6.00	1.36	36.000	36.000	1.8496
14	2		7.50	5.25	1.25	56.250	27.563	1.5625
15	3		4.67	2.62	0.00	21.809	6.864	0.0000
16	4		1.70	1.79	2.50	2.890	2.890	6.2500
17	1	RE -F	4.67	2.62	3.81	21.809	6.864	14.5161
18	2		4.67	4.67	2.62	21.909	21.809	6.8644
19	3		2.67	2.67	0.00	7.129	7.129	0.0000
20	4		1.69	0.79	2.50	2.856	0.624	6.2500
Total			81.20	56.16	34.48	397.470	199.860	92.9084

$\bar{X}_L = 4.06$, $\bar{X}_M = 2.81$, $\bar{X}_S = 1.72$ $= 690.24$

$\bar{X}_t = 2.864$

Method # 1 = CPM Method # 2 = GBC Method # 3 = PERT Method # 4 = PND
(S) - Successful (F) - Failure

Summing for all three = 67.798 + 42.163 + 33.465 = 143.426

The variations of within sum-of-squares added to the between sum-of-squares could result in the total of sum-of-squares.

$$\Sigma X^2_{total} = 54.833 + 143.426 = 189.259$$

Degree of Freedom

Since there are 60 categories under all the five factors which have been tested in this analysis and (N-1) is equal to (60-1) = 59 df. In large firms, there are 20 categories, hence df = 19 for this group. However, there are three groups. Then every one of them have 19 df. Then, it follows that there are 2 df for the groups.

df for total groups = Number of cases in total (N) minus 1.

df for between groups = Number of groups (K) minus 1.

df for within groups = Sum of the number of cases within each subsample

Table 4.39 : Analysis of Variance for the Three Test Groups

Source of Variation	df	Sum-of-Squares	Mean-of* Squares
Between groups	2	54.659	27.330
Within groups	57	143,426	2.516
Total	59	198.085	29.846

* The mean square is equal the sum-of-squares divided by its respective number of df.

Consequently, between and within mean-square are two estimates of the population variance. The F-test is used here to test the difference between two variances to conclude whether or not we should pool them. The analysis of variance listed in the above table (4.39) is evaluated by computing the following F test :

$$F = \frac{\text{Mean square for between groups}}{\text{Mean square for within groups}} \tag{4.6}$$

$$= \frac{27.330}{2.516} = 10.86$$

F ratios are figured by the use of the F-table and for this we go over to 2 df and down to 57 df. In that location, the critical value of F which is needed for significance at 5 percent confidence interval is 3.162.

Decision Rule

Since our obtained value is greater than $F_{(tabulated)}$, we reject the null hypothesis of no difference among these means at the 5 percent level of significance.

Previously, we found that there were significant differences between the means of variances. The next task is to figure out where the differences are. Winer (1971) and Scheffe (1957) introduce such methods to compute the abovementioned difference. There are three variances, thus giving three comparisons among them as follows :

$$\bar{L} \text{ vs. } \bar{M}, \bar{L} \text{ vs. } \bar{S}, \bar{M} \text{ vs. } \bar{S}.$$

For each comparison between groups, the F ratio could be computed with the following formula :

$$F = \frac{\bar{X}_1 - \bar{X}_2^{\,2}}{S_w^2\,(N_1 + N_2)/N_1N_2} \qquad (4.7)$$

Where:

F = F-statis

$\bar{X}_1$ = Mean of variance of group 1

$\bar{X}_2$ = Mean of variance of group 2

$\bar{S}_w^2$ = Mean square within groups

N_1 = Number of cases in group 1

N_2 = Number of cases in group 2

For Distribution of Large and Medium:

$$F_{LM} = \frac{(4.06-2.81)^2}{(2.516)(40)/(20)(20)} = \frac{1.5625}{0.2516} = 6.210$$

For Distribution of Large and Small:

$$F_{LS} = \frac{(4.06-1.72)^2}{(2.516)(40)/(20)(20)} = \frac{5.476}{0.2516} = 21.763$$

For Distribution of Medium and Small:

$$F_{MS} = \frac{(2.81-1.72)^2}{(2.516)(40)/(20)(20)} = \frac{1.1881}{0.2516} = 4.722$$

The F-value at 5 percent level of significance for 2, 57 df is 3.162. This value is multiplied by (K-1), where K is the number of groups. So we have (3-1) (3.162) which equals to 6.324. At 1 percent value of F for 2, 57 df which is 4.998, is multiplied by (K-1) giving (2) (4.998) = 9.999. The hypothesis is to compare the F_{LM} ,F_{LS} and F_{MS} computed above with these values of 6.324 and 9.999. One of them is larger than the 5 percent value which equals to 21.763. This indicates the F-value computed between groups of large firms and small firms.

Decision Rule:

Since 21.763 is greater than the value of F at either 5 percent or 1 percent, then it follows that the mean of large firm differs significantly from that of small firm at the either 5 percent level or 1 percent levels and there is small significant difference between each of the other comparisons, and we conclude that there is difference among these groups.

4.7 General Comments by Participating Contractors

The following is a sampling of the many comments that were made. Some comments have been selected to reflect the respondent's description of the Systematic Examination Techniques used by their organization. These comments would assist and help to understand their firm's implementation and evaluation.

1. "In our company, the major work is road and highway construction. Scheduling turn out to be pretty simple and clear to the point that sometimes it appears to be of small importance. This is due to the fact that the number of different activities is very small and there are almost no interface issues."

2. "In street works or for structural works, the importance of scheduling is very clearly pronounced."

3. "The material management and document management systems for planning and scheduling were both developed in-house, run on PCs, and oracle relational database which have proved to be the most powerful and practical control tools on sizeable projects."

4. "At present, we feel these methods are not useful for a small contracting operation. We are always open for correction."

5. "Any firm which wants to have better control on planning and cost must adopt one of the planning methods and train their personnel. The main difficulty in realizing the importance of any one of these methods is that after preparation of these charts, nobody takes care of reviewing and taking benefits from these."

6. "We started one year ago with Systematic Examination Techniques, but we think, better knowledge of computer applications shall improve our present situation."

7. "The GBC, CPM and PERT methods must be implemented in any construction firms in order to maintain the status and to be aware of the projects going on before the unexpected happens. These are very essential tools to monitor the project construction margin which is expected before any particular project starts."

8. "PND method is a very fast and applicable tool that is mostly implemented in our firm, but it depends on the computer programs such as print-out, timeline and open-plan. It depends on the personnel using the system and the purposes of implementation."

9. "GBC is a very simple and more understandable by workers and labors because it does not require more training."

10. "Based on our experience, we prefer using GBC for implementation purposes because this can be easily understood by lower rank personnel at the site, while CPM is preferred when it comes to (I-J)

sorting and cost sorting."

11. "SET for planning and scheduling are most helpful in cost evaluation, work progress, material procurement, equipment control and subcontracting work on monthly basis. In addition, cash flow charts provide a good support for scheduling the bank finance, bid bond and performance bond."

12. "We believe that the most important aspect of any project control method is that once a decision has been made to adopt any particular method, it must be wholeheartedly supported by top management and all concerned with the implementation and operation of the method. It is also important to accept the fact that no method, no matter how good, is a substitute for good management."

13. "CPM is only one of the tools that good management may utilize to help ensure success."

14. "Most methods, except for the Bar chart method, are too complicated for the lower level of field personnel, so that most construction companies try to get away from complicated methods, which makes the GBC more popular than the other methods."

15. "Construction middle management cannot understand difficult programs; hence, at the foreman/supervisory level, weekly and monthly work load bar charts are issued to meet targets. However, CPM is used by our planning engineer to overcome material shortfalls at job continuity."

16. "Planning and scheduling systems that will be used for any project depends on size, scope and complexity of the project itself. In fact, the bar chart is commonly used for every project we handle, while CPM is more practical especially for the coordination of different activities, deliveries of materials and equipment, progress payment, accounting and budget control, personnel and labor record, procurement and materials control and cost control."

17. "For small size projects containing simple activities, the bar chart is commonly used. On the other hand, for large size projects of multi-disciplines, the CPM is a more effective and practical tool to implement."

18. "To obtain the degree of success on construction work, depends not only on the completion of the project based on the accurate cost estimate, but most likely on the manner of preparing a practical plan in carrying out the work activities."

19. "The monitoring and subsequent control of project works of the company can be successfully achieved by the application of the Systematic Examination Techniques ."

20. "We find that the control chart will be informal or hand drawn and without controls of this nature, the project almost certainly tends to reach failure stage."

21. "Our firm believes that using these methods helps us to avoid any

delays, disputes and sometimes things attempt to litigation. We try to clear out all of these problems and difficulty by utilizing both CPM and GBC systems."

22. "We do not find the implementation of the previously mentioned Systematic Examination Techniques as a contributing factor due to the low yearly turnover which is about SR15,000,000 and low value of project which is SR9,000,000.

23. "In general, these Systematic Examination Techniques must be studied carefully because of the demand for more sophisticated techniques as projects have become increasingly more complex, adding risk and inaccuracy and uncertainty especially among most of the engineering projects which require more detailed information for implementing the planning and scheduling tools."

24. "Our firm has been in existence for more than twelve years and has operated with an industry average overhead of about 55% of turnover capital. We utilize the CPM and GBC techniques. Sometimes, many inquiries are issued urgently that do not allow enough time to repair a schedule."

25. "CPM and GBC is very useful in implementing project programming and monitoring of progress. It also helps a lot in material ordering especially for long load materials."

26. "The major area of concern that arises in utilizing such a system is the gap that exists between the planning department and site staff

responsible for day-to-day activities."

27. "We do 85% construction work and maintenance, but we do not like to use CPM or other methods."

28. "CPM has been proved to be an extremely useful planning tool. It enables a project manager to see the interrelationship of the work elements which make up the whole project. It shows which work elements are critical to the completion of a project. GBC is helpful in scheduling manpower and equipment, deliveries of material and planning cash needs as well as in preparing monthly progress and performance report."

CHAPTER 5

SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

This chapter is devoted to a summary of the research and the summary of the results (conclusions), general recommendations and recommendations for further research needed in the planning and scheduling process, based thereon are summarized in the following.

5.1 Summary

The following summary for both the research and the result can be derived from the work reported on the Systematic Examination Techniques (SET):

5.1.1 Summary of the Research

The fact is that, the recent environmental situation in Saudi Arabia is forcing contractors to ensure for themselves an adequate market share to ensure survival to continue in the current construction business. However, the survivability of a contractor's firm is totally dependent on how effective the management functions are performed. A contractor must plan, schedule, coordinate, and control the various activities involved in any project construction process. Therefore, it was decided that a clear visualization study of the Systematic Examination Techniques (SET) for planning and scheduling in Saudi construction industry must be conducted. This research study investigates the application of five techniques include, CPM, PND, PERT, GERT and GBC for planning and scheduling in the area of construction projects in Saudi Arabia. Also, it seeks top management's views about the scope and nature of SET's utilization with levels of importance and degree of success. It serves as basic study to help in establishing and formulating research for the future.

An intensive review of the relevant literature was performed for two purposes. The first is studying the historical development, the basic data, procedure and methodology, and the advantages and disadvantages of each technique involved in the SET. This is supported by a comparison study among these technique through fundamental factors. The second is to establish a foundation for the development of a survey questionnaire. This questionnaire was designed to measure SET's implementation and evaluation.

Questionnaires were sent to 63 randomly selected construction contractors located in the Eastern, Central and Western Provinces of Saudi Arabia. Data were collected by means of a mailed questionnaire from the contractors, incorporated in this survey, but the questionnaires distributed to the construction firms in the Eastern Province were collected by hand in a second visit.

The statistical package SAS that is available at King Fahd University of Petroleum & Minerals (KFUPM) mainframe computer was used to analyze the data.

The analysis of five factors corresponding to each question in the questionnaire set was conducted to figure out the major points they contained. The variables examined and analyzed are : aspects of utilizing the SET (SET function), user's levels of information gained from SET's utilization, criteria of measuring the success of implementation, the causes of success (success factor) in using the SET and causes of failure (factor of spurious application). The statistical measures for the interpretation, correlation, statistical method and other statistical analysis were utilized in this research. The results of each factor and the information addressed by each variable was obtained. The importance and success indices were used to indicate the level of importance and the degree of utilization (ranking analysis). The hypothesis of the agreement for the rank of the factors was tested through using the statistical techniques.

5.1.2 Conclusions

The following conclusions can be drawn from the discussion and data analysis. These conclusions seem to be warranted based on the major findings of this research.

1. The CPM technique is widely known by all contractors in Saudi Arabia, but it is not used by all of them. A sizeable majority of contractors use CPM and GBC as one subset for project planning and scheduling.

2. The GBC technique is known by all construction firms in Saudi Arabia.

3. None of the construction contractors in Saudi Arabia use the GERT technique in their projects. The technique is known by only a few of them. Some do not know what it means or have never heard of it, and some of them have misunderstood this technique and regard it as a graphical computer application of representing activities only.

4. The sizeable majority of all contractors are not familiar with all planning and scheduling techniques involved in the SET.

5. The major sources of knowing the SET techniques by construction firms in Saudi Arabia are university education, institute education resources and experience.

6. Small contractors in Saudi Arabia do not use the PERT technique and most of them either do not know what PERT means or they have never heard of it.

7. CPM and PERT are effectively used in large size construction projects while CPM and GBC seem applicable for use on both large and small size construction projects. CPM plus PERT and GBC are frequently used by medium size construction firms. PND permits computations easily and effectively. It usually used to produce initial plan of work schedule of any project in short time.

8. The majority of construction contractors in Saudi Arabia use

computer for formalizing project planning and scheduling by utilizing the SET techniques on their projects.

9. The combination of CPM and GBC techniques is frequently used by building, building plus other types of contractors such as structure or heavy contractors. Building plus structure-type contractors and structure contractors employ either CPM, PERT or GBC on their projects.

10. Heavy-type contractors usually use CPM or PERT technique. They are the most users of the PERT technique due to the work involved in heavy construction , while building plus the other two types of contractors usually use PERT and/or GBC.

11. GBC is frequently used on all contracts by large and medium sized firms. Small firms use it only when required by contracts. This result was expected due to the simplicity of applying this method, while CPM, PERT and PND are frequently used in construction contracts when required by owner or clients.

12. The CPM technique is frequently used by medium sized firms on "50% or more of all contracts" using criteria. PND is mostly used by large sized contractors on all contracts or on "less than 50% of contracts" using criteria. PERT is usually used by large and medium sized firms on all frequent

using criteria such as, on all contracts, less than 50% of contract, and when required by owner or clients.

13. CPM is being employed significantly more for planning rather than for control or controlling material purchases and delivery and cash needs purposes. PERT and PND are being employed more for control rather than for planning cash needs and material purchases purposes.

14. GBC is frequently used for planning and controlling material purchases and delivery and predicting cash needs rather than for detailed planning of construction . Large and medium firms used CPM and GBC for both planning and controlling aspects purposes, while small sized firms used them as detailed planning and controlling of material purchases and delivery only.

15. PND and PERT are usually used for planning of construction and controlling aspects purposes by large and medium sized firms, while PND was used as a control tool only by small firms.

16. All firms (large, medium and small firms) generally agree to using CPM and GBC as detailed planning and control tools, based on the level of importance to the business, current success by contractor's view, but PERT and PND are usually used as detailed planning of construction only as aspect of

utilization. These occupied the first significant rank by all of them.

17. Large and medium sized firms generally agree on using information from the SET at project manager, site manager, division or group and at bidding and estimating levels rather than at trade superintendent's level. Small firms obtained information from CPM at project management and site manager levels rather than at division or group, trade superintendent and bidding and estimating levels. PND by small firms constitute the vise versa of CPM by small firm groups, but GBC utilized at all levels of information users.

18. All contractors gave first rank to information gained by users at each level of planning, scheduling and controlling for each method. Both CPM and PND users are ranked "project management and trade superintendent" at the highest level. Users of GBC are rated "division (department) or group manager level" as the highest. Users of PERT rated "trade superintendent level" as the highest. These cited the most frequent level of gaining information from SET implementation.

19. Only a small percentage of users firms (2 firms who use CPM) feel that they are unsuccessful in achieving the numerous benefits attributed to use of these systems.

20. All contractors usually regard the defining of cost saving plus improvements of planning and controlling as first importance factor categories of the criteria for measuring the successful utilization of the SET. Improvement of communication and bidding or estimating occupied the other ranks.

21. A small percentage of users (3 firms) feel that SET is relatively unimportant to their firms as obtaining the various benefits and analyzing the problems associated with the use of these techniques. No one of the firms feel that PND and PERT is relatively unimportant.

22. The majority of contractors view these SET as very important to the current success of their organization. They feel that they are very successful in achieving the numerous benefits attributed to use of these SET.

23. Good training of personnel and good management support are the main important causes of successful implementation of the SET. These two factors lead to successful programming techniques in planning and scheduling and can help build successful and effective management.

24. Lack of support from people who use the system, lack of top management support and poor training of personnel are the three main causes of failure in using SET. This may simply reflect a relative increase in importance of other failures such

as labor problems, controls, monitoring and updating problems. All of these reasons have adverse effect on the firm's position in the market.

25. The majority of contractors regarded that the approximate percentage of cost saving is ranged between "4-14% of contract cost amount". The mean of cost saving per project obtained when using the SET in their project is about 12.22% of contract amount.

5.2 Recommendations

The result of this research suggests the following directions for both the general recommendations and the recommendations of further research.

5.2.1 General Recommendations

The present research helped in performing the following recommendations. These are the most important suggestions and opinion from the author's viewpoint.

1. It is recommended that the contractors use an appropriate SET technique for managing their projects. This is due to the benefits attributed to the use of these SET, because they provide both evidence of honest work accomplishment and an increase in profit margins due to cost savings.

2. It is advisable that the contractor should use a SET technique for all project management aspects such as, planning, scheduling, control, controlling material purchase and delivery and cash needs purposes. A realization of cost savings is evident.

3. Contractors are advised to encourage their personnel to use these SET techniques especially at the site management level because they reflect the actual construction condition for progress and for future status of the project.

4. It is imperative to use these techniques to become more competitive and to survive in the current construction business market because the survey showed that contractors are realizing cost savings when implementing these SET in their organizations. Also, they feel that the application of these techniques is very important to their firms' success.

5. Contractors should formulate an early plan of work performance before work starts by using an appropriate SET technique. This will lead to indirect improvement of quality and will help in the prediction of cash flow. This is strongly recommended because it helps top management or any party to look at the overall project and to see it as a "big picture", as well as visualizing the complete idea of the control process.

6. Supportive coordination of all activities of a project with

incentive top management support and actual support from the people who are really using the SET for controlling all phases of construction project is extremely important and is strongly recommended to avoid delays, claims and litigation. It is the responsibility of the contractor to follow through in order to obtain sufficient work.

7. It is recommended that the contractor should utilize the information generated from SET application especially at the bidding and estimating levels because this will improve bidding and estimating process and will lead to improve their own efficiency for securing enough market share from the projects available in the construction market.

8. One of the benefits obtained from SET implementation in an organization is the quick response to a management crisis. It is recommended that these SET should be trained as a response to the needs expressed by all technical staff at the managerial level, so that any scheduled change will be negotiated and properly adjusted.

9. Close, early cooperation of planning and scheduling, control and communication among work forces especially between top management and the lower level of personnel is of great importance, and is strongly recommended for improving communication practices, control problems, avoiding delays, claims and litigation and avoiding any changes and disputes.

10. It is recommended that contractors should teach their lower level personnel the concepts and procedures of the Systematic Examination Techniques through short courses or others means in relation to their work handled in order to improve communication among middle management, the project team and the client. Good communication means defining assignments clearly to subordinates.

11. Top management is recommended to establish a set of policies of a proper SET implementation and to develop a set of procedures for SET utilization in its organization.

12. Top management is recommended to encourage its personnel to understand and follow the project activities as a schedule. This will directly lead to fill the gap of the lack of communication between the management and the lower level who are working at construction site.

13. Top management is advised to support the utilization of the SET technique in its organization and to encourage its personnel to use and follow the information generated from the used SET.

14. Top management is advised to encourage its personnel who are really using the SET systems to use advanced technology for project control with a good base for effective planning

and scheduling. This will lead to effective managerial skills.

15. In response to contractor complaints of spurious SET application by poorly trained personnel, the contractors are advised to establish a training institute in the Kingdom of Saudi Arabia in order to help avoid the problem of a shortage of local skilled labor.

16. Due to the major concerns with regard to SET operation of both the requirement of excessive work of SET implementation and the complexity of input and output. Good computer programs can be effectively utilized in formalizing the planning and scheduling process in order to systematically follow up and help upgrade the performance of any construction projects. They help the contractors in speeding up the planning, scheduling and eliminating computational errors.

5.2.2 Recommendations for Further Research

The result of this study suggested that further research is needed in the areas outlined below :

1. The same research study might be performed for measuring the cost saving by utilizing the SET through analysis of a real on-going construction project.

2. This research is limited to construction firms. It is suggested that the same research could be done for other types of con-

tractors with other construction parties.

3. The scope of this thesis is limited to the Eastern, Western and Central Provinces in Saudi Arabia. Further studies might be conducted in the other regions of Saudi Arabia or in in the Gulf region.

4. A study could be performed to investigate ways of measuring the successful utilization of SET for planning and scheduling.

5. A system could be developed to measure the amount of cost saving through SET implementation.

6. A study could be performed to find the relationship between the size, cost and complexity of the project and the most suitable method to use.

7. The actual effects of planning and scheduling techniques on delays, litigation, claims and change order can be studied.

8. A model between the SET and the contribution of profitability, uncertainty and project characteristics can be developed.

9. The effects of complexity of input and output of information on SET implementation can be studied.

10. A study of SET characteristics and the forecasting for cost reductions in order to determine which technique is more effective and more efficient.

11. A study could be performed to search for a relationship between organizational, managerial and control problems and SET utilization faced during construction .

12. A study of the effect of SET implementation and the improvements of communication between management and lower levels could be investigated.

13. Research on the most effective factors of the utilization of computer technology in the process of formulating planning and scheduling could be conducted.

APPENDICES

APPENDIX A : Construction Firm's Questionnaire

APPENDIX B : Pearson Correlation Between all questions and the Computation of Spearman, Partial and Multiple Correlations with Their Diagrams

APPENDIX C : Construction Firm's Names and Locations

APPENDIX (A)

CONSTRUCTION FIRM'S QUESTIONNAIRE

بسم الله الرحمن الرحيم

Ministry of Higher Education
g Fahd University of Petroleum & Minerals
DHAHRAN 31261, SAUDI ARABIA

وزارة التعليم العالي
جامعة الملك فهد للبترول و المعادن
الظهران ٣١٢٦١ المملكة العربية السعودية

Dear Manager,

The Construction Engineering & Management Department of the College of Environmental Design at King Fahd University of Petroleum & Minerals is presently engaged in a study of the Systematic Examination Techniques (SET).

The purpose of the study is to establish the scope and nature of use of SET among construction firms in Saudi Arabia.

We are asking you to participate by providing needed information related to the method(s) your firm is using, assessment on the benefits and problems associated with the use of the method(s), and the degree of importance to your firm. We will hold all data on individual firms in strict confidence. We know that there are numerous demands on your time. However, your involvement is important in contributing to the study. The questionnaire will take less than 15 minutes of your valuable time.

The attached questionnaire consists of three sections. The first section seeks information about your firm. The second section seeks information related to the method(s) your firm is using for cost reduction. The third section seeks information related to the evaluation of the method(s) which has been in use in your firm.

Your immediate action will be highly solicited. Please return your completed questionnaire in the enclosed self-addressed envelope not later than 15th July, 1989.

Thank you in anticipation for your co-operation.

Sincerely yours,

DR. ALI A. SHASH, Ph.D.
STUDY DIRECTOR

ABDULLATIF M.H. AL-ABDULLATIF
RESEARCH ASSOCIATE

ephone : 860-0000
ex : 801060 KFUPM SJ
ble. : AL-JAMAAH

تلفون : ٠٠٠٠ - ٨٦٠ (٠٣)
تلكس : ٨٠١٩٥٠ جافهد
برقيا : الجامعة

CONSTRUCTION FIRM'S QUESTIONNAIRES

PURPOSE:

The objective of this survey is to establish the scope and nature of use of Systematic Examination Technique (SET) among construction firms in Saudi Arabia and to obtain top management views on the benefits and problems associated with use of these methods, as well as their importance to the firm.

SYNOPSIS:

These questionnaires are prepared for certain requirements related to the methods of construction operations for planning & scheduling. The result of these questionnaires will be written in Master Degree Research. This research contains a survey study based on the Systematic Examination Techniques (SET) which have been in use in Saudi Arabia in construction companies in order to find out the most successful method in achieving any project with the numerous benefits attributed to use of these techniques.

DESIGN:

These questionnaires contain three sections which will be considered in turn :-

Section (1) : Part A (Firms's information).
Section (2) : Part B (SET implementation).
Section (3) : Part C (SET Evaluation).

We will be most grateful to you for answering these questionnaires and we will thank you for this act of kindness.

PART "A": GENERAL FIRMS'S INFORMATION"

THIS SECTION CONTAINS QUESTIONS SEEKING INFORMATION ABOUT YOUR FIRM.

Please fill the following :-

Company name :- - - - - - - - - - - - - - Co. Nationality:- - - - - - -

Location of Main Office:- - - - - - - - - No. of Branches: - - - - - -

Total Number of Employees:- - - - - - - Region of operation:- - - - -

Title or position of the Respondent - - - - - - - - - - - - - - - - - -

---

Please answer the following questions by placing a check (√) in the appropriate box :

1- What is the size of your firm in terms of Saudi Riyals volume of construction ?

☐ (56,000,000 plus) ☐ (15,000,000 - 24000000)

☐ (25,000,000 - 55,000,000) ☐ (5,000,000 - 14000000 or less)

2- Which of the following most closely describes your's Company principal activity ?

☐ Building (Educational, Commercial, etc.) ☐ Heavy construction (bridges, dams, harbours, roads, etc.)

☐ Structural contractors ☐ Other (Please specify:- -

3- What is the average amount of work subcontracted on average job ?

☐ 19% or less of one job. ☐ 50% - 99% of one job.

☐ 20% - 49% of one job. ☐ all of the job (100%).

4- What is average job size in terms of Saudi Riyals of each project ?

(:-------------------SR)

5- What is average job duration of each project ?

(:------------------- YEARS)

PART "B": SYSTEMATIC EXAMINATION TECHNIQUE "SET IMPLEMENTATION"

THIS SECTION OF QUESTIONNAIRE IS DESIGNED TO INVESTIGATE THE SYSTEM EXAMINATION TECHNIQUE (SET), YOUR FIRM IS IMPLEMENTING.

Please answer the following questions by placing a a check (√) in the appropriate box(es). If you have used more than one method in your firm choose the right answer by marking (√) in the table with respect of each method as they are arranged in Question No.3 (PART "B").

Q.1 Please indicate the method(s) you know ?

(1) Critical Path Method (C.P.M.) - Method No.1. ☐
(2) Precedence Network Diagramming (P.N.D) - Method No.2. ☐
(3) Program Evaluation & Review Technique (P.E.R.T.) - Method No.3. ☐
(4) Graphical Evaluation & Review Technique (G.E.R.T.) - Method No.4. ☐
(5) Gantt (Bar) chart (G.B.C.) - Method No.5. ☐
(6) Other methods you know, please specify - - - - - - - -
- -
Method No.6. ☐

Q.2 How do you know this (these) Method(s) mentioned in Question No.1 (PART B) ?

- University of Institution ☐ — Research agencies.— — — — ☐
- Experience — — — — — — — ☐ — Other, please specify - - - ☐
- - - - - - - - - - - - - - - -

Q.3 Which method(s) has been in use in your firm ?
(You can indicate more than one method).

(1) Critical Path Method (C.P.M.) - - - - - - Method No.1. ☐
(2) Precedence Network Diagramming (P.N.D) - Method No.2. ☐
(3) Program Evaluation & Review Technique (P.E.R.T.) - Method No.3. ☐
(4) Graphical Evaluation & Review Technique (G.E.R.T.) - Method No.4. ☐
(5) Gantt (Bar) chart (G.B.C.) - Method No.5. ☐
(6) Others, please specify : - - - - - - - - - - - - - - - -
- -
Method No.6. ☐

Q.4 Do you use any computer system(s) in your firm to assess for formalizing project planning & scheduling ?

		(Name)	(language program)	(made in)
☐ Yes--If yes,specify	1)	-----------,	-----------,	-----------
	2)	-----------,	-----------,	-----------
☐ No	3)	-----------,	-----------,	-----------

Choose the right answer by placing (√) in the table with respect of each Method(s) as they arranged in Question No.3 (PART B).

Methods	CPM 1	PND 2	PERT 3	GERT 4	GBS 5	Other 6
Q.5 How frequent do you use this (these) Method(s) mentioned in question No.3 (PART B) ?						
i) On all Contracts						
ii) 50% or more of all Projects						
iii) Less than 50% of all Projects						
iv) When required by Contract						
Q.6 In which aspect do you use this (these) Method(s) mentioned in question No.3 (PART B) ?						
i) As a detailed planning of construction						
ii) As a control tool						
iii) As planning and controlling material purchases and delivery						
iv) As planning cash needs						
Q.7 Who uses information from this (these) method(s) mentioned in question No.3 (PART B) ?						
i) At the project management level (Project Manager & Site Manager)						
ii) At the division or group manager level						
iii) At the trade Superintendent level						
iv) At the bidding or estimating						

PART "C": SYSTEMATIC EXAMINATION TECHNIQUES "SET EVALUATION"

THIS SECTION SEEKS YOUR EVALUATION ON THE METHOD(S) THAT YOUR FIRM HAS BEEN USING.

Please answer the following questions by placing (✓) in the table with respect of each method as they arranged in Question No.3 (PART B).

	CPM	PND	PERT	GERT	GBC	Other
Methods	1	2	3	4	5	6
Q.1 What benefits have you obtained from this (these) method(s) mentioned in question No.3 (PART B) ?						
i) Definite cost saving						
ii) Improved bidding/estimating						
iii) Improved planning before work starts						
iv) Improved project control after work starts						
v) Faster response to management crisis						
vi) Improved communication among work forces						
vii) No benefits (only higher costs).						
Q.2 What is the approximate (%) of cost saving obtaining when using this (these) Method(s) mentioned in question No.3 (PART B) ?						
i) (26-30) % of the total contract cost amount						
ii) (20-25) % " " " "						
iii) (15-19) % " " " "						
iv) (10-14) % " " " "						
v) (5 - 9) % " " " "						
vi) 4% or less " " " "						
vii) No cost saving at all						

Methods	1 CPM	2 PND	3 PERT	4 GERT	5 GBC	6 Other
Q.3 What are your major concern with regard to the operation and use of this (these) menthod(s) mentioned in question No.3 (PART B) ? i) Construction personnel (not using the method)						
ii) Implementation of them on (excessive) work						
iii) Complexity of input and output						
iv) Other major concerns						
If you choose (iv) please write the other concerns here :						
- - - - - - - - - - - - - - - - - - -						
- - - - - - - - - - - - - - - - - - -						
- - - - - - - - - - - - - - - - - - -						
- - - - - - - - - - - - - - - - - - -						
Q.4 How important do you view this (these) method(s) mentioned in question No.3 (PART B) ? i) Very important to the current success of your firm						
ii) Modest important for the current success of your firm						
iii) Relatively unimportant						

Methods	CPM 1	PND 2	PERT 3	GERT 4	GBC 5	Other 6
Q.5 How successful your Company has been in realizing the various advantages attributed to the use of this (these) method(s) mentioned in question No.3 (PART B) ?						
i) Very successfull						
ii) Modest successful						
iii) Unsuccessful						
If you choose (iii) - What do you think the reasons of unsuccessfulness :						
A. Required extra cost						
B. It is too complex to deal with it						
C. It needs specialists						
D. Difficult to divide the job in phases						
E. Other (list them here) :						
- - - - - - - - - - - - - - - - -						
- - - - - - - - - - - - - - - - -						
- - - - - - - - - - - - - - - - -						
Q.6 In which criteria do you measure the successful use of this(these) method(s) mentioned in question No.3(PART B) ?						
i) Improvement of planning and control						
ii) Defining cost saving						
iii) Improvement of communication among work force						
iv) Achieved such benefits (other benefits)						
If you choose (iv) - please list the benefits :						
- - - - - - - - - - - - - - - - - -						
- - - - - - - - - - - - - - - - - -						
- - - - - - - - - - - - - - - - - -						

Methods	CPM 1	PND 2	PERT 3	GERT 4	GBC 5	Other 6
Q.7 What do you think the reasons for successful use of this (these) method(s) mentioned in question No.3 (PART B) ?						
i) Good top management support						
ii) Good training of personnel						
iii) Good support for personnel using the system						
iv) Good computer programs						
v) Other reasons (List them here)						
- - - - - - - - - - - - - - - -						
- - - - - - - - - - - - - - - -						
- - - - - - - - - - - - - - - -						
- - - - - - - - - - - - - - - -						
Q.8 What do you think the reason for failure in using this (these) method(s) mentioned in question No.3 (PART B) ?						
i) Lack of top management support						
ii) Lack of support from people who must use the system						
iii) Poor training of personnel						
iv) Poor Computer programs						
v) Other reasons (List them here)						
- - - - - - - - - - - - - - - -						
- - - - - - - - - - - - - - - -						
- - - - - - - - - - - - - - - -						
- - - - - - - - - - - - - - - -						

- -

- -

COMMENTS

Q. IF YOU HAVE ANY ADDITIONAL COMMENTS THAT WOULD HELP US TO UNDERSTAND YOUR FIRM'S IMPLEMENTATION AND EVALUATION, PLEASE ADD THESE BELOW :-

THANK YOU VERY MUCH FOR YOUR COOPERATION.

APPENDIX (B)

PEARSON CORRELATION BETWEEN ALL QUESTIONS AND THE COMPUTATION OF SPEARMAN, PARTIAL AND MULTIPLE CORRELATIONS WITH THEIR DIAGRAMS

The Statistical Measures of Variables in the Study (SAS)

VARIABLE	N	MEAN	STD DEV	SUM	MINIMUM	MAXIMUM
NORESPON	61	31.00000000	17.75293403	1891.00000000	1.00000000	61.00000000
NATIONAL	61	1.44262295	0.76425503	88.00000000	1.00000000	3.00000000
LOCATION	61	2.67213115	1.92112217	163.00000000	1.00000000	7.00000000
NOBRANCH	49	2.46938776	1.64699272	121.00000000	1.00000000	9.00000000
NOEMPLOY	61	3.01639344	2.06146655	184.00000000	1.00000000	9.00000000
REGION	61	2.39344262	2.06783855	146.00000000	1.00000000	8.00000000
KEYINFOR	61	3.24590164	2.48056579	198.00000000	1.00000000	9.00000000
SRVOLUM	61	1.80327869	1.02988142	110.00000000	1.00000000	4.00000000
WORKACT	61	5.47540984	2.46716137	334.00000000	1.00000000	9.00000000
AVWORKSU	61	1.45901639	0.74327587	89.00000000	1.00000000	4.00000000
AVJOBSIZ	61	4.98360656	1.94500503	304.00000000	1.00000000	9.00000000
AVJOBDUR	61	4.29508197	1.76393747	262.00000000	1.00000000	9.00000000
QA1FAM	61	8.93442623	2.77405557	545.00000000	1.00000000	15.00000000
QA2SOU	61	3.93442623	2.24995446	240.00000000	1.00000000	9.00000000
QA3NUSE	61	7.39344262	2.84768145	451.00000000	1.00000000	13.00000000
QA4COM	61	10.04918033	7.79193222	613.00000000	0.00000000	19.00000000
QA5CPM	50	2.52000000	1.29740715	126.00000000	1.00000000	4.00000000
QA5PND	13	2.46153846	1.26592421	32.00000000	1.00000000	4.00000000
QA5PERT	19	2.73684211	1.24016600	52.00000000	1.00000000	4.00000000
QA5GOC	53	1.54716981	0.95204310	82.00000000	1.00000000	4.00000000
QA6CPM	48	5.41666667	3.32516730	260.00000000	1.00000000	9.00000000
QA6PND	13	5.07692308	3.22649290	66.00000000	1.00000000	9.00000000
QA6PERT	15	3.73333333	3.08143442	56.00000000	1.00000000	9.00000000
QA6GOC	52	5.40384615	3.22526555	281.00000000	1.00000000	9.00000000
QA7CPM	47	5.51063830	3.01353714	259.00000000	1.00000000	9.00000000
QA7PND	13	4.46153846	3.07179059	58.00000000	1.00000000	9.00000000
QA7PERT	17	2.64705882	2.23442320	45.00000000	1.00000000	9.00000000
QA7GOC	53	5.52830189	2.59884422	293.00000000	1.00000000	7.00000000
QB1CPM	48	15.10416667	8.52590442	725.00000000	1.00000000	9.00000000
QB1PND	12	15.16666667	5.74983531	182.00000000	3.00000000	31.00000000
QB1PERT	18	15.44444444	8.23151908	278.00000000	1.00000000	20.00000000
QB1GOC	53	14.24528302	8.25065419	755.00000000	2.00000000	30.00000000
QB2CPM	40	3.70000000	1.63613052	148.00000000	1.00000000	31.00000000
QB2PND	11	4.18181818	1.40129810	46.00000000	1.00000000	6.00000000
QB2PERT	13	3.76923077	1.96442723	49.00000000	2.00000000	6.00000000
QB2GOC	44	4.27272727	1.63342466	198.00000000	1.00000000	6.00000000
QB3CPM	46	3.52173913	2.58834250	162.00000000	1.00000000	6.00000000
QB3PND	12	4.25000000	2.66714011	51.00000000	1.00000000	9.00000000
QB3PERT	16	4.37500000	2.62995564	70.00000000	1.00000000	7.00000000
QB3GOC	35	3.42857143	2.54703651	120.00000000	1.00000000	9.00000000
QB4CPM	48	1.33333333	0.55062039	64.00000000	1.00000000	9.00000000
QB4PND	12	1.33333333	0.49236596	16.00000000	1.00000000	3.00000000
QB4PERT	17	1.47058824	0.51449576	25.00000000	1.00000000	2.00000000
QB4GOC	50	1.30000000	0.50507627	65.00000000	1.00000000	2.00000000
QB5CPM	50	1.60000000	0.57142857	80.00000000	1.00000000	3.00000000
QB5PND	11	1.45454545	0.52223297	16.00000000	1.00000000	3.00000000
QB5PERT	17	1.47058824	0.51449576	25.00000000	1.00000000	2.00000000
QB5GOC	51	1.37254902	0.48829435	70.00000000	1.00000000	2.00000000
QB6CPM	47	4.36170213	2.64102691	205.00000000	1.00000000	2.00000000
QB6PND	11	5.00000000	2.68328157	55.00000000	1.00000000	9.00000000
QB6PERT	16	3.81250000	2.85700893	61.00000000	1.00000000	9.00000000
QB6GOC	51	4.50980392	2.70830241	230.00000000	1.00000000	9.00000000
QB7CPM	49	4.79591837	3.04124147	235.00000000	1.00000000	9.00000000
QB7PND	12	6.33333333	2.18812221	76.00000000	1.00000000	9.00000000
QB7PERT	17	4.52941176	3.06426270	77.00000000	1.00000000	9.00000000
QB7GOC	50	4.60000000	2.85714286	230.00000000	1.00000000	9.00000000
QB8CPM	43	4.16279070	2.85290701	179.00000000	1.00000000	9.00000000
QB8PND	10	5.80000000	2.29975844	58.00000000	1.00000000	8.00000000
QB8PERT	16	4.25000000	2.56904652	68.00000000	1.00000000	9.00000000
QB8GOC	41	4.43902439	2.72991557	182.00000000	1.00000000	9.00000000

Pearson Correlation between All Questions (Variables) (SAS)

SAS

11:36 MONDAY, FEBRUARY 12, 1990 25

PEARSON CORRELATION COEFFICIENTS / PROB > |R| UNDER HO:RHO=0 / NUMBER OF OBSERVATIONS

	NORESPON	NATIONAL	LOCATION	NOBRANCH	NOEMPLOY	REGION	KEYINFOR	SRVOLUM	WORKACT	AVWORKSU	AVJOBSIZ	AVJOBDUR	QAIFAM
NORESPON	1.00000	0.13757	-0.15442	-0.00885	-0.00638	0.13075	0.11806	-0.04284	0.38281	-0.05810	0.18921	0.23737	0.05719
	0.0000	0.2904	0.2347	0.9519	0.9611	0.3152	0.3648	0.7430	0.0023	0.6565	0.1442	0.0655	0.6615
	61	61	61	49	61	61	61	61	61	61	61	61	61
NATIONAL	0.13757	1.00000	0.48641	0.08126	0.13283	0.15161	-0.04078	-0.31101	0.24893	0.01780	0.24040	0.14875	0.19471
	0.2904	0.0000	0.0001	0.5789	0.3075	0.2435	0.7550	0.0147	0.0530	0.8917	0.0620	0.2526	0.1326
	61	61	61	49	61	61	61	61	61	61	61	61	61
LOCATION	-0.15442	0.48641	1.00000	0.49766	0.32542	0.24279	-0.12268	-0.32797	0.19870	0.09548	0.26170	0.18641	0.20856
	0.2347	0.0001	0.0000	0.0003	0.0105	0.0594	0.3463	0.0099	0.1247	0.4642	0.0416	0.1503	0.1068
	61	61	61	49	61	61	61	61	61	61	61	61	61
NOBRANCH	-0.00885	0.08126	0.49766	1.00000	0.62061	0.21005	0.14818	-0.29661	0.21591	0.09456	0.17121	0.28257	0.04255
	0.9519	0.5789	0.0003	0.0000	0.0001	0.1474	0.3096	0.0385	0.1362	0.5181	0.2395	0.0492	0.7716
	49	49	49	49	49	49	49	49	49	49	49	49	49
NOEMPLOY	-0.00638	0.13283	0.32542	0.62061	1.00000	0.10012	0.19146	-0.49302	0.21144	0.21255	0.43236	0.55324	0.19545
	0.9611	0.3075	0.0105	0.0001	0.0000	0.4427	0.1394	0.0001	0.1019	0.1001	0.0005	0.0001	0.1312
	61	61	61	49	61	61	61	61	61	61	61	61	61
REGION	0.13075	0.15161	0.24279	0.21005	0.10012	1.00000	0.15951	0.09173	0.21754	0.08657	0.00992	0.12757	-0.03320
	0.3152	0.2435	0.0594	0.1474	0.4427	0.0000	0.2195	0.4820	0.0922	0.5071	0.9395	0.3272	0.7995
	61	61	61	49	61	61	61	61	61	61	61	61	61
KEYINFOR	0.11806	-0.04078	-0.12268	0.14818	0.19146	0.15951	1.00000	-0.13730	0.20386	0.10046	0.07683	0.05550	-0.06542
	0.3648	0.7550	0.3463	0.3096	0.1394	0.2195	0.0000	0.2913	0.1151	0.4411	0.5562	0.6709	0.6164
	61	61	61	49	61	61	61	61	61	61	61	61	61
SRVOLUM	-0.04284	-0.31101	-0.32797	-0.29661	-0.49302	0.09173	-0.13730	1.00000	-0.18560	-0.25021	-0.57574	-0.44458	-0.20293
	0.7430	0.0147	0.0099	0.0385	0.0001	0.4820	0.2913	0.0000	0.1521	0.0518	0.0001	0.0003	0.1168
	61	61	61	49	61	61	61	61	61	61	61	61	61
WORKACT	0.38281	0.24893	0.19870	0.21591	0.21144	0.21754	0.20386	-0.18560	1.00000	0.20621	0.10585	0.11276	0.21406
	0.0023	0.0530	0.1247	0.1362	0.1019	0.0922	0.1151	0.1521	0.0000	0.1108	0.4169	0.3869	0.0976
	61	61	61	49	61	61	61	61	61	61	61	61	61
AVWORKSU	-0.05810	0.01780	0.09548	0.09456	0.21255	0.08657	0.10046	-0.25021	0.20621	1.00000	0.32809	0.28904	0.14417
	0.6565	0.8917	0.4642	0.5181	0.1001	0.5071	0.4411	0.0518	0.1108	0.0000	0.0098	0.0239	0.2676
	61	61	61	49	61	61	61	61	61	61	61	61	61
AVJOBSIZ	0.18921	0.24040	0.26170	0.17121	0.43236	0.00992	0.07683	-0.57574	0.10585	0.32809	1.00000	0.67667	0.12644
	0.1442	0.0620	0.0416	0.2395	0.0005	0.9395	0.5562	0.0001	0.4169	0.0098	0.0000	0.0001	0.3315
	61	61	61	49	61	61	61	61	61	61	61	61	61
AVJOBDUR	0.23737	0.14875	0.18641	0.28257	0.55324	0.12757	0.05550	-0.44458	0.11276	0.28904	0.67667	1.00000	0.07214
	0.0655	0.2526	0.1503	0.0492	0.0001	0.3272	0.6709	0.0003	0.3869	0.0239	0.0001	0.0000	0.5806
	61	61	61	49	61	61	61	61	61	61	61	61	61
QAIFAM	0.05719	0.19471	0.20856	0.04255	0.19545	-0.03320	-0.06542	-0.20293	0.21406	0.14417	0.12644	0.07214	1.00000
	0.6615	0.1326	0.1068	0.7716	0.1312	0.7995	0.6164	0.1168	0.0976	0.2676	0.3315	0.5806	0.0000
	61	61	61	49	61	61	61	61	61	61	61	61	61

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PEARSON CORRELATION COEFFICIENTS / PROB > |R| UNDER HO:RHO=0 / NUMBER OF OBSERVATIONS

	NORESPUN	NATIONAL	LOCATION	NOBRANCH	NOEMPLOY	REGION	KEYINFOR	SRVOLUM	WORKACT	AVWORKSU	AVJOBSIZ	AVJOBDUR	QA1FAM
QA2SOU	0.03255 0.8034 61	0.04300 0.5148 61	0.03350 0.7977 61	-0.05836 0.6904 49	0.05414 0.6786 61	-0.10899 0.4031 61	0.21154 0.1011 61	-0.07039 0.5898 61	0.22789 0.0773 61	0.11796 0.3653 61	-0.17163 0.1860 61	-0.16722 0.1977 61	0.16486 0.2042 61
QA3MUSE	-0.01549 0.9057 61	0.11775 0.3661 61	0.02093 0.8728 61	0.08376 0.5672 49	0.22601 0.0799 61	-0.25881 0.0440 61	0.02854 0.8272 61	-0.19480 0.1325 61	0.21965 0.0890 61	0.05499 0.6738 61	0.12155 0.3507 61	-0.07659 0.5574 61	0.39785 0.0015 61
QA4COM	-0.15314 0.2387 61	0.20338 0.1159 61	0.22155 0.0862 61	0.03096 0.8327 49	0.12342 0.3433 61	0.01740 0.8941 61	0.13127 0.3132 61	-0.19193 0.1384 61	0.02130 0.8705 61	-0.08742 0.5029 61	0.17161 0.1860 61	0.00984 0.9400 61	0.03870 0.7671 61
QA5CPM	-0.09354 0.5182 50	0.08556 0.5501 50	0.31117 0.0278 50	0.20716 0.1880 42	0.03370 0.8163 50	0.14510 0.3147 50	0.21778 0.1287 50	-0.02825 0.8456 50	0.09198 0.5252 50	-0.13895 0.3359 50	-0.18331 0.2026 50	-0.17638 0.2205 50	-0.05930 0.6825 50
QA5PND	0.05389 0.8485 13	-0.31650 0.2921 13	0.29759 0.3234 13	0.10354 0.7619 11	0.08211 0.7897 13	-0.04346 0.8879 13	0.24364 0.4225 13	0.35796 0.2298 13	0.26353 0.3843 13	0.30925 0.3039 13	-0.28467 0.3458 13	-0.38799 0.1902 13	-0.23622 0.4372 13
QA5PERT	-0.34767 0.1447 19	-0.09934 0.6858 19	0.33945 0.1551 19	0.32136 0.2249 16	0.32112 0.1801 19	0.08338 0.7343 19	-0.02332 0.9245 19	-0.15327 0.5310 19	0.06442 0.7933 19	0.10132 0.6798 19	0.13798 0.5732 19	0.18611 0.4455 19	0.21651 0.3733 19
QA5GBC	0.13247 0.3443 53	-0.22630 0.1032 53	-0.17507 0.2099 53	-0.22978 0.1335 44	-0.06367 0.6506 53	-0.15252 0.2756 53	0.14203 0.3104 53	0.24618 0.0756 53	0.00945 0.9465 53	-0.09100 0.5169 53	-0.23285 0.0934 53	-0.21286 0.1259 53	-0.20453 0.1418 53
QA6CPM	0.11364 0.4419 48	-0.01399 0.9409 48	0.19516 0.1838 48	0.16064 0.3221 40	-0.02978 0.8407 48	0.00075 0.9960 48	-0.00126 0.9932 48	-0.14342 0.3308 48	0.12305 0.4047 48	0.08688 0.5571 48	0.02542 0.8638 48	0.11128 0.4515 48	0.05910 0.6899 48
QA6PND	-0.30381 0.3046 13	-0.32339 0.2811 13	0.10723 0.7273 13	0.34676 0.2961 11	-0.00859 0.9778 13	0.25578 0.3990 13	0.20759 0.4962 13	0.07249 0.8140 13	-0.60548 0.0283 13	-0.04237 0.8907 13	-0.22905 0.4516 13	-0.22649 0.4568 13	0.56740 0.0431 13
QA6PERT	0.16908 0.5469 15	-0.39521 0.1448 15	0.22235 0.4257 15	0.15979 0.6021 13	-0.40508 0.1342 15	-0.47623 0.0727 15	-0.12646 0.6534 15	0.54306 0.0364 15	-0.11657 0.6791 15	-0.31651 0.2504 15	-0.20995 0.4526 15	-0.39075 0.1498 15	-0.09257 0.7428 15
QA6GBC	0.04437 0.7548 52	-0.22695 0.1057 52	-0.19200 0.1727 52	-0.14784 0.3441 43	-0.02545 0.8578 52	-0.27604 0.0476 52	0.00636 0.9643 52	-0.03850 0.7864 52	-0.21113 0.1330 52	-0.03540 0.8032 52	-0.08187 0.5639 52	-0.13449 0.3418 52	0.12582 0.3741 52
QA7CPM	-0.01919 0.8981 47	-0.05432 0.7169 47	0.11093 0.4579 47	-0.03318 0.8411 39	-0.17999 0.2260 47	0.15499 0.2982 47	0.00612 0.9674 47	-0.20805 0.1605 47	0.02917 0.8457 47	0.22233 0.1331 47	0.08244 0.5817 47	-0.22034 0.1367 47	-0.04382 0.7699 47
QA7PND	-0.08606 0.7798 13	-0.48370 0.0940 13	0.03587 0.9074 13	0.16316 0.6317 11	0.22445 0.4610 13	0.07797 0.8001 13	-0.05545 0.8572 13	0.33311 0.2661 13	-0.35802 0.2297 13	-0.39853 0.1774 13	-0.22783 0.4541 13	-0.51479 0.0718 13	0.58173 0.0370 13

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PEARSON CORRELATION COEFFICIENTS / PROB > |R| UNDER HO:RHO=0 / NUMBER OF OBSERVATIONS

	NORESPUN	NATIONAL	LOCATION	NOBRANCH	NOEMPLOY	REGION	KEYINFOR	SRVOLUM	WORKACT	AVWORKSU	AVJOBSIZ	AVJOBCUR	QAIFAM
QA7PERT	-0.03990	-0.28881	0.11652	-0.07386	-0.49556	-0.38812	-0.17749	0.56792	0.00843	-0.32840	-0.35629	-0.45877	0.11136
	0.8792	0.2609	0.6561	0.7936	0.0431	0.1237	0.4955	0.0174	0.9744	0.1981	0.1604	0.0640	0.6705
	17	17	17	15	17	17	17	17	17	17	17	17	17
QA7GBC	-0.03395	0.01712	0.12961	0.20788	0.10331	0.06882	0.05849	-0.25592	0.05032	0.21629	0.07054	-0.08089	0.08156
	0.8093	0.9032	0.3550	0.1757	0.4616	0.6244	0.6774	0.0644	0.7205	0.1198	0.6157	0.5648	0.5615
	53	53	53	44	53	53	53	53	53	53	53	53	53
QB1CPM	0.23758	0.19810	0.13480	0.07936	0.09898	-0.23177	-0.01879	-0.01218	0.15624	0.06790	-0.02264	-0.06363	0.31331
	0.1040	0.1771	0.3610	0.6264	0.5033	0.1130	0.8991	0.9345	0.2889	0.6465	0.8786	0.6674	0.0301
	48	48	48	40	48	48	48	48	48	48	48	48	48
QB1PND	0.25770	-0.49419	-0.62260	-0.16367	-0.23813	-0.16056	0.59876	0.06732	-0.12877	0.29216	-0.07475	-0.04172	0.46145
	0.4187	0.1024	0.0306	0.6306	0.4561	0.6181	0.0397	0.8353	0.6900	0.3568	0.8174	0.8976	0.1310
	12	12	12	11	12	12	12	12	12	12	12	12	12
QB1PERT	0.30264	0.09370	0.27792	-0.00324	-0.47768	-0.24123	-0.04639	0.46486	-0.04586	-0.17561	-0.22772	-0.45067	0.20562
	0.2222	0.7204	0.2642	0.9909	0.0450	0.3349	0.8550	0.0519	0.8566	0.4858	0.3634	0.0605	0.4130
	18	18	18	15	18	18	18	18	18	18	18	18	18
QB1GBC	0.45142	0.08084	-0.07051	0.08265	-0.05663	-0.11352	0.14822	-0.01886	0.10082	-0.24921	-0.07474	-0.09586	0.21587
	0.0007	0.5650	0.6159	0.5938	0.6871	0.4183	0.2895	0.8933	0.4726	0.0719	0.5948	0.4947	0.1206
	53	53	53	44	53	53	53	53	53	53	53	53	53
QB2CPM	0.02896	0.16816	0.13736	-0.06178	-0.18363	-0.10655	-0.16925	-0.10381	0.06084	-0.17859	0.04403	0.19133	-0.02588
	0.8592	0.2996	0.3980	0.7285	0.2567	0.5128	0.2965	0.5238	0.7092	0.2702	0.7873	0.2369	0.8741
	40	40	40	34	40	40	40	40	40	40	40	40	40
QB2PND	-0.54525	0.04951	0.50161	0.25559	0.18843	0.18002	-0.69923	0.13334	0.37874	-0.15794	-0.40716	-0.34340	-0.18700
	0.0828	0.8851	0.1159	0.4760	0.5790	0.5963	0.0166	0.6959	0.2507	0.6428	0.2139	0.3012	0.5819
	11	11	11	10	11	11	11	11	11	11	11	11	11
QB2PERT	-0.08911	0.05985	0.45161	0.13439	0.06425	0.19489	-0.05851	-0.49242	-0.04373	-0.16900	-0.03446	-0.03317	0.21255
	0.7722	0.8460	0.1213	0.6771	0.8348	0.5234	0.8494	0.0874	0.8872	0.5810	0.9110	0.9143	0.4857
	13	13	13	12	13	13	13	13	13	13	13	13	13
QB2GBC	-0.25338	0.19727	0.19343	-0.06276	0.00067	-0.14385	-0.32740	-0.09136	-0.06214	0.06217	0.10845	0.14376	-0.03024
	0.0970	0.1993	0.2084	0.7082	0.9965	0.3516	0.0301	0.5553	0.6887	0.6885	0.4835	0.3519	0.8455
	44	44	44	38	44	44	44	44	44	44	44	44	44
QB3CPM	0.12642	-0.03181	-0.08482	0.02324	-0.00193	-0.01765	0.13714	-0.04069	0.24280	-0.08974	-0.16020	-0.07233	-0.03618
	0.4025	0.8338	0.5752	0.8883	0.9899	0.9073	0.3634	0.7883	0.1040	0.5531	0.2875	0.6329	0.8113
	46	46	46	39	46	46	46	46	46	46	46	46	46
QB3PND	-0.01044	0.17513	-0.24272	-0.27521	-0.24818	0.21065	0.11602	-0.25554	-0.04274	-0.31763	-0.26896	0.01038	0.37184
	0.9743	0.5862	0.4472	0.4415	0.4367	0.5111	0.7195	0.4228	0.8951	0.3144	0.3979	0.9745	0.2340
	12	12	12	10	12	12	12	12	12	12	12	12	12
QB3PERT	0.45937	0.13358	0.05173	-0.04359	-0.18898	0.01451	-0.19195	0.28121	0.18255	-0.13625	-0.02028	-0.23100	0.33674
	0.0734	0.4587	0.8491	0.8774	0.4833	0.9575	0.4763	0.2914	0.4986	0.6149	0.9406	0.3894	0.2022
	16	16	16	15	16	16	16	16	16	16	16	16	16

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PEARSON CORRELATION COEFFICIENTS / PROB > |R| UNDER HO:RHO=0 / NUMBER OF OBSERVATIONS

	NORESPON	NATIONAL	LOCATION	NORRANCH	NOEMPLOY	REGION	KEYINFOR	SRVOLUM	WORKACT	AVWORKSU	AVJOBSIZ	AVJOBDUR	QAIFAN
Q83GHC	0.01471	0.12509	-0.20445	-0.06162	0.09057	-0.12681	0.06030	-0.23522	-0.06183	-0.09111	0.05363	-0.14328	0.14606
	0.9331	0.4740	0.2387	0.7509	0.6049	0.4679	0.7308	0.1738	0.7242	0.6027	0.7596	0.4116	0.4025
	35	35	35	29	35	35	35	35	35	35	35	35	35
Q84CPM	0.04002	0.16931	0.16715	0.18091	0.05951	0.03555	0.07497	-0.01277	0.06645	-0.19129	-0.08554	0.09057	0.06441
	0.7871	0.2500	0.2562	0.2639	0.6878	0.8104	0.6125	0.9314	0.6536	0.1928	0.5632	0.5404	0.6636
	48	48	48	40	48	48	48	48	48	48	48	48	48
Q84PND	-0.13197	-0.39528	-0.07204	-0.01351	0.03201	0.36515	0.32230	0.34179	0.36479	0.22942	-0.55849	-0.52467	-0.20927
	0.6827	0.2034	0.8239	0.9705	0.9213	0.2432	0.3069	0.2769	0.2437	0.4732	0.0591	0.0799	0.5139
	12	12	12	10	12	12	12	12	12	12	12	12	12
Q84PERT	0.10514	-0.23570	-0.14803	0.28022	-0.04201	0.17743	-0.09667	0.33672	0.31426	0.11609	-0.10557	-0.01473	0.10259
	0.6880	0.3624	0.5707	0.3117	0.8728	0.4957	0.7121	0.1863	0.2193	0.6573	0.6868	0.9553	0.6952
	17	17	17	15	17	17	17	17	17	17	17	17	17
Q84GBC	-0.05993	-0.04775	-0.14283	-0.11223	-0.25409	-0.07641	0.27782	0.18195	-0.00744	0.12756	-0.31300	-0.18979	-0.00676
	0.6793	0.7419	0.3224	0.4848	0.0750	0.5979	0.0508	0.2060	0.9591	0.3774	0.0269	0.1868	0.9628
	50	50	50	41	50	50	50	50	50	50	50	50	50
Q85CPM	0.08546	-0.03771	0.01917	0.21040	0.25016	0.27993	0.03132	0.17389	0.01150	-0.05448	-0.14582	0.06022	0.03105
	0.5551	0.5447	0.8949	0.1811	0.0798	0.0490	0.8290	0.2271	0.9368	0.7071	0.3123	0.6778	0.8305
	50	50	50	42	50	50	50	50	50	50	50	50	50
Q85PND	-0.06680	-0.39853	0.22707	0.55709	0.48575	0.32203	0.04967	0.16948	0.16087	0.41007	-0.08032	-0.26961	-0.26734
	0.8453	0.2247	0.5019	0.0943	0.1298	0.3342	0.8847	0.6184	0.6365	0.2103	0.8144	0.4227	0.4268
	11	11	11	10	11	11	11	11	11	11	11	11	11
Q85PERT	0.06318	-0.09260	-0.20655	-0.30138	0.23267	-0.17743	-0.31291	0.05051	-0.41189	0.11609	0.11877	0.11049	0.01954
	0.8096	0.7237	0.4264	0.2750	0.3688	0.4957	0.2214	0.8473	0.1004	0.6573	0.6498	0.6729	0.9407
	17	17	17	15	17	17	17	17	17	17	17	17	17
Q85GBC	0.02661	-0.08491	0.13398	0.03783	-0.06235	0.13582	-0.10474	0.14678	-0.04934	0.07748	-0.07647	0.12423	-0.21079
	0.8530	0.5536	0.3486	0.8120	0.6638	0.3420	0.4645	0.3040	0.7310	0.5889	0.5938	0.3851	0.1376
	51	51	51	42	51	51	51	51	51	51	51	51	51
Q85CPM	-0.01143	0.03282	0.13302	0.20383	0.03314	-0.06231	-0.10015	-0.07734	0.15067	0.10287	-0.06141	-0.29583	0.36915
	0.9390	0.8263	0.3727	0.2071	0.8250	0.6774	0.5030	0.6053	0.3121	0.4914	0.6818	0.0435	0.0107
	47	47	47	40	47	47	47	47	47	47	47	47	47
Q86PND	0.23916	-0.14220	-0.39775	-0.13800	-0.02000	-0.07387	-0.12153	0.00000	-0.01640	-0.13506	0.04299	0.17760	0.31797
	0.4788	0.6766	0.2257	0.7038	0.9535	0.8291	0.7219	1.0000	0.9618	0.6921	0.9001	0.6014	0.3406
	11	11	11	10	11	11	11	11	11	11	11	11	11
Q85PERT	0.33712	0.10856	0.00079	0.02528	-0.35352	-0.19116	-0.39909	0.36105	0.00744	-0.37244	-0.37335	-0.65920	0.11969
	0.2016	0.6890	0.9977	0.9316	0.1792	0.4782	0.1257	0.1695	0.9782	0.1554	0.1543	0.0055	0.6588
	16	16	16	14	16	16	16	16	16	16	16	16	16
Q86GBC	-0.05273	0.20763	0.21222	0.22273	0.08388	-0.22751	-0.04399	-0.13521	0.01206	-0.18747	0.03823	-0.20614	0.10675
	0.7133	0.1437	0.1349	0.1563	0.5584	0.1084	0.7592	0.3441	0.9331	0.1877	0.7900	0.1467	0.4559
	51	51	51	42	51	51	51	51	51	51	51	51	51

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SAS   11:36 MONDAY, FEBRUARY 12, 1990   29

PEARSON CORRELATION COEFFICIENTS / PROB > |R| UNDER HO:RHO=0 / NUMBER OF OBSERVATIONS

	NORESPON	NATIONAL	LOCATION	NOBRANCH	NCEMPLCY	REGION	KEYINFOR	SRVOLUM	WORKACT	AVWORKSU	AVJOBSIZ	AVJOBDUR	QA1FAM
QB7CPM	0.08346	-0.14294	0.02750	0.08376	0.26301	0.17005	0.25759	-0.14147	0.33365	0.15124	-0.01191	-0.06856	0.30276
	0.5686	0.3272	0.8512	0.6026	0.0679	0.2427	0.0740	0.3322	0.0191	0.2996	0.9353	0.6397	0.0345
	49	49	49	41	49	49	49	49	49	49	49	49	49
QB7PND	-0.06294	-0.43662	-0.37134	0.00629	-0.13239	0.02071	0.15880	0.21535	-0.39774	0.12906	-0.39616	-0.14336	0.39596
	0.8459	0.1559	0.2347	0.9862	0.6817	0.9491	0.6220	0.5015	0.2004	0.6893	0.2024	0.6567	0.2026
	12	12	12	10	12	12	12	12	12	12	12	12	12
QB7PERT	0.09344	0.07518	0.18920	-0.38351	-0.45928	0.00209	-0.36136	0.32791	0.10637	0.02784	-0.24225	-0.51262	0.33143
	0.7213	0.7743	0.4671	0.1582	0.0636	0.9936	0.1541	0.1988	0.6845	0.9155	0.3489	0.0354	0.1938
	17	17	17	15	17	17	17	17	17	17	17	17	17
QB7GBC	0.03167	-0.14819	-0.10310	0.09152	0.13570	-0.15170	0.30296	-0.09992	0.18591	-0.10129	-0.06455	-0.00945	-0.00577
	0.8272	0.3044	0.4761	0.5693	0.3474	0.2930	0.0325	0.4900	0.1961	0.4840	0.6560	0.9481	0.9683
	50	50	50	41	50	50	50	50	50	50	50	50	50
QB8CPM	-0.21919	-0.20598	0.11879	0.24973	0.17247	0.13533	0.22837	0.02854	0.07670	0.12041	-0.12235	-0.20256	0.11364
	0.1579	0.1851	0.4480	0.1419	0.2688	0.3869	0.1408	0.8558	0.6249	0.4418	0.4344	0.1927	0.4681
	43	43	43	36	43	43	43	43	43	43	43	43	43
QB8PND	-0.53385	-0.44689	-0.14392	-0.24209	-0.41955	-0.06870	-0.14150	0.63150	-0.03512	-0.06667	-0.71683	-0.51316	0.33035
	0.1120	0.1954	0.6916	0.5635	0.2274	0.8504	0.6966	0.0502	0.9233	0.8548	0.0197	0.1293	0.3512
	10	10	10	8	10	10	10	10	10	10	10	10	10
QB8PERT	-0.17702	-0.14116	0.35384	-0.13624	-0.09815	-0.20796	-0.30118	0.18182	-0.17516	-0.21990	-0.07822	-0.40337	0.24131
	0.5119	0.6020	0.1788	0.6423	0.7176	0.4396	0.2570	0.5004	0.5164	0.4132	0.7734	0.1213	0.3679
	16	16	16	14	16	16	16	16	16	16	16	16	16
QB8GBC	-0.46737	-0.17117	0.06275	0.13019	0.02498	-0.08129	0.04932	0.06196	-0.16909	-0.02406	-0.21783	-0.29536	-0.13443
	0.0021	0.2846	0.6967	0.4560	0.8768	0.6134	0.7594	0.7003	0.2906	0.8813	0.1713	0.0608	0.4020
	41	41	41	35	41	41	41	41	41	41	41	41	41

	QA2SOU	QA3MUSE	QA4COM	QA5CPM	QA5PND	QA5PERT	QA5GBC	QA6CPM	QA6PND	QA6PERT	QA6GBC	QA7CPM	QA7PND
NORESPON	0.03255	-0.01549	-0.15314	-0.09354	0.05889	-0.34767	0.13247	0.11364	-0.30881	0.16908	0.04437	-0.01919	-0.08606
	0.8034	0.9057	0.2387	0.5182	0.8485	0.1447	0.3443	0.4419	0.3046	0.5469	0.7548	0.8981	0.7798
	61	61	61	50	13	19	53	48	13	15	52	47	13
NATIONAL	0.08500	0.11775	0.20338	0.08656	-0.31650	-0.09934	-0.22630	-0.01099	-0.32339	-0.39521	-0.22695	-0.05432	-0.48370
	0.5148	0.3661	0.1159	0.5501	0.2921	0.6858	0.1032	0.9409	0.2811	0.1448	0.1057	0.7169	0.0940
	61	61	61	50	13	19	53	48	13	15	52	47	13
LOCATION	0.03350	0.02093	0.22155	0.31117	0.29759	0.33945	-0.17507	0.19516	0.10723	0.22235	-0.19200	0.11093	0.03587
	0.7977	0.8728	0.0862	0.0278	0.3234	0.1551	0.2099	0.1838	0.7273	0.4257	0.1727	0.4579	0.9074
	61	61	61	50	13	19	53	48	13	15	52	47	13
NOBRANCH	-0.05836	0.03376	0.03096	0.20716	0.10354	0.32136	-0.22979	0.16064	0.34676	0.15979	-0.14784	-0.03318	0.16316
	0.6904	0.5672	0.8327	0.1880	0.7619	0.2249	0.1335	0.3221	0.2961	0.6021	0.3441	0.8411	0.6317
	49	49	49	42	11	16	44	40	11	13	43	39	11
NCEMPLCY	0.03414	0.22601	0.12342	0.03370	0.08211	0.32112	-0.06367	-0.02978	-0.00859	-0.40508	-0.02545	-0.17999	0.22445
	0.6786	0.0799	0.3433	0.8163	0.7897	0.1801	0.6506	0.8407	0.9778	0.1342	0.8578	0.2260	0.4610
	61	61	61	50	13	19	53	48	13	15	52	47	13

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	QA2SOU	QA3MUSE	QA4COM	QA5CPM	QA5PND	QA5PERT	QA5GBC	QA6CPM	QA6PND	QA6PERT	QA6GBC	QA7CPM	QA7PND
REGION	-0.10899	-0.25881	0.01740	0.14510	-0.04346	0.08338	-0.15252	0.00075	0.25578	-0.47623	-0.27604	0.15499	0.07797
	0.4031	0.0440	0.8941	0.3147	0.8879	0.7343	0.2756	0.9960	0.3990	0.0727	0.0476	0.2982	0.8001
	61	61	61	50	13	19	53	48	13	15	52	47	13
KEYINFOR	0.21194	0.02854	0.13127	0.21778	0.24364	-0.02332	0.14203	-0.00126	0.20759	-0.12646	0.00636	0.00612	-0.05545
	0.1011	0.8272	0.3132	0.1287	0.4225	0.9245	0.3104	0.9932	0.4962	0.6534	0.9643	0.9674	0.8572
	61	61	61	50	13	19	53	48	13	15	52	47	13
SRVOLUM	-0.07039	-0.19480	-0.19193	-0.02825	0.35796	-0.15327	0.24618	-0.14342	0.07249	0.54306	-0.03850	-0.20805	0.33311
	0.5898	0.1325	0.1384	0.8456	0.2298	0.5310	0.0756	0.3308	0.8140	0.0364	0.7864	0.1605	0.2661
	61	61	61	50	13	19	53	48	13	15	52	47	13
WORKACT	0.22789	0.21965	0.02130	0.09198	0.26353	0.06442	0.00945	0.12305	-0.60548	-0.11657	-0.21113	0.02917	-0.35802
	0.0773	0.0890	0.8705	0.5252	0.3843	0.7933	0.9465	0.4047	0.0283	0.6791	0.1330	0.8457	0.2297
	61	61	61	50	13	19	53	48	13	15	52	47	13
AVWORKSU	0.11796	0.05499	-0.08742	-0.13895	0.30925	0.10132	-0.09100	0.08688	-0.04237	-0.31651	-0.03540	0.22233	-0.39853
	0.3653	0.6738	0.5029	0.3359	0.3039	0.6798	0.5169	0.5571	0.8907	0.2504	0.8032	0.1331	0.1774
	61	61	61	50	13	19	53	48	13	15	52	47	13
AVJOBSIZ	-0.17163	0.12155	0.17161	-0.18331	-0.28467	0.13798	-0.23285	0.02542	-0.22905	-0.20995	-0.08187	0.08244	-0.22783
	0.1860	0.3507	0.1860	0.2026	0.3458	0.5732	0.0934	0.8638	0.4516	0.4526	0.5639	0.5817	0.4541
	61	61	61	50	13	19	53	48	13	15	52	47	13
AVJOBDUR	-0.16722	-0.07659	0.00984	-0.17638	-0.38799	0.18611	-0.21286	0.11128	-0.22649	-0.39075	-0.13449	-0.22034	-0.51479
	0.1977	0.5574	0.9400	0.2205	0.1902	0.4455	0.1259	0.4515	0.4568	0.1498	0.3418	0.1367	0.0718
	61	61	61	50	13	19	53	48	13	15	52	47	13
QA1FAM	0.16486	0.39785	0.03870	-0.05930	-0.23622	0.21651	-0.20453	0.05910	0.56740	-0.09257	0.12582	-0.04382	0.58173
	0.2042	0.0015	0.7671	0.6825	0.4372	0.3733	0.1418	0.6899	0.0431	0.7428	0.3741	0.7699	0.0370
	61	61	61	50	13	19	53	48	13	15	52	47	13
QA2SOU	1.00000	0.09514	-0.11389	0.13587	0.05756	-0.00316	-0.12686	0.06635	0.25931	0.04291	0.25481	0.09095	-0.37605
	0.0000	0.4658	0.3821	0.3468	0.8518	0.9898	0.3654	0.6541	0.3923	0.8793	0.0683	0.5432	0.2054
	61	61	61	50	13	19	53	48	13	15	52	47	13
QA3MUSE	0.09514	1.00000	0.22520	0.10400	0.00000	-0.16002	-0.07231	0.05996	-0.33039	0.43058	0.08357	-0.19545	0.19665
	0.4658	0.0000	0.0810	0.4723	1.0000	0.5129	0.6069	0.6856	0.2702	0.1091	0.5559	0.1880	0.5196
	61	61	61	50	13	19	53	48	13	15	52	47	13
QA4COM	-0.11389	0.22520	1.00000	0.04674	-0.07096	0.01117	0.03108	-0.17144	-0.03891	0.12600	-0.11714	0.00241	0.45459
	0.3821	0.0810	0.0000	0.7472	0.8178	0.9638	0.8252	0.2440	0.8996	0.6546	0.4082	0.9872	0.1186
	61	61	61	50	13	19	53	48	13	15	52	47	13
QA5CPM	0.13587	0.10400	0.04674	1.00000	0.37771	0.23781	0.28760	-0.12507	0.27834	0.27104	-0.31044	-0.04845	0.17321
	0.3468	0.4723	0.7472	0.0000	0.2521	0.3580	0.0648	0.3970	0.4072	0.3704	0.0482	0.7464	0.6105
	50	50	50	50	11	17	42	48	11	13	41	47	11
QA5PND	0.05756	0.00000	-0.07096	0.37771	1.00000	0.80296	0.54980	0.20346	0.13340	0.58282	0.21217	0.60698	0.32639
	0.8518	1.0000	0.8178	0.2521	0.0000	0.0544	0.0640	0.5729	0.6639	0.3024	0.5311	0.0830	0.2764
	13	13	13	11	13	6	12	10	13	5	11	9	13

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	QA2SOU	QA3NUSE	QA4CON	QA5CPM	QA5PND	QA5PERT	QA5GBC	QA6CPM	QA6PND	QA6PERT	QA6GBC	QA7CPM	QA7PND
QA5PERT	-0.00316	-0.16002	0.01117	0.23781	0.80296	1.00000	-0.03047	0.11536	0.94293	-0.11411	-0.13397	0.39656	0.60321
	0.9898	0.5129	0.9638	0.3580	0.0544	0.0000	0.9108	0.6823	0.0048	0.6855	0.6208	0.1604	0.2049
	19	19	19	17	6	19	16	15	6	15	16	14	6
QA5GBC	-0.12686	-0.07231	0.03108	0.28760	0.54980	-0.03047	1.00000	-0.27114	-0.22428	-0.39545	-0.40344	-0.11902	0.32630
	0.3654	0.6069	0.8252	0.0648	0.0640	0.9108	0.0000	0.0906	0.4834	0.1811	0.0030	0.4705	0.3006
	53	53	53	42	12	16	53	40	12	13	52	39	12
QA6CPM	0.06635	0.05996	-0.17144	-0.12597	0.20346	0.11536	-0.27114	1.00000	0.44422	0.65065	0.35532	0.36751	-0.20961
	0.6541	0.6856	0.2440	0.3970	0.5729	0.6823	0.0906	0.0000	0.1984	0.0302	0.0264	0.0110	0.5611
	48	48	48	48	10	15	40	48	10	11	39	47	10
QA6PND	0.25931	-0.33039	-0.03891	0.27834	0.13340	0.94293	-0.22428	0.44422	1.00000	0.49411	0.34801	0.53918	0.26518
	0.3923	0.2702	0.8996	0.4072	0.6639	0.0048	0.4834	0.1984	0.0000	0.3975	0.2943	0.1341	0.3812
	13	13	13	11	13	6	12	10	13	5	11	9	13
QA6PERT	0.04291	0.43058	0.12600	0.27104	0.58282	-0.11411	-0.39545	0.65065	0.49411	1.00000	0.54580	0.56075	0.98821
	0.8793	0.1091	0.6546	0.3704	0.3024	0.6855	0.1811	0.0302	0.3975	0.0000	0.0537	0.0727	0.0015
	15	15	15	13	5	15	13	11	5	15	13	11	5
QA6GBC	0.25481	0.08357	-0.11714	-0.31044	0.21217	-0.13397	-0.40344	0.35532	0.34801	0.54580	1.00000	0.28653	0.17991
	0.0683	0.5559	0.4082	0.0482	0.5311	0.6208	0.0030	0.0264	0.2943	0.0537	0.0000	0.0811	0.5966
	52	52	52	41	11	16	52	39	11	13	52	38	11
QA7CPM	0.09095	-0.19545	0.00241	-0.04845	0.60698	0.39656	-0.11902	0.36751	0.53918	0.56075	0.28653	1.00000	0.60567
	0.5432	0.1880	0.9872	0.7464	0.0830	0.1604	0.4705	0.0110	0.1341	0.0727	0.0811	0.0000	0.0839
	47	47	47	47	9	14	39	47	9	11	38	47	9
QA7PND	-0.37605	0.19665	0.45459	0.17321	0.32639	0.60321	0.32630	-0.20961	0.26518	0.98821	0.17991	0.60567	1.00000
	0.2054	0.5196	0.1186	0.6105	0.2764	0.2049	0.3006	0.5611	0.3812	0.0015	0.5966	0.0839	0.0000
	13	13	13	11	13	6	12	10	13	5	11	9	13
QA7PERT	0.18071	0.43425	0.28181	0.10417	0.45316	-0.01072	-0.43971	0.28480	0.18921	0.93818	0.48186	0.61073	0.44634
	0.4876	0.0816	0.2731	0.7118	0.3668	0.9674	0.1010	0.3237	0.7196	0.0001	0.0689	0.0266	0.3749
	17	17	17	15	6	17	15	14	6	14	15	13	6
QA7GBC	0.12610	-0.10550	0.12205	-0.22948	0.53150	0.22087	-0.21235	0.33653	0.39863	0.18039	0.28934	0.83792	0.56124
	0.3683	0.4521	0.3840	0.1438	0.0753	0.4111	0.1269	0.0337	0.1993	0.5554	0.0375	0.0001	0.0576
	53	53	53	42	12	16	53	40	12	13	52	39	12
QB1CPM	0.06792	0.10314	0.09914	-0.08627	-0.04078	0.19069	-0.00722	0.11087	0.04806	0.16717	0.06707	0.18971	0.34671
	0.6465	0.4854	0.5026	0.5642	0.9170	0.5137	0.9647	0.4582	0.9023	0.6232	0.6850	0.2015	0.3607
	48	48	48	47	9	14	40	47	9	11	39	47	9
QB1PND	0.16428	-0.19227	-0.15264	-0.62106	0.00201	-0.03769	0.03424	0.27022	0.29196	0.38227	0.52719	0.55246	0.23147
	0.6099	0.5494	0.6358	0.0553	0.9951	0.9435	0.9204	0.4819	0.3571	0.5254	0.1174	0.1556	0.4691
	12	12	12	10	12	6	11	9	12	5	10	8	12
QB1PERT	0.00414	0.14447	0.00631	0.12157	-0.04464	0.00963	0.33952	0.02705	0.13980	0.34330	-0.09230	0.09505	0.84590
	0.9870	0.5674	0.9802	0.6538	0.9331	0.9698	0.2157	0.9238	0.7917	0.2295	0.7435	0.7465	0.0338
	18	18	18	16	6	18	15	15	6	14	15	14	6

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	QA2SUU	QA3MUSE	QA4CON	QA5CPM	QA5PND	QA5PERT	QA5GBC	QA6CPM	QA6PND	QA6PERT	QA6GBC	QA7CPM	QA7PND
QB1GBC	0.03860	0.01045	0.00439	-0.12393	0.07141	-0.24794	0.09588	0.19413	0.38885	0.11394	0.11023	0.22572	0.56842
	0.7838	0.9408	0.9751	0.4342	0.8347	0.3545	0.4989	0.2300	0.2372	0.7109	0.4366	0.1671	0.0681
	53	53	53	42	11	16	52	40	11	13	52	39	11
QB2CPM	-0.09414	-0.08309	0.12936	0.05366	-0.09304	-0.02689	-0.04654	0.09420	-0.39712	-0.04013	-0.11303	-0.15463	-0.06786
	0.5634	0.6102	0.4263	0.7456	0.8427	0.9339	0.7971	0.5684	0.3777	0.9184	0.5311	0.3473	0.8851
	40	40	40	39	7	12	33	39	7	9	33	39	7
QB2PND	-0.04210	-0.13190	0.53662	0.59662	0.30600	0.00000	0.62470	-0.20038	-0.23445	0.32275	-0.28868	0.23993	0.22796
	0.9022	0.6991	0.0888	0.0899	0.3601	1.0000	0.0535	0.6342	0.4877	0.5963	0.4186	0.6043	0.5002
	11	11	11	9	11	6	10	8	11	5	10	7	11
QB2PERT	0.20878	-0.33122	-0.16470	0.59701	-0.24343	-0.14556	0.74624	0.17355	0.04837	-0.29820	-0.31562	-0.21044	0.00000
	0.4936	0.2690	0.5908	0.0404	0.7566	0.6352	0.0083	0.6098	0.9516	0.3731	0.3444	0.5345	1.0000
	13	13	13	12	4	13	11	11	4	11	11	11	4
QB2GBC	-0.14625	0.09796	0.10949	0.10010	-0.02311	0.14121	-0.04010	-0.02862	-0.21974	-0.41201	-0.11720	-0.06040	0.16922
	0.3435	0.5702	0.4792	0.5673	0.9529	0.6454	0.7985	0.8744	0.5700	0.2368	0.4542	0.7426	0.6634
	44	44	44	35	9	13	43	33	9	10	43	32	9
QB3CPM	0.34274	0.08088	0.00826	0.21094	0.01105	-0.04285	-0.02224	0.09846	0.16352	0.04790	-0.07163	-0.12998	-0.29315
	0.0197	0.5931	0.9565	0.1642	0.9775	0.8795	0.8946	0.5199	0.6742	0.8888	0.6736	0.4004	0.4439
	46	46	46	45	9	15	38	45	9	11	37	44	9
QB3PND	0.46038	-0.09421	0.06591	0.13496	-0.47979	-0.56254	-0.52292	0.32070	0.07390	0.35498	0.21269	-0.07291	-0.22607
	0.1320	0.7709	0.8387	0.7101	0.1144	0.2452	0.0988	0.4001	0.8195	0.5577	0.5552	0.8638	0.4799
	12	12	12	10	12	6	11	9	12	5	10	8	12
QB3PERT	0.27192	-0.25327	-0.48079	0.28766	-0.27911	-0.01511	0.07173	0.01904	-0.15098	0.05251	-0.12481	0.01480	0.64006
	0.3083	0.3341	0.0594	0.3186	0.6493	0.9557	0.8075	0.9508	0.8085	0.8647	0.6707	0.9636	0.2447
	16	16	16	14	5	16	14	13	5	13	14	12	5
QB3GBC	0.07610	0.37098	0.13919	0.45418	-0.73621	-0.57735	0.00269	-0.21260	0.17912	-0.00861	-0.00867	-0.14865	0.13277
	0.6639	0.0282	0.4252	0.0198	0.0952	0.1036	0.9879	0.3076	0.7342	0.9839	0.9612	0.4782	0.8020
	35	35	35	26	6	9	34	25	6	8	34	25	6
QB4CPM	-0.05086	0.02605	0.02492	0.44188	-0.06250	0.00000	0.00843	-0.14271	0.05000	-0.03348	-0.13204	-0.35492	0.30151
	0.7314	0.8605	0.8665	0.0019	0.8731	1.0000	0.9588	0.3386	0.8984	0.9221	0.4230	0.0155	0.4304
	48	48	48	47	9	15	40	47	9	11	39	46	9
QB4PND	0.17370	-0.08165	-0.36179	0.40109	0.56195	0.30619	0.15658	0.35255	0.15250	-0.32275	0.35355	0.44361	-0.03842
	0.5893	0.8008	0.2478	0.2507	0.0572	0.5551	0.6457	0.3521	0.6361	0.5963	0.3162	0.2709	0.9056
	12	12	12	10	12	6	11	9	12	5	10	8	12
QB4PERT	-0.04049	0.01325	-0.23533	0.08983	-0.13245	0.32593	-0.04029	0.17911	0.10370	-0.07604	-0.00268	0.42026	0.09950
	0.8774	0.9597	0.3632	0.7502	0.8025	0.2017	0.8866	0.5401	0.8450	0.7961	0.9924	0.1528	0.8512
	17	17	17	15	6	17	15	14	6	14	15	13	6
QB4GBC	-0.11945	0.11054	-0.24081	0.30986	0.63427	0.30177	0.25365	0.02223	0.00683	-0.32611	-0.10477	-0.01172	0.24929
	0.4087	0.4447	0.0921	0.0549	0.0489	0.2744	0.0786	0.8961	0.9851	0.3009	0.4737	0.9459	0.4873
	50	50	50	39	10	15	49	37	10	12	49	36	10

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PEARSON CORRELATION COEFFICIENTS / PROB > |R| UNDER HO:RHO=0 / NUMBER OF OBSERVATIONS

	QA2SUU	QA3MUSE	QA4CON	QA5CPM	QA5PND	QA5PERT	QA5GBC	QA6CPM	QA6PND	QA6PERT	QA6GBC	QA7CPM	QA7PND
QB5CPM	-0.26417	0.04035	-0.02738	0.30284	0.24845	0.04957	0.29102	-0.12930	0.04772	-0.26171	-0.22792	-0.33301	0.45124
	0.0638	0.7809	0.8503	0.0344	0.4888	0.8553	0.0615	0.3811	0.8959	0.4113	0.1518	0.0222	0.1905
	50	50	50	49	10	16	42	48	10	12	41	47	10
QB5PND	-0.39923	-0.11524	-0.09515	0.11180	0.66147	0.57735	0.58835	-0.20672	0.20607	-0.32275	0.01552	0.54290	0.29993
	0.2238	0.7358	0.7808	0.7746	0.0267	0.2302	0.0736	0.6233	0.5433	0.5963	0.9684	0.2079	0.3702
	11	11	11	9	11	6	10	8	11	5	9	7	11
QB5PERT	-0.19932	-0.13692	-0.23533	-0.04222	0.28098	0.12805	0.04029	-0.29299	0.54993	-0.23187	0.08308	-0.35464	0.35180
	0.4431	0.6003	0.3632	0.8812	0.5896	0.6243	0.8866	0.3094	0.2583	0.4251	0.7685	0.2344	0.4941
	17	17	17	15	6	17	15	14	6	14	15	13	6
QB5GBC	-0.37012	-0.29778	-0.09640	0.02265	0.62963	-0.02822	0.18867	0.21204	0.00000	-0.42100	-0.08155	-0.12654	0.04840
	0.0075	0.0338	0.5010	0.8896	0.0379	0.9205	0.1895	0.2012	1.0000	0.1729	0.5734	0.4555	0.8876
	51	51	51	40	11	15	50	38	11	12	50	37	11
QB6CPM	0.23490	0.19438	0.03306	-0.04106	-0.02624	-0.23295	-0.08858	0.20555	-0.07004	0.29679	0.27906	0.22438	0.35120
	0.1120	0.1904	0.8254	0.7864	0.9508	0.4229	0.5901	0.1706	0.8691	0.3755	0.0898	0.1338	0.3936
	47	47	47	46	8	14	39	46	8	11	38	46	8
QB6PND	-0.15935	-0.03524	0.42945	-0.57150	-0.38126	-0.45303	0.07309	-0.04134	-0.22058	0.17642	-0.03942	0.16589	0.34399
	0.6398	0.9181	0.1875	0.1079	0.2473	0.3669	0.8410	0.9226	0.5146	0.7765	0.9198	0.7222	0.3003
	11	11	11	9	11	6	10	8	11	5	9	7	11
QB6PERT	0.08621	0.21398	-0.25702	0.25805	-0.36116	-0.52986	0.36309	-0.19069	-0.22964	0.20993	0.11907	-0.22767	-0.40825
	0.7509	0.4152	0.3366	0.3731	0.5504	0.0348	0.2020	0.5326	0.7102	0.4713	0.6852	0.4544	0.4950
	16	16	16	14	5	16	14	13	5	14	14	13	5
QB6GBC	0.29930	0.37288	0.29595	0.12752	0.17440	-0.23378	-0.10400	0.07942	0.36439	0.22178	0.21704	-0.05783	0.09768
	0.0329	0.0070	0.0350	0.4269	0.6080	0.4017	0.4723	0.6308	0.2706	0.4885	0.1300	0.7302	0.7751
	51	51	51	41	11	15	50	39	11	12	50	38	11
QB7CPM	0.40790	0.21659	-0.05345	-0.00607	0.17541	0.11693	-0.13163	0.05669	0.62497	-0.09248	0.15972	0.15982	0.57998
	0.0036	0.1350	0.7153	0.9673	0.6517	0.6781	0.4120	0.7051	0.0719	0.7750	0.3249	0.2832	0.1016
	49	49	49	48	9	15	41	47	9	12	40	47	9
QB7PND	0.09545	-0.34509	0.12672	-0.55398	-0.02112	0.00000	0.25265	0.45870	0.48260	0.63117	0.15682	0.42961	0.28901
	0.7679	0.2719	0.6947	0.0966	0.9481	1.0000	0.4535	0.1824	0.1120	0.3688	0.6653	0.2485	0.3623
	12	12	12	10	12	5	11	10	12	4	10	9	12
QB7PERT	0.47892	-0.34855	-0.33601	-0.08403	0.36116	-0.12118	0.12791	-0.13634	0.16585	-0.03304	0.04287	0.31115	0.91856
	0.0518	0.1703	0.1873	0.7659	0.5504	0.6432	0.6496	0.6570	0.7898	0.9069	0.8794	0.3008	0.0276
	17	17	17	15	5	17	15	13	5	15	15	13	5
QB7GBC	0.39212	0.20246	0.03705	-0.03584	0.10381	-0.19603	-0.22061	0.16698	0.22950	0.00533	0.33511	0.08687	0.05403
	0.0049	0.1585	0.7984	0.8285	0.7754	0.4838	0.1277	0.3233	0.5236	0.9869	0.0186	0.6144	0.8821
	50	50	50	39	10	15	49	37	10	12	49	36	10
QB8CPM	0.41365	0.07941	-0.01331	-0.03115	0.17566	0.23941	-0.22411	0.30133	0.69559	0.41551	0.27690	0.20281	0.49947
	0.0037	0.6127	0.9325	0.8447	0.6773	0.4097	0.1956	0.0525	0.0554	0.2038	0.1129	0.1977	0.2076
	43	43	43	42	8	14	35	42	8	11	34	42	8

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PEARSON CORRELATION COEFFICIENTS / PROB > |R| UNDER HO:RHO=0 / NUMBER OF OBSERVATIONS

	QA2SUU	JA3MUSE	QA4CON	QA5CPM	QA5PND	QA5PERT	CA5GBC	QA6CPM	QA6PND	QA6PERT	QA6GBC	QA7CPM	QA7PND
QB9PND	0.35381 0.3159 10	-0.61767 0.0571 10	0.18293 0.6130 10	-0.20089 0.6333 8	0.16849 0.6417 10	0.33333 0.6667 4	0.16241 0.6763 9	0.46524 0.2454 8	0.28096 0.4317 10	0.81557 0.1844 4	0.15913 0.7066 8	0.57053 0.1397 8	0.51176 0.1305 10
QB9PERT	0.50577 0.0456 16	-0.31409 0.2361 16	-0.28725 0.2807 16	0.39274 0.1648 14	0.68852 0.1986 5	0.22083 0.4111 16	-0.16132 0.5817 14	0.00171 0.9954 14	0.57350 0.3121 5	0.32060 0.2855 13	0.31012 0.2806 14	0.32641 0.2764 13	0.53566 0.3522 5
QB8GBC	0.36166 0.0202 41	0.14739 0.3512 41	0.11109 0.4893 41	0.11333 0.5438 31	0.59561 0.1582 7	0.16024 0.6379 11	-0.26324 0.1008 40	0.09685 0.6107 30	0.43422 0.3303 7	0.27308 0.4771 9	0.31423 0.0483 40	0.15453 0.4149 30	0.82210 0.0232 7

	QA7PERT	QA7GBC	QB1CPM	QB1PND	QB1PERT	QB1GBC	QB2CPM	QB2PND	QB2PERT	QB2GBC	QB3CPM	QB3PND	QB3PERT
NORESPON	-0.03990 0.8792 17	-0.03395 0.8093 53	0.23758 0.1040 48	0.25770 0.4187 12	0.30264 0.2222 18	0.45142 0.0007 53	0.02896 0.8592 40	-0.54525 0.0828 11	-0.08911 0.7722 13	-0.25338 0.0970 44	0.12642 0.4025 46	-0.01044 0.9743 12	0.45937 0.0734 16
NATIONAL	-0.28381 0.2609 17	0.01712 0.9032 53	0.19810 0.1771 48	-0.49419 0.1024 12	0.09070 0.7204 18	0.08084 0.5650 53	0.16816 0.2996 40	0.04951 0.8851 11	0.05985 0.8460 13	0.19727 0.1993 44	-0.03181 0.8338 46	0.17513 0.5862 12	0.19958 0.4587 16
LOCATION	0.11652 0.6561 17	0.12961 0.3550 53	0.13480 0.3610 48	-0.62260 0.0306 12	0.27792 0.2642 18	-0.07051 0.6159 53	0.13736 0.3980 40	0.50161 0.1159 11	0.45161 0.1213 13	0.19343 0.2084 44	-0.08482 0.5752 46	-0.24272 0.4472 12	0.05173 0.8491 16
NOBRANCH	-0.07386 0.7936 15	0.20788 0.1757 44	0.07936 0.6264 40	-0.16367 0.6306 11	-0.00324 0.9909 15	0.08265 0.5938 44	-0.06178 0.7285 34	0.25559 0.4760 10	0.13439 0.6771 12	-0.06276 0.7082 38	0.02324 0.8883 39	-0.27521 0.4415 10	-0.04359 0.8774 15
NJEMPLOY	-0.49556 0.0431 17	0.10331 0.4616 53	0.09898 0.5033 48	-0.23813 0.4561 12	-0.47768 0.0450 18	-0.05663 0.6871 53	-0.18363 0.2567 40	0.18843 0.5790 11	0.06425 0.8348 13	0.00067 0.9965 44	-0.00193 0.9899 46	-0.24818 0.4367 12	-0.18898 0.4833 16
REGION	-0.38812 0.1237 17	0.06882 0.6244 53	-0.23177 0.1130 48	-0.16056 0.6181 12	-0.24123 0.3349 18	-0.11352 0.4183 53	-0.10655 0.5128 40	0.18002 0.5963 11	0.19489 0.5234 13	-0.14385 0.3516 44	-0.01765 0.9073 46	0.21065 0.5111 12	0.01451 0.9575 16
KEYINFOR	-0.17749 0.4955 17	0.05849 0.6774 53	-0.01879 0.8991 48	0.59876 0.0397 12	-0.04639 0.8550 18	0.14822 0.2895 53	-0.16925 0.2965 40	-0.69923 0.0166 11	-0.05851 0.8494 13	-0.32740 0.0301 44	0.13714 0.3634 46	0.11602 0.7195 12	-0.19195 0.4763 16
SRVOLUM	0.56792 0.0174 17	-0.25592 0.0644 53	-0.01218 0.9345 48	0.06732 0.8353 12	0.46486 0.0519 18	-0.01886 0.8933 53	-0.10381 0.5238 40	0.13334 0.6959 11	-0.49242 0.0874 13	-0.09136 0.5553 44	-0.04069 0.7883 46	-0.25554 0.4228 12	0.28121 0.2914 16
WORKACT	0.00843 0.9744 17	0.05032 0.7205 53	0.15624 0.2889 48	-0.12877 0.6900 12	-0.04586 0.8566 18	0.10082 0.4726 53	0.06084 0.7092 40	0.37874 0.2507 11	-0.04373 0.8872 13	-0.06214 0.6887 44	0.24280 0.1040 46	-0.04274 0.8951 12	0.18255 0.4986 16
AVWORKSU	-0.32840 0.1981 17	0.21629 0.1198 53	0.06790 0.6465 48	0.29216 0.3568 12	-0.17561 0.4858 18	-0.24921 0.0719 53	-0.17859 0.2702 40	-0.15794 0.6428 11	-0.16900 0.5810 13	0.06217 0.6885 44	-0.08974 0.5531 46	-0.31763 0.3144 12	-0.13625 0.6149 16

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PEARSON CORRELATION COEFFICIENTS / PROB > |R| UNDER HO:RHO=0 / NUMBER OF OBSERVATIONS

	QA7PERT	QA7GBC	QB1CPM	QB1PND	QB1PERT	QB1GBC	QB2CPM	QB2PND	QB2PERT	QB2GBC	QB3CPM	QB3PND	QB3PERT
AVJOBSIZ	-0.35629	0.07054	-0.02264	-0.07475	-0.22772	-0.07474	0.04403	-0.40716	-0.03446	0.10845	-0.16020	-0.26896	-0.02028
	0.1604	0.6157	0.8786	0.8174	0.3634	0.5948	0.7873	0.2139	0.9110	0.4835	0.2875	0.3979	0.9406
	17	53	48	12	18	53	40	11	13	44	46	12	16
AVJOBDUR	-0.45877	-0.08083	-0.06363	-0.04172	-0.45067	-0.09586	0.19133	-0.34340	-0.03317	0.14376	-0.07233	0.01038	-0.23100
	0.0640	0.5648	0.6674	0.8976	0.0605	0.4947	0.2369	0.3012	0.9143	0.3519	0.6329	0.9745	0.3894
	17	53	48	12	18	53	40	11	13	44	46	12	16
QA1FAM	0.11136	0.08156	0.31331	0.46145	0.20562	0.21587	-0.02588	-0.18700	0.21255	-0.03024	-0.03618	0.37184	0.33674
	0.6705	0.5615	0.0301	0.1310	0.4130	0.1206	0.8741	0.5819	0.4857	0.8455	0.8113	0.2340	0.2022
	17	53	48	12	18	53	40	11	13	44	46	12	16
QA2SOU	0.18071	0.12610	0.06792	0.16428	0.00414	0.03860	-0.09414	-0.04210	0.20878	-0.14625	0.34274	0.46038	0.27192
	0.4876	0.3683	0.6465	0.6095	0.9870	0.7838	0.5634	0.9022	0.4936	0.3435	0.0197	0.1320	0.3083
	17	53	48	12	18	53	40	11	13	44	46	12	16
QA3MUSE	0.43425	-0.10350	0.10314	-0.19227	0.14447	0.01045	-0.08309	-0.13190	-0.33122	0.08796	0.08088	-0.09421	-0.25827
	0.0816	0.4521	0.4854	0.5494	0.5674	0.9408	0.6102	0.6991	0.2690	0.5702	0.5931	0.7709	0.3341
	17	53	48	12	18	53	40	11	13	44	46	12	16
QA4COM	0.28181	0.12205	0.09914	-0.15264	0.00631	0.00439	0.12936	0.53662	-0.16470	0.10949	0.00826	0.06591	-0.48079
	0.2731	0.3840	0.5026	0.6358	0.9802	0.9751	0.4263	0.0888	0.5908	0.4792	0.9565	0.8387	0.0594
	17	53	48	12	18	53	40	11	13	44	46	12	16
QA5CPM	0.10417	-0.22948	-0.08627	-0.62106	0.12157	-0.12393	0.05366	0.59662	0.59701	0.10010	0.21094	0.13496	0.28766
	0.7118	0.1438	0.5642	0.0553	0.6538	0.4342	0.7456	0.0899	0.0404	0.5673	0.1642	0.7101	0.3186
	15	42	47	10	16	42	39	9	12	35	45	10	14
QA5PND	0.45316	0.53150	-0.04078	0.00201	-0.04464	0.07141	-0.09304	0.30600	-0.24343	-0.02311	0.01105	-0.47979	-0.27911
	0.3668	0.0753	0.9170	0.9951	0.9331	0.8347	0.8427	0.3601	0.7566	0.9529	0.9775	0.1144	0.6493
	6	12	9	12	6	11	7	11	4	9	9	12	5
QA5PERT	-0.01072	0.22087	0.19069	-0.03769	0.00963	-0.24794	-0.02689	0.00000	-0.14556	0.14121	-0.04285	-0.56254	-0.01511
	0.9674	0.4111	0.5137	0.9435	0.9698	0.3545	0.9339	1.0000	0.6352	0.6454	0.8795	0.2452	0.9557
	17	16	14	6	18	16	12	6	13	13	15	6	16
QA5GBC	-0.43971	-0.21235	-0.00722	0.03424	0.33952	0.09588	-0.04654	0.62470	0.74624	-0.04010	-0.02224	-0.52292	0.07173
	0.1010	0.1269	0.9647	0.9204	0.2157	0.4989	0.7971	0.0535	0.0083	0.7985	0.8946	0.0988	0.8075
	15	53	40	11	15	52	33	10	11	43	38	11	14
QA6CPM	0.28480	0.33653	0.11087	0.27022	0.02705	0.19413	0.09420	-0.20038	0.17355	-0.02862	0.09846	0.32070	0.01904
	0.3237	0.0337	0.4582	0.4819	0.9238	0.2300	0.5684	0.6342	0.6098	0.8744	0.5199	0.4001	0.9508
	14	40	47	9	15	40	39	8	11	33	45	9	13
QA6PND	0.18921	0.39863	0.04806	0.29196	0.13980	0.38885	-0.39712	-0.23445	0.04837	-0.21974	0.16352	0.07390	-0.15098
	0.7196	0.1993	0.9023	0.3571	0.7917	0.2372	0.3777	0.4877	0.9516	0.5700	0.6742	0.8195	0.8085
	6	12	9	12	6	11	7	11	4	9	9	12	5
QA6PERT	0.93818	0.18039	0.16717	0.38227	0.34330	0.11394	-0.04013	0.32275	-0.29820	-0.41201	0.04790	0.35498	0.05251
	0.0001	0.5554	0.6232	0.5254	0.2295	0.7109	0.9184	0.5963	0.3731	0.2368	0.8888	0.5577	0.8647
	14	13	11	5	14	13	9	5	11	10	11	5	13

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Pearson Correlation between All Questions (Variables)

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PEARSON CORRELATION COEFFICIENTS / PROB > |R| UNDER HO:RHO=0 / NUMBER OF OBSERVATIONS

	QA7PERT	QA7GBC	QB1CPM	QB1PND	QB1PERT	QB1GBC	QB2CPM	QB2PND	QB2PERT	QB2GBC	QB3CPM	QB3PND	QB3PERT
QA6GBC	0.48186	0.28934	0.06707	0.52719	-0.09230	0.11023	-0.11303	-0.28868	-0.31562	-0.11720	-0.07163	0.21269	-0.12481
	0.0689	0.0375	0.6850	0.1174	0.7435	0.4366	0.5311	0.4186	0.3444	0.4542	0.6736	0.5552	0.6707
	15	52	39	10	15	52	33	10	11	43	37	10	14
QA7CPM	0.61073	0.83792	0.18971	0.55246	0.09505	0.22572	-0.15463	0.23993	-0.21044	-0.06040	-0.12998	-0.07291	0.01480
	0.0266	0.0001	0.2015	0.1556	0.7465	0.1671	0.3473	0.6043	0.5345	0.7426	0.4004	0.8638	0.9636
	13	39	47	8	14	39	39	7	11	32	44	8	12
QA7PND	0.44634	0.56124	0.34671	0.23147	0.84590	0.56842	-0.06786	0.22796	0.00000	0.16922	-0.29315	-0.22607	0.64006
	0.3749	0.0576	0.3607	0.4691	0.0338	0.0681	0.8851	0.5002	1.0000	0.6634	0.4439	0.4799	0.2447
	6	12	9	12	6	11	7	11	4	9	9	12	5
QA7PERT	1.00000	0.25518	0.11632	0.49631	0.20336	-0.07651	-0.11722	0.33006	-0.54216	-0.29238	0.00000	0.51855	-0.10051
	0.0000	0.3587	0.7051	0.3167	0.4337	0.7864	0.7314	0.5229	0.0556	0.3564	1.0000	0.2919	0.7111
	17	15	13	6	17	15	11	6	13	12	14	6	16
QA7GBC	0.25518	1.00000	0.17861	0.39722	-0.27978	0.26876	-0.17078	0.40001	-0.06243	-0.10484	-0.14413	-0.19684	-0.22332
	0.3587	0.0000	0.2701	0.2264	0.3125	0.0540	0.3420	0.2521	0.8553	0.5034	0.3880	0.5618	0.4428
	15	53	40	11	15	52	33	10	11	43	38	11	14
QB1CPM	0.11632	0.17861	1.00000	0.75519	0.87590	0.68647	-0.23652	0.14497	-0.17025	-0.08014	0.04434	0.04444	0.15609
	0.7051	0.2701	0.0000	0.0303	0.0001	0.0001	0.1417	0.7565	0.6167	0.6575	0.7724	0.9168	0.6281
	13	40	48	8	14	40	40	7	11	33	45	8	12
QB1PND	0.49631	0.39722	0.75519	1.00000	0.35204	0.57676	-0.57043	-0.37372	-0.83833	-0.68776	0.56748	0.26351	0.59149
	0.3167	0.2264	0.0303	0.0000	0.4938	0.0809	0.1811	0.2576	0.1617	0.0406	0.1423	0.4337	0.2935
	6	11	8	12	6	10	7	11	4	9	8	11	5
QB1PERT	0.20336	-0.27978	0.87590	0.35204	1.00000	0.89703	0.10990	-0.17187	0.01074	-0.18496	0.10068	-0.08028	0.25613
	0.4337	0.3125	0.0001	0.4938	0.0000	0.0001	0.7338	0.7447	0.9722	0.5650	0.7211	0.8798	0.3383
	17	15	14	6	18	15	12	6	13	12	15	6	16
QB1GBC	-0.07651	0.26876	0.68647	0.57676	0.89703	1.00000	0.03257	-0.04746	0.26137	-0.15979	0.14237	0.23237	0.27237
	0.7864	0.0540	0.0001	0.0809	0.0001	0.0000	0.8549	0.8964	0.4376	0.3002	0.3938	0.5183	0.3462
	15	52	40	10	15	53	34	10	11	44	38	10	14
QB2CPM	-0.11722	-0.17078	-0.23652	-0.57043	0.10990	0.03257	1.00000	0.62572	0.95661	0.85008	0.14149	0.45178	0.31890
	0.7314	0.3420	0.1417	0.1811	0.7338	0.8549	0.0000	0.1328	0.0001	0.0001	0.3968	0.3684	0.3691
	11	33	40	7	12	34	40	7	10	33	38	6	10
QB2PND	0.33006	0.40001	0.14497	-0.37372	-0.17187	-0.04746	0.62572	1.00000	1.00000	0.81892	-0.06844	0.10978	-0.49320
	0.5229	0.2521	0.7565	0.2576	0.7447	0.8964	0.1328	0.0000	0.0001	0.0069	0.8841	0.7627	0.3985
	6	10	7	11	6	10	7	11	4	9	7	10	5
QB2PERT	-0.54216	-0.06243	-0.17025	-0.83833	0.01074	0.26137	0.95661	1.00000	1.00000	0.65943	0.31323	0.62479	0.28475
	0.0556	0.8553	0.6167	0.1617	0.9722	0.4376	0.0001	0.0001	0.0000	0.0273	0.3483	0.3752	0.3697
	13	11	11	4	13	11	10	4	13	11	11	4	12
QB2GBC	-0.29238	-0.10484	-0.08014	-0.68776	-0.18496	-0.15979	0.85008	0.81892	0.65943	1.00000	0.13302	0.05865	0.13563
	0.3564	0.5034	0.6575	0.0406	0.5650	0.3002	0.0001	0.0069	0.0273	0.0000	0.4680	0.8903	0.6909
	12	43	33	9	12	44	33	9	11	44	32	8	11

(Cont.)

Pearson Correlation between All Questions (Variables)

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PEARSON CORRELATION COEFFICIENTS / PROB > |R| UNDER HO:RHO=0 / NUMBER OF OBSERVATIONS

	QA7PERT	QA7GBC	QB1CPM	QB1PND	QB1PERT	QB1GBC	QB2CPM	QB2PND	QB2PERT	QB2GBC	QB3CPM	QB3PND	QB3PERT
QB3CPM	0.00000	-0.14413	0.04434	0.56748	0.10068	0.14237	0.14149	-0.06844	0.31323	0.13302	1.00000	0.69109	0.80565
	1.0000	0.3880	0.7724	0.1423	0.7211	0.3938	0.3968	0.8841	0.3483	0.4680	0.0000	0.0392	0.0009
	14	38	45	8	15	38	38	7	11	32	46	9	13
QB3PND	0.51835	-0.19684	0.04444	0.26351	-0.08028	0.23237	0.45178	0.10978	0.62479	0.05865	0.69109	1.00000	-0.18380
	0.2919	0.5618	0.9168	0.4337	0.8798	0.5183	0.3684	0.7627	0.3752	0.8903	0.0392	0.0000	0.7673
	6	11	8	11	6	10	6	10	4	8	9	12	5
QB3PERT	-0.10051	-0.22332	0.15609	0.59149	0.25613	0.27237	0.31890	-0.49320	0.28475	0.13563	0.80565	-0.18380	1.00000
	0.7111	0.4428	0.6281	0.2935	0.3383	0.3462	0.3651	0.3985	0.3697	0.6909	0.0009	0.7673	0.0000
	16	14	12	5	16	14	10	5	12	11	13	5	16
QB3GBC	-0.31102	-0.16712	-0.00189	0.33522	0.04065	0.07214	0.46579	-0.14484	0.86594	0.29921	0.65502	1.00000	0.74512
	0.4534	0.3448	0.9927	0.5813	0.9239	0.6805	0.0289	0.8162	0.0117	0.1020	0.0003	0.0000	0.0339
	8	34	26	5	8	35	22	5	7	31	26	6	8
QB4CPM	-0.33333	-0.15858	-0.32336	-0.85270	0.12029	-0.07641	0.40611	0.23009	0.56545	0.26038	0.21733	-0.15271	0.53069
	0.2442	0.3284	0.0266	0.0071	0.6694	0.6394	0.0103	0.6196	0.0698	0.1433	0.1468	0.6949	0.0621
	14	40	47	8	15	40	39	7	11	33	46	9	13
QB4PND	-0.37632	0.41132	-0.59779	-0.22292	-0.74148	-0.06900	-0.66436	0.26984	0.00000	-0.04364	0.46771	-0.20768	-0.80678
	0.4622	0.2088	0.1175	0.5100	0.0916	0.8498	0.1501	0.4509	1.0000	0.9183	0.2042	0.5172	0.0989
	6	11	8	11	6	10	6	10	4	8	9	12	5
QB4PERT	-0.06396	0.12804	0.03718	0.08704	0.09581	0.04019	0.13472	-0.37210	0.01289	0.05032	0.42239	-0.58461	0.51331
	0.8073	0.6493	0.9040	0.8698	0.7145	0.8869	0.6929	0.4676	0.9667	0.8766	0.1324	0.2230	0.0420
	17	15	13	6	17	15	11	6	13	12	14	6	16
QB4GBC	-0.28689	-0.08002	-0.08074	0.08033	0.37324	-0.05472	0.17880	-0.14286	0.15467	0.25345	0.14170	-0.38080	0.01566
	0.3200	0.5847	0.6348	0.8372	0.1887	0.7058	0.3359	0.7139	0.6696	0.1098	0.4097	0.2777	0.9595
	14	49	37	9	14	50	31	9	10	41	36	10	13
QB5CPM	-0.38730	-0.30023	-0.31085	-0.56857	-0.38969	-0.29209	0.13051	0.12039	0.16481	0.10821	0.01305	-0.13313	0.26773
	0.1713	0.0534	0.0315	0.1102	0.1511	0.0605	0.4222	0.7764	0.6282	0.5361	0.9314	0.7328	0.3765
	14	42	48	9	15	42	40	8	11	35	46	9	13
QB5PND	-0.53220	0.57932	0.00000	-0.10981	-0.26215	0.08779	-0.66436	0.23757	0.00000	0.00000	-0.39598	-0.79612	-0.37966
	0.2771	0.0792	1.0000	0.7479	0.6158	0.8223	0.1501	0.5087	1.0000	1.0000	0.3315	0.0034	0.5285
	6	10	7	11	6	9	6	10	4	8	8	11	5
QB5PERT	-0.39016	-0.05345	-0.02721	0.00000	-0.11149	-0.17054	-0.12948	-0.61394	0.01289	0.21262	0.19645	-0.96456	0.44179
	0.1216	0.8333	0.9297	1.0000	0.6701	0.5434	0.7044	0.1948	0.9667	0.5070	0.5009	0.0019	0.0867
	17	15	13	6	17	15	11	6	13	12	14	6	16
QB5GBC	-0.42267	-0.01972	-0.06754	0.06206	0.25902	-0.06186	0.09391	-0.16667	0.22389	0.13913	0.15106	-0.67862	0.38277
	0.1322	0.8919	0.6870	0.8648	0.3712	0.6663	0.6092	0.6454	0.5341	0.3795	0.3792	0.0310	0.1967
	14	50	38	10	14	51	32	10	10	42	36	10	13
QB6CPM	0.30664	0.14914	0.41088	0.70402	0.31767	0.22303	-0.17626	0.39706	0.14615	-0.09559	0.34004	0.31759	0.72943
	0.3082	0.3649	0.0041	0.0513	0.2684	0.1723	0.2766	0.3778	0.6681	0.5967	0.0239	0.4876	0.0071
	13	39	47	8	14	39	40	7	11	33	44	7	12

(Cont.)

Pearson Correlation between All Questions (Variables)

PEARSON CORRELATION COEFFICIENTS / PROB > |R| UNDER HO:RHO=0 / NUMBER OF OBSERVATIONS

	QA7PERT	QA7GBC	QB1CPM	QB1PND	QB1PERT	QB1GBC	QB2CPM	QB2PND	QB2PERT	QB2GBC	QB3CPM	QB3PND	QB3PERT
QB6PND	0.32701 0.5270 6	0.15422 0.6706 10	0.61369 0.1427 7	0.54440 0.0834 11	0.40923 0.4204 6	0.40891 0.2745 9	0.33592 0.5151 6	0.11750 0.7465 10	0.13875 0.8613 4	0.09572 0.8216 8	0.14639 0.7294 8	0.43666 0.1793 11	0.76321 0.1333 5
QB6PERT	0.07467 0.7834 16	-0.44662 0.1094 14	0.23546 0.4387 13	-0.64416 0.2407 5	0.35538 0.1768 16	0.26799 0.3543 14	0.09627 0.7783 11	0.16667 0.7888 5	0.29249 0.3322 13	0.13804 0.6857 11	0.35835 0.2292 13	0.10999 0.8602 5	0.48650 0.0659 15
QB6GBC	0.18446 0.5279 14	0.05061 0.7271 50	0.28311 0.0807 39	-0.15871 0.6614 10	0.19199 0.5108 14	0.20335 0.1524 51	-0.20229 0.2589 33	-0.39718 0.2557 10	-0.06161 0.8657 10	-0.17321 0.2667 43	0.14730 0.3843 37	-0.43087 0.2138 10	0.40067 0.1749 13
QB7CPM	0.15400 0.6154 13	0.20397 0.1898 41	0.15384 0.2965 48	0.87849 0.0041 8	-0.16242 0.5790 14	-0.01527 0.9245 41	-0.11232 0.4902 40	-0.15715 0.7365 7	0.05817 0.8651 11	-0.05984 0.7367 34	0.41454 0.0046 45	0.32383 0.4339 8	0.76087 0.0041 12
QB7PND	0.73515 0.1570 5	0.51665 0.1037 11	0.54356 0.1304 9	0.83844 0.0013 11	-0.08536 0.8915 5	0.56828 0.0865 10	-0.25313 0.5839 7	-0.14199 0.6956 10	0.94491 0.2123 3	-0.18783 0.6560 8	0.40100 0.2848 9	0.31394 0.3471 11	0.00000 1.0000 4
QB7PERT	0.21420 0.4257 16	0.32861 0.2318 15	-0.00430 0.9889 13	0.74805 0.1459 5	0.13326 0.6227 16	0.06443 0.8196 15	0.04100 0.9047 11	-0.02778 0.9646 5	0.09060 0.7685 13	0.28225 0.3741 12	0.71233 0.0063 13	0.34829 0.5657 5	0.64787 0.0090 15
QB7GBC	0.29066 0.3134 14	0.33390 0.0190 49	0.13388 0.4295 37	0.82334 0.0064 9	-0.11519 0.6950 14	0.11291 0.4350 50	0.05700 0.7567 32	0.00000 1.0000 9	0.32626 0.3575 10	0.06751 0.6710 42	0.43966 0.0073 36	0.56552 0.0884 10	0.19046 0.5331 13
QB8CPM	0.53752 0.0582 13	0.30723 0.0726 35	0.01833 0.9071 43	0.52186 0.2296 7	-0.14287 0.6261 14	-0.17531 0.3138 35	-0.13997 0.4155 36	0.16593 0.7534 6	0.16797 0.6215 11	-0.12167 0.5295 29	0.26980 0.0802 43	0.26123 0.5320 8	0.53931 0.0704 12
QB8PND	0.87039 0.1296 4	0.64222 0.0622 9	0.56952 0.1406 8	0.51921 0.1520 9	0.43627 0.5637 4	0.41978 0.3005 8	-0.11255 0.8313 6	0.53521 0.1717 8	0.94491 0.2123 3	0.05962 0.9107 6	0.68877 0.0589 8	0.21329 0.5541 10	0.50000 0.6667 3
QB8PERT	0.33215 0.2088 16	0.07478 0.7994 14	-0.02810 0.9274 13	0.34931 0.5645 5	0.03663 0.8929 16	-0.28211 0.3285 14	0.05940 0.8623 11	-0.09241 0.8825 5	0.01436 0.9647 12	0.09744 0.7756 11	0.49104 0.0746 14	-0.08339 0.8940 5	0.65084 0.0086 15
QB8GBC	0.50506 0.1365 10	0.30084 0.0593 40	-0.20832 0.2608 31	0.47862 0.3369 6	-0.59640 0.0688 10	-0.31791 0.0428 41	-0.15580 0.4377 27	0.61057 0.1980 6	0.16062 0.7040 8	-0.01459 0.9337 35	0.17923 0.3347 31	-0.02455 0.9583 7	0.21156 0.5574 10

	QB3GBC	QB4CPM	QB4PND	QB4PERT	QB4GBC	QB5CPM	QB5PND	QB5PERT	QB5GBC	QB6CPM	QB6PND	QB6PERT	QB6GBC
NORESPON	0.01471 0.9331 35	0.04002 0.7871 48	-0.13197 0.6827 12	0.10514 0.6880 17	-0.05993 0.6793 50	0.08546 0.5551 50	-0.06680 0.8453 11	0.06318 0.8096 17	0.02661 0.8530 51	-0.01148 0.9390 47	0.23916 0.4788 11	0.33712 0.2016 16	-0.05273 0.7133 51
NATIONAL	0.12509 0.4740 35	0.16931 0.2500 48	-0.39528 0.2034 12	-0.23570 0.3624 17	-0.04775 0.7419 50	-0.08771 0.5447 50	-0.39853 0.2247 11	-0.09260 0.7237 17	-0.08491 0.5536 51	0.03289 0.8263 47	-0.14220 0.6766 11	0.10856 0.6890 16	0.20763 0.1437 51

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Pearson Correlation between All Questions (Variables)

PEARSON CORRELATION COEFFICIENTS / PROB > |R| UNDER HO:RHO=0 / NUMBER OF OBSERVATIONS

	QB3GBC	QB4CPM	QB4PND	QB4PERT	QB4GBC	QB5CPM	QB5PND	QB5PERT	QB5GBC	QB6CPM	QB6PND	QB6PERT	QB6GBC
LOCATION	-0.20445	0.16715	-0.07204	-0.14803	-0.14283	0.01917	0.22707	-0.20655	0.13398	0.13302	-0.39775	0.00079	0.21222
	0.2387	0.2562	0.8239	0.5707	0.3224	0.8949	0.5019	0.4264	0.3486	0.3727	0.2257	0.9577	0.1349
	35	48	12	17	50	50	11	17	51	47	11	16	51
NUBRANCH	-0.06162	0.18091	-0.01351	0.28022	-0.11223	0.21040	0.55709	-0.30138	0.03783	0.20383	-0.13800	0.02528	0.22273
	0.7509	0.2639	0.9705	0.3117	0.4848	0.1811	0.0943	0.2750	0.8120	0.2071	0.7038	0.9316	0.1563
	29	40	10	15	41	42	10	15	42	40	10	14	42
NOEMPLOY	0.09057	0.05951	0.03201	-0.04201	-0.25409	0.25016	0.48575	0.23267	-0.06235	0.03314	-0.02000	-0.35352	0.08388
	0.6049	0.6878	0.9213	0.8728	0.0750	0.0798	0.1258	0.3688	0.6638	0.8250	0.9535	0.1792	0.5584
	35	48	12	17	50	50	11	17	51	47	11	16	51
REGION	-0.12681	0.03555	0.36515	0.17743	-0.07641	0.27993	0.32203	-0.17743	0.13582	-0.06231	-0.07387	-0.19116	-0.22751
	0.4679	0.8104	0.2432	0.4957	0.5979	0.0490	0.3342	0.4957	0.3420	0.6774	0.8291	0.4782	0.1084
	35	48	12	17	50	50	11	17	51	47	11	16	51
KEYINFOR	0.06030	0.07497	0.32230	-0.09667	0.27782	0.03132	0.04967	-0.31291	-0.10474	-0.10015	-0.12153	-0.39909	-0.04399
	0.7308	0.6125	0.3069	0.7121	0.0508	0.8290	0.8847	0.2214	0.4645	0.5030	0.7219	0.1257	0.7592
	35	48	12	17	50	50	11	17	51	47	11	16	51
SRVOLUM	-0.23522	-0.01277	0.34179	0.33672	0.18195	0.17389	0.16948	0.05051	0.14678	-0.07734	0.00000	0.36105	-0.13521
	0.1738	0.9314	0.2769	0.1863	0.2060	0.2271	0.6184	0.8473	0.3040	0.6053	1.0000	0.1695	0.3441
	35	48	12	17	50	50	11	17	51	47	11	16	51
WORKACT	-0.06183	0.06545	0.36479	0.31426	-0.00744	0.01150	0.16087	-0.41189	-0.04934	0.15067	-0.01640	0.00744	0.01206
	0.7242	0.6536	0.2437	0.2193	0.9591	0.9368	0.6365	0.1004	0.7310	0.3121	0.9618	0.9782	0.9331
	35	48	12	17	50	50	11	17	51	47	11	16	51
AVWORKSU	-0.09111	-0.19129	0.22942	0.11609	0.12756	-0.05448	0.41007	0.11609	0.07748	0.10287	-0.13506	-0.37244	-0.18747
	0.6027	0.1928	0.4732	0.6573	0.3774	0.7071	0.2103	0.6573	0.5889	0.4914	0.6921	0.1554	0.1877
	35	48	12	17	50	50	11	17	51	47	11	16	51
AVJOBSIZ	0.05363	-0.08554	-0.55849	-0.10557	-0.31300	-0.14582	-0.08032	0.11877	-0.07647	-0.06141	0.04299	-0.37335	0.03823
	0.7596	0.5632	0.0591	0.6868	0.0269	0.3123	0.8144	0.6498	0.5938	0.6818	0.9001	0.1543	0.7900
	35	48	12	17	50	50	11	17	51	47	11	16	51
AVJOBDUR	-0.14323	0.09057	-0.52467	-0.01473	-0.18979	0.06022	-0.26961	0.11049	0.12423	-0.29583	0.17760	-0.65920	-0.20614
	0.4116	0.5404	0.0799	0.9553	0.1868	0.6778	0.4227	0.6729	0.3851	0.0435	0.6014	0.0055	0.1467
	35	48	12	17	50	50	11	17	51	47	11	16	51
QA1FAM	0.14606	0.06441	-0.20927	0.10259	-0.00676	0.03105	-0.26734	0.01954	-0.21079	0.36915	0.31797	0.11969	0.10675
	0.4025	0.6636	0.5139	0.6952	0.9628	0.8305	0.4268	0.9407	0.1376	0.0107	0.3406	0.6588	0.4559
	35	48	12	17	50	50	11	17	51	47	11	16	51
QA2SOU	0.07610	-0.05086	0.17370	-0.04049	-0.11945	-0.26417	-0.39923	-0.19932	-0.37012	0.23490	-0.15935	0.08621	0.29930
	0.6639	0.7314	0.5893	0.8774	0.4087	0.0638	0.2238	0.4431	0.0075	0.1120	0.6398	0.7509	0.0329
	35	48	12	17	50	50	11	17	51	47	11	16	51
QA3MUSE	0.37098	0.02605	-0.08165	0.01325	0.11054	0.04035	-0.11524	-0.13692	-0.29778	0.19438	-0.03524	0.21898	0.37288
	0.0282	0.9605	0.8008	0.9597	0.4447	0.7809	0.7358	0.6003	0.0338	0.1904	0.9181	0.4152	0.0070
	35	48	12	17	50	50	11	17	51	47	11	16	51

(Cont.)

Pearson Correlation between All Questions (Variables)

PEARSON CORRELATION COEFFICIENTS / PROB > |R| UNDER HO:RHO=0 / NUMBER OF OBSERVATIONS

	QB3GBC	QB4CPM	QB4PND	QB4PERT	QB4GBC	QB5CPM	QB5PND	QB5PERT	QB5GBC	QB6CPM	QB6PND	QB6PERT	QB6GBC
QA4CPM	0.13919	0.02492	-0.36179	-0.23533	-0.24081	-0.02738	-0.09515	-0.23533	-0.09640	0.03306	0.42945	-0.25702	0.29595
	0.4252	0.8665	0.2478	0.3632	0.0921	0.8503	0.7808	0.3632	0.5010	0.8254	0.1875	0.3366	0.0350
	35	48	12	17	50	50	11	17	51	47	11	16	51
QA5CPM	0.45418	0.44188	0.40109	0.08983	0.30986	0.30284	0.11180	-0.04222	0.02265	-0.04106	-0.57150	0.25805	0.12752
	0.0198	0.0019	0.2507	0.7502	0.0549	0.0344	0.7746	0.8812	0.8896	0.7864	0.1079	0.3731	0.4269
	26	47	10	15	39	49	9	15	40	46	9	14	41
QA5PND	-0.73621	-0.06250	0.56195	-0.13245	0.63427	0.24845	0.66147	0.28098	0.62963	-0.02624	-0.38126	-0.36116	0.17440
	0.0952	0.8731	0.0572	0.8025	0.0489	0.4888	0.0267	0.5896	0.0379	0.9508	0.2473	0.5504	0.6080
	6	9	12	6	10	10	11	6	11	8	11	5	11
QA5PERT	-0.57735	0.00000	0.30619	0.32593	0.30177	0.04957	0.57735	0.12805	-0.02822	-0.23295	-0.45303	-0.52986	-0.23378
	0.1036	1.0000	0.5551	0.2017	0.2744	0.8553	0.2302	0.6243	0.9205	0.4229	0.3669	0.0348	0.4017
	9	15	6	17	15	16	6	17	15	14	6	16	15
QA5GBC	0.00269	0.00843	0.15658	-0.04029	0.25365	0.29102	0.58835	0.04029	0.18867	-0.08898	0.07309	0.36309	-0.10400
	0.9879	0.9588	0.6457	0.8866	0.0786	0.0615	0.0736	0.8866	0.1895	0.5901	0.8410	0.2020	0.4723
	34	40	11	15	49	42	10	15	50	39	10	14	50
QA6CPM	-0.21260	-0.14271	0.35255	0.17911	0.02223	-0.12930	-0.20672	-0.29299	0.21204	0.20555	-0.04134	-0.19069	0.07942
	0.3076	0.3386	0.3521	0.5401	0.8961	0.3811	0.6233	0.3094	0.2012	0.1706	0.9226	0.5326	0.6308
	25	47	9	14	37	48	8	14	38	46	8	13	39
QA6PND	0.17912	0.05000	0.15250	0.10370	0.00683	0.04772	0.20607	0.54993	0.00000	-0.07004	-0.22058	-0.22964	0.36439
	0.7342	0.8984	0.6361	0.8450	0.9851	0.8959	0.5433	0.2583	1.0000	0.8691	0.5146	0.7102	0.2706
	6	9	12	6	10	10	11	6	11	8	11	5	11
QA6PERT	-0.00361	-0.03348	-0.32275	-0.07604	-0.32611	-0.26171	-0.32275	-0.23187	-0.42100	0.29679	0.17642	0.20993	0.22178
	0.9839	0.9221	0.5963	0.7961	0.3009	0.4113	0.5963	0.4251	0.1729	0.3755	0.7765	0.4713	0.4885
	8	11	5	14	12	12	5	14	12	11	5	14	12
QA6GBC	-0.00967	-0.13204	0.35355	-0.00268	-0.10477	-0.22792	0.01552	0.08308	-0.08155	0.27906	-0.03942	0.11907	0.21704
	0.9612	0.4230	0.3162	0.9924	0.4737	0.1518	0.9684	0.7685	0.5734	0.0898	0.9198	0.6852	0.1300
	34	39	10	15	49	41	9	15	50	38	9	14	50
QA7CPM	-0.14865	-0.35492	0.44361	0.42026	-0.01172	-0.33301	0.54290	-0.35464	-0.12654	0.22438	0.16589	-0.22767	-0.05783
	0.4782	0.0155	0.2709	0.1528	0.9459	0.0222	0.2079	0.2344	0.4555	0.1338	0.7222	0.4544	0.7302
	25	46	8	13	36	47	7	13	37	46	7	13	38
QA7PND	0.11277	0.30151	-0.03842	0.09950	0.24929	0.45124	0.29993	0.35180	0.04840	0.35120	0.34399	-0.40825	0.09768
	0.8020	0.4304	0.9056	0.8512	0.4873	0.1905	0.3702	0.4941	0.8876	0.3936	0.3003	0.4950	0.7751
	6	9	12	6	10	10	11	6	11	8	11	5	11
QA7PERT	-0.31102	-0.33333	-0.37632	-0.06396	-0.28689	-0.39730	-0.53220	-0.39016	-0.42267	0.30664	0.32701	0.07467	0.18446
	0.4534	0.2442	0.4622	0.8073	0.3200	0.1713	0.2771	0.1216	0.1322	0.3082	0.5270	0.7834	0.5279
	8	14	6	17	14	14	6	17	14	13	6	16	14
QA7GBC	-0.16712	-0.15858	0.41132	0.12804	-0.08002	-0.30023	0.57932	-0.05945	-0.01972	0.14914	0.15422	-0.44662	0.05061
	0.3448	0.3284	0.2088	0.6493	0.5847	0.0534	0.0792	0.8333	0.8919	0.3649	0.6706	0.1094	0.7271
	34	40	11	15	49	42	10	15	50	39	10	14	50

(Cont.)

Pearson Correlation between All Questions (Variables)

PEARSON CORRELATION COEFFICIENTS / PROB > |R| UNDER H0:RHO=0 / NUMBER OF OBSERVATIONS

	QB3GBC	QB4CPM	QB4PND	QB4PERT	QB4GBC	QB5CPM	QB5PND	QB5PERT	QB5GBC	QB6CPM	QB6PND	QB6PERT	QB6GBC
QB1CPM	-0.00189	-0.32336	-0.59779	0.03718	-0.08074	-0.31085	0.00000	-0.02721	-0.06754	0.41088	0.61369	0.23546	0.28311
	0.9927	0.0266	0.1175	0.9040	0.6348	0.0315	1.0000	0.9297	0.6870	0.0041	0.1427	0.4387	0.0807
	26	47	8	13	37	48	7	13	38	47	7	13	39
QB1PND	0.33522	-0.85270	-0.22292	0.08704	0.08033	-0.56857	-0.10981	0.00000	0.06206	0.70402	0.54440	-0.64416	-0.15871
	0.5813	0.0071	0.5100	0.8698	0.8372	0.1102	0.7479	1.0000	0.8648	0.0513	0.0834	0.2407	0.6614
	5	8	11	6	9	9	11	6	10	8	11	5	10
QB1PERT	0.04065	0.12029	-0.74148	0.09581	0.37324	-0.38969	-0.26215	-0.11149	0.25902	0.31767	0.40923	0.35538	0.19199
	0.9239	0.6694	0.0916	0.7145	0.1887	0.1511	0.6158	0.6701	0.3712	0.2684	0.4204	0.1768	0.5108
	8	15	6	17	14	15	6	17	14	14	6	16	14
QB1GBC	0.07214	-0.07641	-0.06900	0.04019	-0.05472	-0.29209	0.08779	-0.17054	-0.06186	0.22303	0.40891	0.26799	0.20335
	0.6805	0.6394	0.8498	0.8869	0.7058	0.0605	0.8223	0.5434	0.6663	0.1723	0.2745	0.3543	0.1524
	35	40	10	15	50	42	9	15	51	39	9	14	51
QB2CPM	0.46579	0.40611	-0.66436	0.13472	0.17880	0.13051	-0.66436	-0.12948	0.09391	-0.17626	0.33592	0.09627	-0.20229
	0.0289	0.0103	0.1501	0.6929	0.3359	0.4222	0.1501	0.7044	0.6092	0.2766	0.5151	0.7783	0.2589
	22	39	6	11	31	40	6	11	32	40	6	11	33
QB2PND	-0.14484	0.23009	0.26984	-0.37210	-0.14286	0.12039	0.23757	-0.61394	-0.16667	0.39706	0.11750	0.16667	-0.39718
	0.8162	0.6196	0.4509	0.4676	0.7139	0.7764	0.5087	0.1948	0.6454	0.3778	0.7465	0.7888	0.2557
	5	7	10	6	9	8	10	6	10	7	10	5	10
QB2PERT	0.86594	0.56545	0.00000	0.01289	0.15467	0.16481	0.00000	0.01289	0.22389	0.14615	0.13875	0.29249	-0.06161
	0.0117	0.0698	1.0000	0.9667	0.6696	0.6282	1.0000	0.9667	0.5341	0.6681	0.8613	0.3322	0.8657
	7	11	4	13	10	11	4	13	10	11	4	13	10
QB2GBC	0.29921	0.26038	-0.04364	0.05032	0.25345	0.10821	0.00000	0.21262	0.13913	-0.09559	0.09572	0.13804	-0.17321
	0.1020	0.1433	0.9183	0.8766	0.1098	0.5361	1.0000	0.5070	0.3795	0.5967	0.8216	0.6857	0.2667
	31	33	8	12	41	35	8	12	42	33	8	11	43
QB3CPM	0.65502	0.21733	0.46771	0.42239	0.14170	0.01305	-0.39598	0.19645	0.15106	0.34004	0.14639	0.35835	0.14730
	0.0003	0.1468	0.2042	0.1324	0.4097	0.9314	0.3315	0.5009	0.3792	0.0239	0.7294	0.2292	0.3843
	26	46	9	14	36	46	8	14	36	44	8	13	37
QB3PND	1.00000	-0.15271	-0.20768	-0.58461	-0.38080	-0.13313	-0.79612	-0.96456	-0.67862	0.31759	0.43666	0.10599	-0.43087
	0.0000	0.6949	0.5172	0.2230	0.2777	0.7328	0.0034	0.0019	0.0310	0.4876	0.1793	0.8602	0.2138
	6	9	12	6	10	9	11	6	10	7	11	5	10
QB3PERT	0.74512	0.53069	-0.80678	0.51331	0.01566	0.26773	-0.37966	0.44179	0.38277	0.72943	0.76321	0.48650	0.40067
	0.0339	0.0621	0.0989	0.0420	0.9595	0.3765	0.5285	0.0867	0.1967	0.0071	0.1333	0.0659	0.1749
	8	13	5	16	13	13	5	16	13	12	5	15	13
QB3GBC	1.00000	0.25181	-0.44721	0.04086	-0.02232	0.17424	-0.94984	0.44945	-0.12485	0.53211	0.77056	0.85661	0.37395
	0.0000	0.2146	0.3739	0.9235	0.8987	0.3847	0.0683	0.2639	0.4749	0.0062	0.1273	0.0066	0.0269
	35	26	6	8	35	27	5	8	35	25	5	8	35
QB4CPM	0.25181	1.00000	0.18898	0.44721	0.56788	0.42033	0.14907	0.25820	0.08872	-0.29108	-0.38759	0.33437	-0.16610
	0.2146	0.0000	0.6263	0.1089	0.0002	0.0029	0.7246	0.3728	0.5963	0.0497	0.3428	0.2642	0.3122
	26	48	9	14	38	48	8	14	38	46	8	13	39

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PEARSON CORRELATION COEFFICIENTS / PROB > |R| UNDER HO:RHO=0 / NUMBER OF OBSERVATIONS

	QB3GBC	QB4CPM	QB4PND	QB4PERT	QB4GBC	QB5CPM	QB5PND	QB5PERT	QB5GBC	QB6CPM	QB6PND	QB6PERT	QB6GBC
QB4PND	-0.44721	0.14398	1.00000	0.00000	0.80178	0.34684	0.67082	0.25000	0.61237	-0.08492	-0.63828	0.16667	-0.04536
	0.3739	0.6263	0.0000	1.0000	0.0053	0.3605	0.0239	0.6328	0.0598	0.8564	0.0346	0.7888	0.9010
	6	9	12	6	10	9	11	6	10	7	11	5	10
QB4PERT	0.04986	0.44721	0.00000	1.00000	0.42008	0.00000	0.33333	0.29167	0.10050	0.48752	0.11625	-0.03131	-0.20172
	0.9235	0.1089	1.0000	0.0000	0.1348	1.0000	0.5185	0.2560	0.7325	0.0910	0.8264	0.9084	0.4892
	8	14	6	17	14	14	6	17	14	13	6	16	14
QB4GBC	-0.02232	0.56788	0.80178	0.42008	1.00000	0.27297	0.59761	0.07001	0.18954	-0.24880	-0.34684	-0.23400	-0.41154
	0.8987	0.0002	0.0053	0.1348	0.0000	0.0927	0.0892	0.8120	0.1874	0.1434	0.3605	0.4416	0.0033
	35	38	10	14	50	39	9	14	50	36	9	13	49
QB5CPM	0.17424	0.42033	0.34684	0.00000	0.27297	1.00000	0.46667	0.70833	0.41610	-0.15740	-0.14667	0.22469	-0.06764
	0.3947	0.0029	0.3605	1.0000	0.0927	0.0000	0.2437	0.0046	0.0076	0.2907	0.7289	0.4605	0.6744
	27	48	9	14	39	50	8	14	40	47	8	13	41
QB5PND	-0.84984	0.14907	0.67082	0.33333	0.59761	0.46667	1.00000	0.70711	0.59761	0.17541	-0.42817	0.16667	0.23307
	0.0683	0.7246	0.0239	0.5185	0.0892	0.2437	0.0000	0.1161	0.0892	0.7068	0.1889	0.7888	0.5462
	5	8	11	6	9	8	11	6	9	7	11	5	9
QB5PERT	0.44945	0.25820	0.25000	0.29167	0.07001	0.70833	0.70711	1.00000	0.60302	-0.01292	-0.41100	0.10532	0.31468
	0.2639	0.3728	0.6328	0.2560	0.8120	0.0046	0.1161	0.0000	0.0224	0.9666	0.4182	0.6979	0.2732
	8	14	6	17	14	14	6	17	14	13	6	16	14
QB5GBC	-0.12485	0.08872	0.61237	0.10050	0.18954	0.41610	0.59761	0.60302	1.00000	-0.13603	-0.34684	0.26220	-0.08809
	0.4749	0.5963	0.0598	0.7325	0.1874	0.0076	0.0892	0.0224	0.0000	0.4221	0.3605	0.3868	0.5430
	35	38	10	14	50	40	9	14	51	37	9	13	50
QB6CPM	0.53211	-0.29108	-0.08492	0.48752	-0.24880	-0.15740	0.17541	-0.01292	-0.13603	1.00000	0.79250	0.62383	0.66113
	0.0062	0.0497	0.8564	0.0910	0.1434	0.2907	0.7068	0.9666	0.4221	0.0000	0.0336	0.0227	0.0001
	25	46	7	13	36	47	7	13	37	47	7	13	38
QB6PND	0.77056	-0.38759	-0.63828	0.11625	-0.34684	-0.14667	-0.42817	-0.41100	-0.34684	0.79250	1.00000	-0.28632	-0.54705
	0.1273	0.3428	0.0346	0.8264	0.3605	0.7289	0.1889	0.4182	0.3605	0.0336	0.0000	0.6405	0.1274
	5	8	11	6	9	8	11	6	9	7	11	5	9
QB6PERT	0.85661	0.33437	0.16667	-0.03131	-0.23400	0.22469	0.16667	0.10532	0.26220	0.62383	-0.28632	1.00000	0.73591
	0.0066	0.2642	0.7888	0.9084	0.4416	0.4605	0.7888	0.6979	0.3868	0.0227	0.6405	0.0000	0.0041
	8	13	5	16	13	13	5	16	13	13	5	16	13
QB6GBC	0.37395	-0.16610	-0.04536	-0.20172	-0.41154	-0.06764	0.23307	0.31468	-0.08809	0.66113	-0.54705	0.73591	1.00000
	0.0269	0.3122	0.9010	0.4892	0.0033	0.6744	0.5462	0.2732	0.5430	0.0001	0.1274	0.0041	0.0000
	35	39	10	14	49	41	9	14	50	38	9	13	51
QB7CPM	0.33078	-0.11584	0.23355	0.53571	-0.01957	0.03480	0.17078	0.11386	-0.03411	0.51345	0.53676	0.22214	0.17312
	0.0919	0.4381	0.5778	0.0592	0.9072	0.8123	0.7143	0.7111	0.8367	0.0002	0.2142	0.4657	0.2854
	27	47	8	13	38	49	7	13	39	47	7	13	40
QB7PND	0.34318	-0.67344	-0.16206	-0.16667	-0.03881	-0.26774	-0.03790	-0.66667	0.02472	0.49465	0.64887	-0.57735	-0.30810
	0.5054	0.0468	0.6340	0.7888	0.9210	0.4545	0.9172	0.2191	0.9460	0.2127	0.0424	0.4226	0.2953
	6	9	11	5	9	10	10	5	10	8	10	4	10

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Pearson Correlation between All Questions (Variables)

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11:36 MONDAY, FEBRUARY 12, 1990 43

PEARSON CORRELATION COEFFICIENTS / PROB > |R| UNDER H0:RHO=0 / NUMBER OF OBSERVATIONS

	QB3GBC	QB4CPM	QB4PND	QB4PERT	QB4GBC	QB5CPM	QB5PND	QB5PERT	QB5GBC	QB6CPM	QB6PND	QB6PERT	QB6GBC
QB7PERT	0.30364 0.4270 9	-0.08333 0.7867 13	-0.58333 0.3019 5	0.24757 0.3552 16	-0.19898 0.4953 14	-0.15291 0.6018 14	-0.58333 0.3019 5	0.20451 0.4474 16	0.39988 0.1566 14	0.73826 0.0040 13	0.41646 0.4855 5	0.42659 0.0994 16	0.43111 0.1238 14
QB7GBC	0.32568 0.0562 35	-0.07430 0.6575 38	0.15309 0.6728 10	0.07093 0.8096 14	-0.05023 0.7318 49	-0.20271 0.2158 39	-0.23905 0.5356 9	-0.13300 0.6504 14	-0.00829 0.9549 49	0.35988 0.0311 36	0.47691 0.1943 9	0.10602 0.7303 13	0.32368 0.0233 49
QB8CPM	0.00222 0.9914 26	-0.18114 0.2451 43	-0.02981 0.9441 8	0.49578 0.0849 13	-0.21586 0.2276 33	0.02530 0.8721 43	-0.03492 0.9408 7	0.00000 1.0000 13	0.07723 0.6692 33	0.42924 0.0046 42	0.33841 0.4578 7	0.19895 0.5147 13	0.19802 0.2616 34
QB8PND	0.01245 0.9813 6	-0.64578 0.0837 8	0.16003 0.6588 10	-0.19245 0.8075 4	0.10768 0.7997 8	-0.41872 0.3018 8	0.13769 0.7239 9	-0.55556 0.4444 4	0.24077 0.5657 8	0.83911 0.0182 7	0.56412 0.1136 9	-0.55556 0.4444 4	-0.26975 0.5182 8
QB8PERT	0.47093 0.2389 8	0.02137 0.9422 14	0.04490 0.9428 5	0.20101 0.4554 16	-0.39936 0.1764 13	-0.03310 0.9106 14	0.07332 0.9067 5	0.30151 0.2564 16	0.11363 0.7117 13	0.59081 0.0335 13	-0.43911 0.4594 5	0.38157 0.1605 15	0.50791 0.0764 13
QB8GBC	0.02817 0.8724 35	-0.08521 0.6485 31	0.35614 0.4330 7	0.07881 0.8287 10	-0.14787 0.3562 41	-0.02697 0.8835 32	0.42875 0.3963 6	0.19305 0.5931 10	0.05518 0.7319 41	0.29791 0.1098 30	0.41644 0.4115 6	0.13863 0.7025 10	0.35539 0.0244 40

	QB7CPM	QB7PND	QB7PERT	QB7GBC	QB8CPM	QB8PND	QB8PERT	QB8GBC
NORESPON	0.08346 0.5686 49	-0.06294 0.8459 12	0.09344 0.7213 17	0.03167 0.8272 50	-0.21919 0.1579 43	-0.53385 0.1120 10	-0.17702 0.5119 16	-0.46737 0.0021 41
NATIONAL	-0.14294 0.3272 49	-0.43662 0.1559 12	0.07518 0.7743 17	-0.14819 0.3044 50	-0.20598 0.1851 43	-0.44689 0.1954 10	-0.14116 0.6020 16	-0.17117 0.2846 41
LOCATION	0.02750 0.8512 49	-0.37134 0.2347 12	0.18920 0.4671 17	-0.10310 0.4761 50	0.11879 0.4480 43	-0.14392 0.6916 10	0.35384 0.1788 16	0.06275 0.6967 41
NOBRANCH	0.09376 0.6026 41	0.00629 0.9362 10	-0.38351 0.1582 15	0.09152 0.5693 41	0.24973 0.1419 36	-0.24209 0.5635 8	-0.13624 0.6423 14	0.13019 0.4560 35
NOEMPLOY	0.26301 0.0679 49	-0.13239 0.6817 12	-0.45928 0.0636 17	0.13570 0.3474 50	0.17247 0.2688 43	-0.41955 0.2274 10	-0.09815 0.7176 16	0.02498 0.8768 41
REGION	0.17005 0.2427 49	0.02071 0.9491 12	0.00209 0.9936 17	-0.15170 0.2930 50	0.13533 0.3869 43	-0.06870 0.8504 10	-0.20796 0.4396 16	-0.08129 0.6134 41
KEYINFOR	0.25759 0.0740 49	0.15380 0.6220 12	-0.36136 0.1541 17	0.30296 0.0325 50	0.22837 0.1408 43	-0.14150 0.6966 10	-0.30118 0.2570 16	0.04932 0.7594 41

(Cont.)

PEARSON CORRELATION COEFFICIENTS / PROB > |R| UNDER HO:RHO=0 / NUMBER OF OBSERVATIONS

	QB7CPM	QB7PND	QB7PERT	QB7GBC	QB8CPM	QB8PND	QB8PERT	QB8GBC
SRVOLUM	-0.14147	0.21535	0.32791	-0.09992	0.02854	0.63150	0.18182	0.06196
	0.3322	0.5015	0.1988	0.4900	0.8558	0.0502	0.5004	0.7003
	49	12	17	50	43	10	16	41
WORKACT	0.33365	-0.39774	0.10637	0.18591	0.07670	-0.03512	-0.17516	-0.16909
	0.0191	0.2004	0.6845	0.1561	0.6249	0.9233	0.5164	0.2906
	49	12	17	50	43	10	16	41
AVWORKSU	0.15124	0.12906	0.02784	-0.10129	0.12041	-0.06667	-0.21990	-0.02406
	0.2996	0.6893	0.9155	0.4840	0.4418	0.8548	0.4132	0.8813
	49	12	17	50	43	10	16	41
AVJOBSIZ	-0.01191	-0.39616	-0.24225	-0.06455	-0.12235	-0.71683	-0.07822	-0.21783
	0.9353	0.2024	0.3489	0.6560	0.4344	0.0197	0.7734	0.1713
	49	12	17	50	43	10	16	41
AVJOBDUR	-0.06856	-0.14336	-0.51262	-0.00945	-0.20256	-0.51316	-0.40337	-0.29536
	0.6397	0.6567	0.0354	0.9481	0.1927	0.1293	0.1213	0.0608
	49	12	17	50	43	10	16	41
QA1FAM	0.30276	0.39596	0.33143	-0.00577	0.11364	0.33035	0.24131	-0.13443
	0.0345	0.2026	0.1938	0.9683	0.4681	0.3512	0.3679	0.4020
	49	12	17	50	43	10	16	41
QA2SOU	0.40790	0.09545	0.47892	0.39212	0.43365	0.35381	0.50577	0.36166
	0.0036	0.7679	0.0518	0.0049	0.0037	0.3159	0.0456	0.0202
	49	12	17	50	43	10	16	41
QA3MUSE	0.21659	-0.34509	-0.34855	0.20246	0.07941	-0.61767	-0.31409	0.14939
	0.1350	0.2719	0.1703	0.1585	0.6127	0.0571	0.2361	0.3512
	49	12	17	50	43	10	16	41
QA4COM	-0.05345	0.12672	-0.33601	0.03705	-0.01331	0.18293	-0.28725	0.11109
	0.7153	0.6947	0.1873	0.7984	0.9325	0.6130	0.2807	0.4893
	49	12	17	50	43	10	16	41
QA5CPM	-0.00607	-0.55398	-0.08403	-0.03584	-0.03115	-0.20089	0.39274	0.11333
	0.9673	0.0966	0.7659	0.8285	0.8447	0.6333	0.1648	0.5438
	48	10	15	39	42	8	14	31
QA5PND	0.17541	-0.02112	0.36116	0.10381	0.17566	0.16849	0.68852	0.59561
	0.6517	0.9481	0.5504	0.7754	0.6773	0.6417	0.1986	0.1582
	9	12	5	10	8	10	5	7
QA5PERT	0.11693	0.00000	-0.12118	-0.19603	0.23941	0.33333	0.22083	0.16024
	0.6781	1.0000	0.6432	0.4838	0.4097	0.6667	0.4111	0.6379
	15	5	17	15	14	4	16	11
QA5GBC	-0.13163	0.25265	0.12791	-0.22061	-0.22411	0.16241	-0.16132	-0.26324
	0.4120	0.4535	0.6496	0.1277	0.1956	0.6763	0.5817	0.1008
	41	11	15	49	35	9	14	40

(Cont.)

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	Q87CPM	Q87PND	Q87PERT	Q87GBC	Q88CPM	Q88PND	Q88PERT	Q88GBC
QA6CPM	0.05669 0.7051 47	0.45870 0.1824 10	-0.13634 0.6570 13	0.16698 0.3233 37	0.30133 0.0525 42	0.46524 0.2454 8	0.00171 0.9954 14	0.09685 0.6107 30
QA6PND	0.62497 0.0719 9	0.48260 0.1120 12	0.16585 0.7898 5	0.22950 0.5236 10	0.69559 0.0554 8	0.28096 0.4317 10	0.57350 0.3121 5	0.43422 0.3303 7
QA6PERT	-0.09248 0.7750 12	0.63117 0.3688 4	-0.03304 0.9069 15	0.00533 0.9869 12	0.41551 0.2038 11	0.81557 0.1844 4	0.32060 0.2855 13	0.27308 0.4771 9
QA6GBC	0.15972 0.3249 40	0.15682 0.6653 10	0.04287 0.8794 15	0.33511 0.0186 49	0.27690 0.1129 34	0.15913 0.7066 8	0.31012 0.2806 14	0.31423 0.0483 40
QA7CPM	0.15982 0.2832 47	0.42961 0.2485 9	0.31115 0.3008 13	0.08687 0.6144 36	0.20281 0.1977 42	0.57053 0.1397 8	0.32641 0.2764 13	0.15453 0.4149 30
QA7PND	0.57998 0.1016 9	0.28901 0.3623 12	0.91856 0.0276 5	0.05403 0.8821 10	0.49947 0.2076 8	0.51176 0.1305 10	0.53566 0.3522 5	0.82210 0.0232 7
QA7PERT	0.15400 0.6154 13	0.73515 0.1570 5	0.21420 0.4257 16	0.29066 0.3134 14	0.53752 0.0582 13	0.87039 0.1296 4	0.33215 0.2088 16	0.50506 0.1365 10
QA7GBC	0.20897 0.1898 41	0.51665 0.1037 11	0.32861 0.2318 15	0.33390 0.0190 49	0.30723 0.0726 35	0.64222 0.0622 9	0.07478 0.7994 14	0.30084 0.0593 40
Q31CPM	0.15334 0.2965 48	0.54356 0.1304 9	-0.00430 0.9889 13	0.13388 0.4295 37	0.01833 0.9071 43	0.56952 0.1406 8	-0.02810 0.9274 13	-0.20832 0.2608 31
Q91PND	0.87849 0.0041 8	0.83844 0.0013 11	0.74805 0.1459 5	0.82334 0.0064 9	0.52186 0.2296 7	0.51921 0.1520 9	0.34931 0.5645 5	0.47862 0.3369 6
Q81PERT	-0.16242 0.5790 14	-0.08536 0.8915 5	0.13326 0.6227 16	-0.11519 0.6950 14	-0.14287 0.6261 14	0.43627 0.5637 4	0.03663 0.8929 16	-0.59640 0.0688 10
Q81GBC	-0.01527 0.9245 41	0.56828 0.0865 10	0.06443 0.8196 15	0.11291 0.4350 50	-0.17531 0.3138 35	0.41978 0.3005 8	-0.28211 0.3285 14	-0.31791 0.0428 41
Q82CPM	-0.11232 0.4902 40	-0.25313 0.5839 7	0.04100 0.9047 11	0.05700 0.7567 32	-0.13997 0.4155 36	-0.11295 0.8313 6	0.05940 0.8623 11	-0.15580 0.4377 27

(Cont.)

Pearson Correlation between All Questions (Variables)

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	Q87CPM	Q87PND	Q87PERT	Q87GBC	Q88CPM	Q88PND	Q88PERT	Q88GBC
Q32PND	-0.15715	-0.14199	-0.02778	0.00000	0.16593	0.53521	-0.09241	0.61057
	0.7365	0.6956	0.9646	1.0000	0.7534	0.1717	0.8825	0.1980
	7	10	5	9	6	8	5	6
Q32PERT	0.05817	0.94491	0.09060	0.32626	0.16797	0.94491	0.01436	0.16062
	0.8651	0.2123	0.7685	0.3575	0.6215	0.2123	0.9647	0.7040
	11	3	13	10	11	3	12	8
Q32GBC	-0.05984	-0.19783	0.28225	0.06751	-0.12167	0.05962	0.09744	-0.01459
	0.7367	0.6560	0.3741	0.6710	0.5295	0.9107	0.7756	0.9337
	34	8	12	42	29	6	11	35
Q33CPM	0.41454	0.40100	0.71233	0.43966	0.26980	0.68877	0.49104	0.17923
	0.0046	0.2848	0.0063	0.0073	0.0802	0.0589	0.0746	0.3347
	45	9	13	36	43	8	14	31
Q33PND	0.32383	0.31394	0.34829	0.56552	0.26123	0.21329	-0.08339	-0.02455
	0.4339	0.3471	0.5657	0.0884	0.5320	0.5541	0.8940	0.9583
	8	11	5	10	8	10	5	7
Q33PERT	0.76087	0.00000	0.64787	0.19046	0.53931	0.50000	0.65084	0.21156
	0.0041	1.0000	0.0090	0.5331	0.0704	0.6667	0.0086	0.5574
	12	4	15	13	12	3	15	10
Q33GBC	0.33078	0.34318	0.30364	0.32568	0.00222	0.01245	0.47093	0.02817
	0.0919	0.5054	0.4270	0.0562	0.9914	0.9813	0.2389	0.8724
	27	6	9	35	26	6	8	35
Q34CPM	-0.11584	-0.67344	-0.08333	-0.07430	-0.18114	-0.64578	0.02137	-0.08521
	0.4381	0.0468	0.7867	0.6575	0.2451	0.0837	0.9422	0.6485
	47	9	13	38	43	8	14	31
Q34PND	0.23355	-0.16206	-0.58333	0.15309	-0.02981	0.16003	0.04490	0.35614
	0.5778	0.6340	0.3019	0.6728	0.9441	0.6588	0.9428	0.4330
	8	11	5	10	8	10	5	7
Q34PERT	0.53571	-0.16667	0.24757	0.07093	0.49578	-0.19245	0.20101	0.07881
	0.0592	0.7888	0.3552	0.8096	0.0849	0.8075	0.4554	0.8287
	13	5	16	14	13	4	16	10
Q34GBC	-0.01957	-0.03881	-0.19898	-0.05023	-0.21586	0.10768	-0.39936	-0.14787
	0.9072	0.9210	0.4953	0.7318	0.2276	0.7997	0.1764	0.3562
	38	9	14	49	33	8	13	41
Q35CPM	0.03480	-0.26774	-0.15291	-0.20271	0.02530	-0.41872	-0.03310	-0.02697
	0.8123	0.4545	0.6018	0.2158	0.8721	0.3018	0.9106	0.8835
	49	10	14	39	43	8	14	32
Q35PND	0.17078	-0.03790	-0.58333	-0.23905	-0.03492	0.13769	0.07332	0.42875
	0.7143	0.9172	0.3019	0.5356	0.9408	0.7239	0.9067	0.3963
	7	10	5	9	7	9	5	6

(Cont.)

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	Q87CPM	Q87PND	Q87PERT	Q87GBC	Q88CPM	Q88PND	Q88PERT	Q88GBC
Q85PERT	0.11386	-0.66667	0.20451	-0.13300	0.00000	-0.55556	0.30151	0.19305
	0.7111	0.2191	0.4474	0.6504	1.0000	0.4444	0.2564	0.5931
	13	5	16	14	13	4	16	10
Q85GBC	-0.03411	0.02472	0.39988	-0.00829	0.07723	0.24077	0.11363	0.05518
	0.8367	0.9460	0.1566	0.9549	0.6692	0.5657	0.7117	0.7319
	39	10	14	49	33	8	13	41
Q86CPM	0.51345	0.43465	0.73826	0.35988	0.42924	0.83511	0.59081	0.29791
	0.0002	0.2127	0.0040	0.0311	0.0046	0.0182	0.0335	0.1098
	47	8	13	36	42	7	13	30
Q86PND	0.53676	0.64087	0.41646	0.47691	0.33841	0.56412	-0.43911	0.41644
	0.2142	0.0424	0.4855	0.1943	0.4578	0.1136	0.4594	0.4115
	7	10	5	9	7	9	5	6
Q86PERT	0.22214	-0.57735	0.42659	0.10602	0.19895	-0.55556	0.38157	0.13863
	0.4657	0.4226	0.0994	0.7303	0.5147	0.4444	0.1605	0.7025
	13	4	16	13	13	4	15	10
Q86GBC	0.17312	-0.36810	0.43111	0.32368	0.19802	-0.26975	0.50791	0.35539
	0.2854	0.2953	0.1238	0.0233	0.2616	0.5182	0.0764	0.0244
	40	10	14	49	34	8	13	40
Q87CPM	1.00000	0.89273	0.85288	0.68850	0.66960	0.73636	0.61641	0.47200
	0.0000	0.0012	0.0001	0.0001	0.0001	0.0372	0.0249	0.0064
	49	9	14	38	43	8	13	32
Q87PND	0.89273	1.00000	0.57735	0.81011	0.73765	0.66388	-0.10999	0.73213
	0.0012	0.0000	0.4226	0.0081	0.0367	0.0363	0.8602	0.0614
	9	12	4	9	8	10	5	7
Q87PERT	0.85288	0.57735	1.00000	0.68754	0.74219	0.77778	0.62716	0.48968
	0.0001	0.4226	0.0000	0.0066	0.0037	0.2222	0.0123	0.1263
	14	4	17	14	13	4	15	11
Q87GBC	0.68850	0.81011	0.68754	1.00000	0.51342	0.79387	0.25715	0.57211
	0.0001	0.0081	0.0066	0.0000	0.0023	0.0187	0.3964	0.0001
	38	9	14	50	33	8	13	41
Q88CPM	0.66960	0.73765	0.74219	0.51342	1.00000	0.67613	0.69525	0.91041
	0.0001	0.0367	0.0037	0.0023	0.0000	0.0656	0.0083	0.0001
	43	8	13	33	43	8	13	31
Q88PND	0.73636	0.66388	0.77778	0.79387	0.67613	1.00000	0.17408	0.93673
	0.0372	0.0363	0.2222	0.0187	0.0656	0.0000	0.8259	0.0019
	8	10	4	8	8	10	4	7
Q88PERT	0.61641	-0.10999	0.62716	0.25715	0.69525	0.17408	1.00000	0.86402
	0.0249	0.8602	0.0123	0.3964	0.0083	0.8259	0.0000	0.0013
	13	5	15	13	13	4	16	10

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	Q87CPM	Q87PND	Q87PERT	Q87GBC	Q88CPM	Q88PND	Q88PERT	Q88GBC
Q88GBC	0.47200	0.73213	0.48968	0.57211	0.91041	0.93673	0.86402	1.00000
	0.0064	0.0614	0.1263	0.0001	0.0001	0.0019	0.0013	0.0000
	32	7	11	41	31	7	10	41

Table B-1 : **Computation of Spearman Rank Correlation of Aspects of Utilization of the SET "Factor Categories".**

#	Technique (SET)	Aspects Categories	Rank on groups: (L) Large Firm	(M) Medium Firm	(S) Small Firm	Difference between Ranks (d): dLM	d^2LM	dLS	d^2LS	dMS	d^2MS
1	CPM	3A6	1	0	0	1	1	1	1	0	0
2	"	7A6	2	2	0	0	0	2	4	2	4
3	"	8A6	3	3	0	0	0	3	9	3	9
4	"	9A6	4	4	1	0	0	3	9	3	9
5	"	1A6	5	1	2	4	26	3	9	1	1
6	"	2A6	6	0	3	6	36	3	9	3	9
7	"	4A6	7	0	0	7	49	7	49	0	0
8	"	6A6	6	0	0	8	64	8	64	0	0
9	GBC	1A6	1	4	0	3	9	1	1	4	16
10	"	3A6	2	0	0	2	4	2	4	0	0
11	"	5A6	3	1	4	2	4	1	1	3	9
12	"	6A6	4	0	0	4	16	4	16	0	0
13	"	8A6	5	0	2	5	25	3	9	2	4
14	"	6	6	2	0	4	16	6	36	2	4
15	"	9A6	7	3	1	4	16	6	36	2	4
16	"	2A6	8	0	3	8	64	5	25	3	9
17	"	4A6	0	5	0	5	25	0	0	5	25
18	PERT	1A6	1	0	0	1	1	1	1	0	0
19	"	9A6	2	2	0	0	0	2	4	2	4
20	"	2A6	3	3	0	0	0	3	9	3	9
21	"	3A6	0	1	0	1	1	0	0	1	1
22	PND	1A6	1	0	0	1	1	1	1	0	0
23	"	2A6	2	0	2	2	4	0	0	2	4
24	"	3A6	3	0	0	3	9	3	9	0	0
25	"	9A6	4	0	1	4	16	3	9	1	1
26	"	6A6	5	0	0	5	25	5	25	0	0
27	"	8A6	6	1	0	5	25	6	36	1	1
		d^2					427		376		123

Where :

CPM = Critical Path Method
GBC = Gantt Bar Chart
PERT = Program Evaluation & Review Technique
PND = Precedence Network Diagramming

L = Large Firms
M = Medium Firms
S = Small Firms

Table B-2 : **Computation of Spearman Rank Correlation of User's Levels of SET Utilization "Factor Categories".**

#	Technique (SET)	Aspects Categories	Rank on groups: Large Firm (L)	Medium Firm (M)	Small Firm (S)	Difference between Ranks (d): dLM	d^2LM	dLS	d^2LS	dMS	d^2MS
1	CPM	5A7	1	5	3	4	16	2	4	2	4
2	"	6A7	2	2	0	0	0	2	4	2	4
3	"	8A7	3	4	0	1	1	3	9	4	16
4	"	7A7	4	3	1	1	1	3	9	2	4
5	"	9A7	5	0	2	5	25	3	9	2	4
6	"	1A7	6	1	4	5	25	2	4	3	9
7	"	2A7	7	0	0	7	49	7	49	0	0
8	GBC	1A7	1	2	3	1	1	2	4	1	1
9	"	2A7	2	0	0	2	4	2	4	0	0
10	"	8A7	3	0	0	3	9	3	9	0	0
11	"	7A7	4	1	2	3	9	2	4	1	1
12	"	9A7	5	0	4	5	25	1	1	4	16
13	"	5A7	6	3	1	3	9	5	25	2	4
14	"	6A7	7	0	0	7	49	7	49	0	0
15	PERT	5A7	1	0	0	1	1	1	1	0	0
16	"	1A7	2	3	0	1	1	2	4	3	9
17	"	2A7	3	4	0	1	1	3	9	4	16
18	"	3A7	0	1	0	1	1	0	0	1	1
19	"	7A7	0	2	0	2	4	0	0	2	4
20	PND	9A7	1	0	0	1	1	1	1	0	0
21	"	1A7	2	3	2	1	1	0	0	1	1
22	"	7A7	3	2	3	1	1	0	0	1	1
23	"	5A7	0	1	1	1	1	1	1	0	0
		d^2					235		200		95

Where :-

CPM = Critical Path Method
GBC = Gantt Bar Chart
PERT = Program Evaluation & Review Technique
PND = Precedence Network Diagramming

L = Large Firms
M = Medium Firms
S = Small Firms

Table B-3 : **Computation of Spearman Rank Correlation of Criteria of Measuring the Successful "Factor Categories"**

#	Technique (SET)	Aspects Categories	Rank on groups (L) Large Firm	(M) Medium Firm	(S) Small Firm	Difference between Ranks (d) dLM	d^2LM	dLS	d^2LS	dMS	d^2MS
1	CPM	6B6	1	3	0	2	4	1	1	3	9
2	"	7B6	2	4	2	2	4	0	0	2	4
3	"	8B6	3	0	3	3	9	0	0	3	9
4	"	5B6	4	2	1	2	4	3	9	1	1
5	"	1B6	5	5	0	0	0	5	25	5	25
6	"	2B6	0	1	0	1	1	0	0	1	1
7	"	3B6	0	0	5	0	0	5	25	5	25
8	"	9B6	0	0	4	0	0	4	16	4	16
9	GBC	5B6	1	1	1	0	0	0	0	0	0
10	"	6B6	2	2	0	0	0	2	4	2	4
11	"	7B6	3	3	2	0	0	1	1	1	1
12	"	1B6	4	5	4	1	1	0	0	1	1
13	"	3B6	5	0	0	5	25	5	25	0	0
14	"	4B6	6	0	0	6	36	6	36	0	0
15	"	2B6	0	4	0	4	16	0	0	4	16
16	"	8B6	0	0	3	0	0	3	9	3	9
17	"	9B6	0	0	5	0	0	5	25	5	25
18	PERT	2B6	1	1	0	0	0	1	1	1	1
19	"	5B6	2	0	0	2	4	2	4	0	0
20	"	6B6	3	0	0	3	9	3	9	0	0
21	"	7B6	4	0	0	4	16	4	16	0	0
22	"	1B6	5	2	0	3	9	5	25	2	4
23	PND	2B6	1	0	0	1	1	1	1	0	0
24	"	5B6	2	1	1	1	1	1	1	0	0
25	"	6B6	3	2	0	1	1	3	9	2	4
26	"	7B6	4	0	0	4	16	4	16	0	0
27	"	9B6	5	0	3	5	25	2	4	3	9
28		1B6	6	4	0	2	4	6	36	4	16
29		8B6	0	3	2	3	9	2	4	1	1
		d^2					195		302		181

Where :-

CPM = Critical Path Method
GBC = Gantt Bar Chart
PERT = Program Fvaluation & Review Technique
PND = Precedence Network Diagramming

L = Large Firms
M = Medium Firms
S = Small Firms

Table B-4 : **Computation of Spearman Rank Correlation of Reasons of Successful "Factor Categories.**

#	Technique Aspects (SFT)	Categories	Pank on groups (L) Large Firm	(M) Medium Firm	(S) Small Firm	Difference between Ranks (d) dLM	d^2LM	dLS	d^2LS	dMS	d^2MS
1	CPM	2B7	1	0	0	1	1	1	1	0	0
2	"	7B7	2	4	1	2	4	1	1	3	9
3	"	8B7	3	5	2	2	4	1	1	3	9
4	"	1B7	4	7	3	3	9	1	1	4	16
5	"	9B7	5	6	0	1	1	5	25	6	36
6	"	3B7	6	1	0	5	25	6	36	1	1
7	"	6B7	7	3	0	4	15	7	49	3	9
8	"	5B7	0	2	0	2	4	0	0	2	4
9	GBC	2B7	1	0	0	1	1	1	1	0	0
10	"	5B7	2	0	0	2	4	2	4	0	0
11	"	6B7	3	2	0	1	1	3	9	2	4
12	"	8B7	4	3	1	1	1	3	9	2	4
13	"	9B7	5	4	0	1	1	5	25	4	16
14	"	7B7	6	6	3	0	0	3	9	3	9
15	"	1B7	7	5	2	2	4	5	25	3	9
16	"	3B7	8	1	0	7	49	8	64	1	1
17	"	4B7	9	0	0	0	81	9	81	0	0
18	PERT	1B7	1	3	0	2	4	1	1	3	9
19	"	3B7	2	1	0	1	1	2	4	1	1
20	"	5B7	3	0	0	3	9	3	9	0	0
21	"	9B7	4	0	0	4	16	4	16	0	0
22	"	6B7	5	4	0	1	1	5	25	4	16
23	"	2B7	6	0	0	6	36	6	36	0	0
24	"	8B7	0	2	0	2	4	0	0	2	4
25	PND	1B7	1	0	1	1	1	0	0	1	1
26	"	7B7	0	0	2	0	0	2	4	2	4
27	"	8B7	2	1	3	1	1	1	1	2	4
28	"	6B7	3	3	0	0	0	3	9	3	9
29	"	9B7	0	2	4	2	4	4	16	2	4
		d^2					283		462		179

Where :-

CPM = Critical Path Method
GBC = Gantt Bar Chart
PERT = Program Evaluation & Review Technique
PND = Precedence Network Diagramming

L = Large Firms
M = Medium Firms
S = Small Firms

Table B-5 : **Computation of Spearman Rank Correlation of Reasons of Failure "Factor Categories".**

#	Technique Aspects (SET)	Categories	Rank on groups (L) Large Firm	(M) Medium Firm	(S) Small Firm	Difference between Ranks (d) dLM	d^2LM	dLS	d^2LS	dMS	d^2MS
1	CPM	6B8	1	0	0	1	1	1	1	0	0
2	"	7B8	2	2	2	0	0	0	0	0	0
3	"	1B8	3	4	1	1	1	2	4	3	9
4	"	8B8	4	3	3	1	1	1	1	0	0
5	"	5B8	5	1	4	4	15	1	1	3	9
6	"	2B8	6	0	5	6	36	1	1	5	25
7	"	3B8	7	0	0	7	49	7	49	0	0
8	GBC	1B8	1	4	1	3	9	0	0	3	9
9	"	6B8	2	1	4	1	1	2	4	3	9
10	"	8B8	3	3	2	0	0	1	1	1	1
11	"	2B8	4	6	0	2	4	4	16	6	36
12	"	5B8	5	5	3	0	0	2	4	2	4
13	"	3B8	6	0	0	6	36	6	36	0	0
14	"	7B8	0	2	0	2	4	0	0	2	4
15	PERT	6B8	1	0	0	1	1	1	1	0	0
16	"	1B8	2	3	0	1	1	2	4	3	9
17	"	5B8	3	4	0	1	1	3	9	4	16
18	"	7B8	4	0	0	4	16	4	16	0	0
19	"	3B8	0	1	0	1	1	0	0	1	1
20	"	8B8	0	2	0	2	4	0	0	2	4
21	PND	1B8	1	0	1	1	1	0	0	1	1
22	"	7B8	2	0	0	2	4	2	4	0	0
23	"	5B8	3	2	2	1	1	1	1	0	0
24	"	8B8	0	1	4	1	1	4	16	3	9
25	"	6B8	0	0	3	0	0	3	9	3	9
		d^2					189		178		155

Where :-

CPM = Critical Path Method
GBC = Gantt Bar Chart
PERT = Program Evaluation & Review Technique
PND = Precedence Network Diagramming

L = Large Firm
M = Medium Firm
S = Small Firms

Rank Correlation Values

FACTOR	SPEARMAN			PARTIAL			MULTIPLE		
	r_{LM}	r_{LS}	r_{MS}	r_{LM-S}	r_{LS-M}	r_{MS-L}	r_{L-MS}	r_{M-LS}	r_{S-LM}
Aspects of Utilization	0.86	0.88	0.96	0.12	0.39	0.83	0.89	0.96	0.97
User's Levels of Utilization	0.88	0.90	0.95	0.21	0.42	0.76	0.90	0.95	0.96
Criteria of Success	0.95	0.93	0.96	0.61	0.20	0.64	0.95	0.97	0.96
Reasons of Success	0.93	0.88	0.95	0.59	0.06	0.73	0.93	0.97	0.95
Reasons of Failure	0.92	0.93	0.94	0.45	0.46	0.56	0.89	0.91	0.88

r = Correlation Coefficient Ratio
L = Large Firms
M = Medium Firms
S = Small Firms

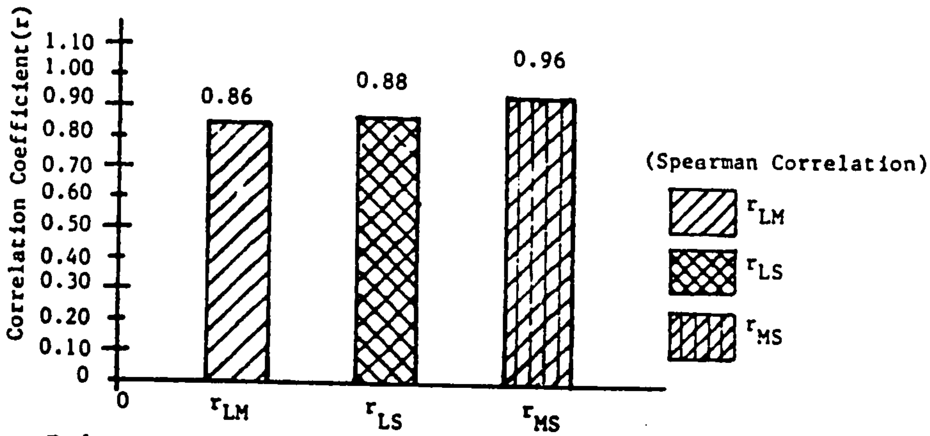

Fig. B-1: The agreement between each two groups as measured by correlation coefficient (Aspects of SET's Implementation)

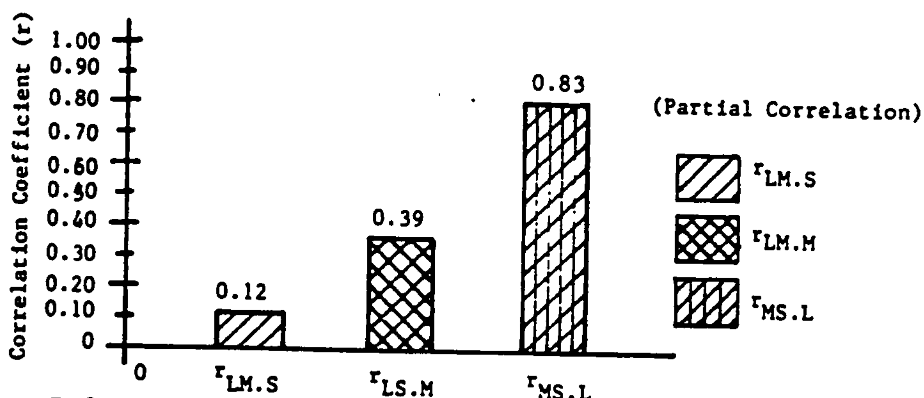

Fig. B-2: The agreement between each two groups when the other is kept constant (Aspects of SET's Implementation)

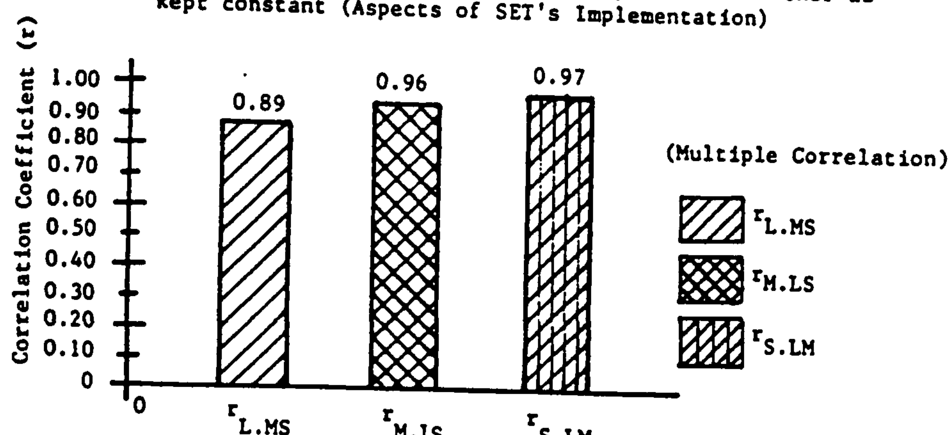

Fig. B-3: The agreement between each group and the other two groups (Aspects of SET's Implementation)

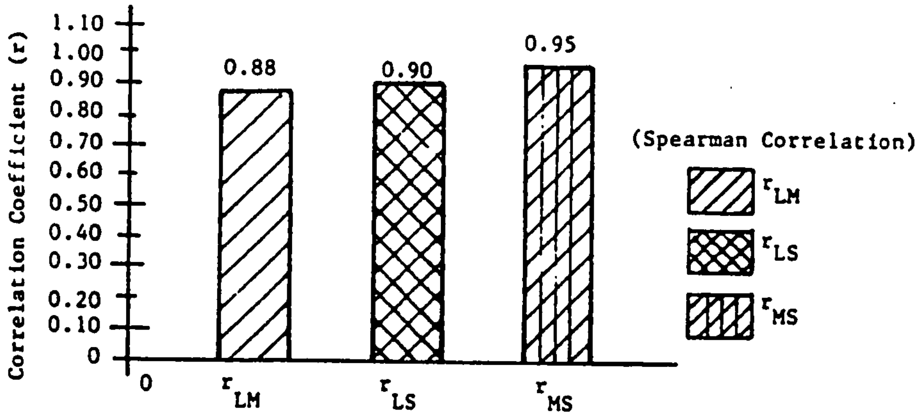

Fig. B-4: The Agreement between each two groups as measured by the Correlation Coefficient (User's levels of Information).

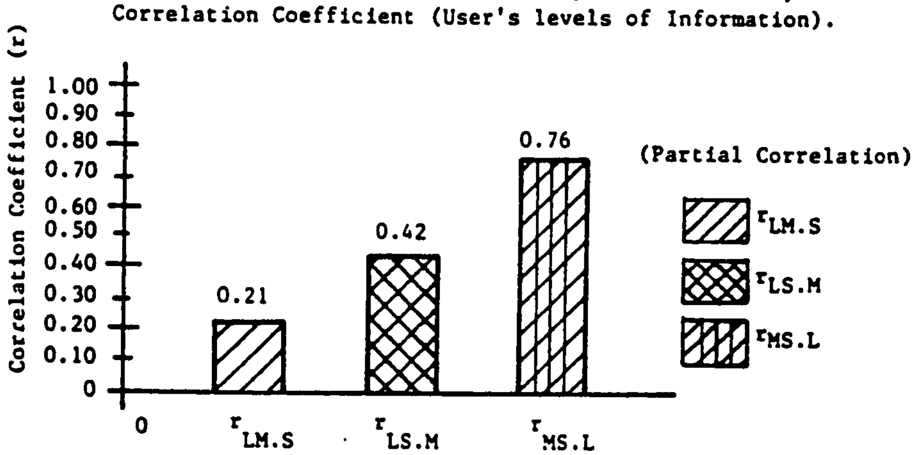

Fig. B-5: The Agreement between each two groups when the other one is kept constant (user's levels of Information)

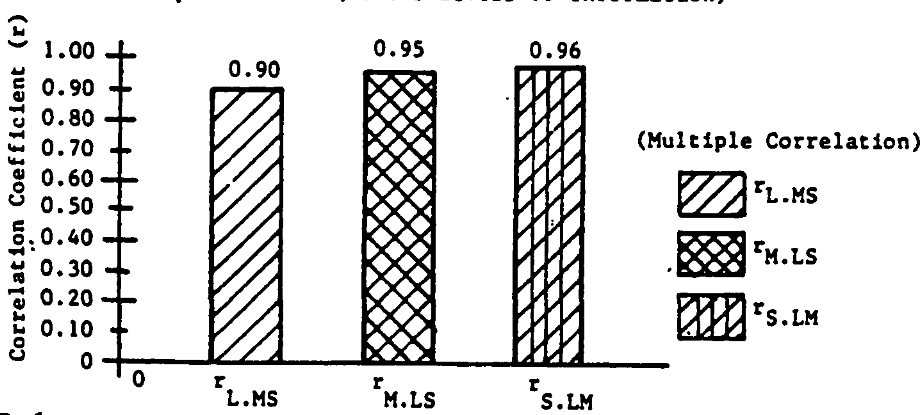

Fig. B-6: The Agreement between each group and the other two groups (User's levels of Information).

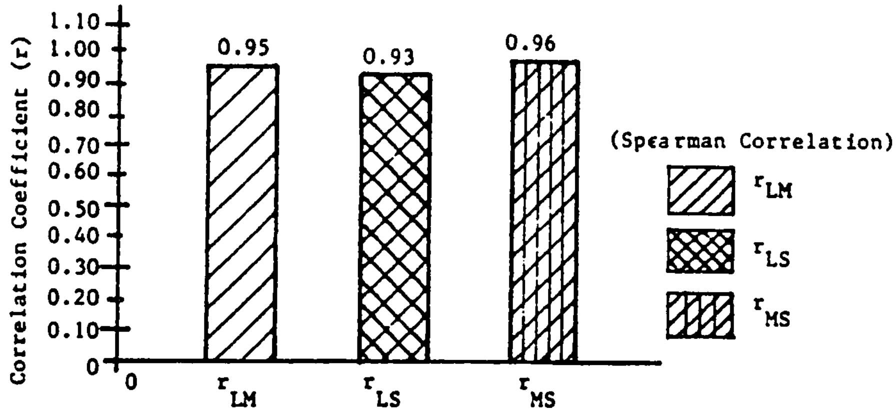

Fig. B-7: The agreement between each two groups as measured by the Correlation Coefficient (Criteria of Measuring the successful of SET's utilization).

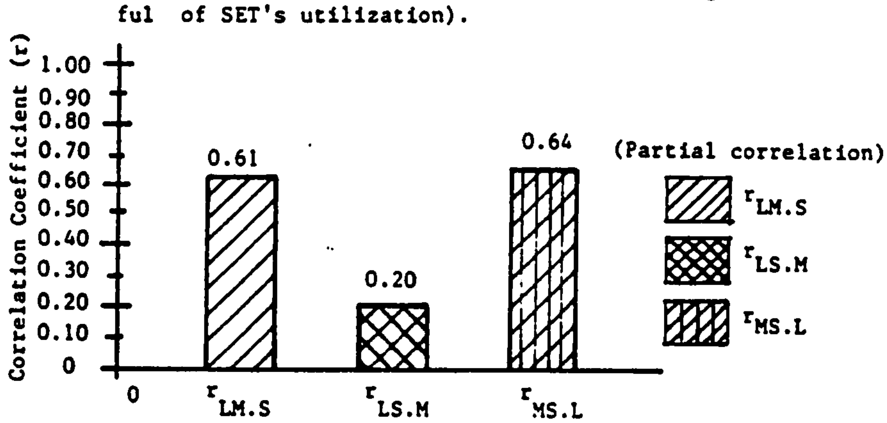

Fig. B-8: The Agreement between each two groups when the other one is kept constant (Criteria of measuring the successful of SET's utilization).

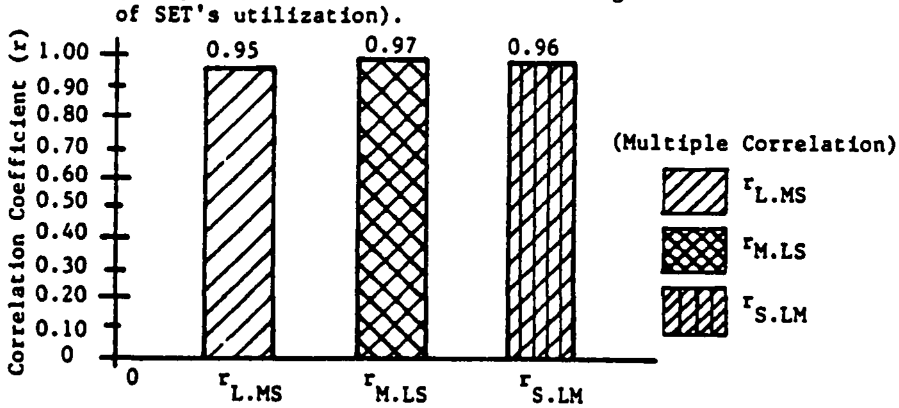

Fig. B-9: The agreement between each group and the other two groups (Criteria of measuring the successful of SET's utilization).

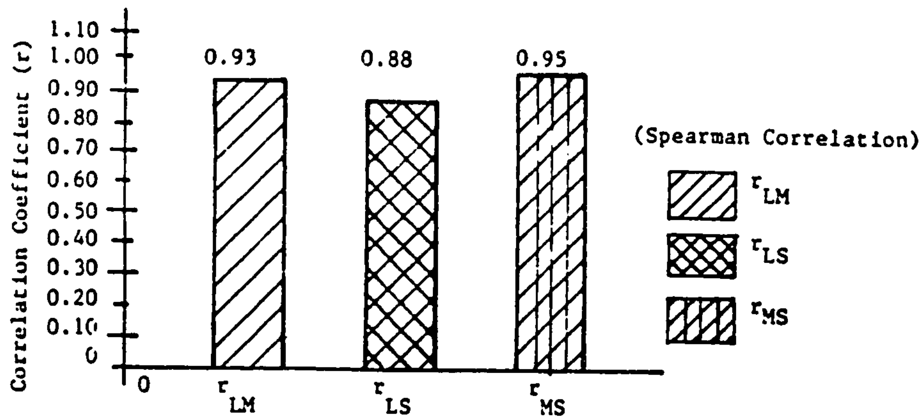

Fig. B-10: The Agreement between each two groups as measured by the Correlation Coefficient (Causes of success of SET's Implementation)

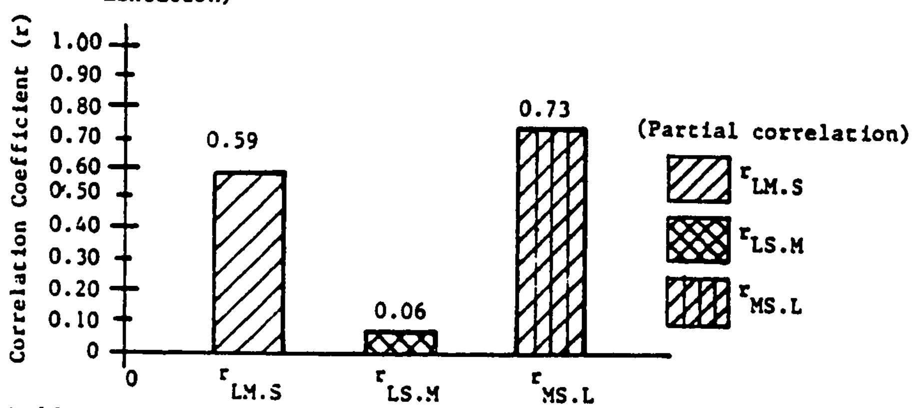

Fig. B-11: The Agreement between each two groups when the other one is kept constant (Causes of success of SET's Implementation).

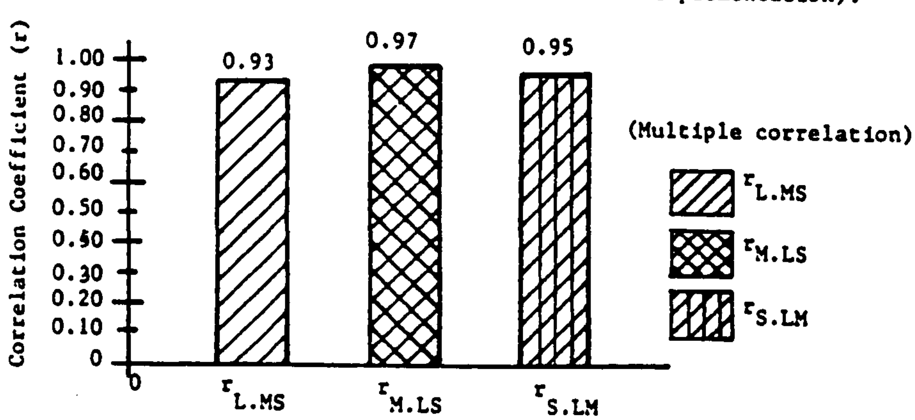

Fig. B-12: The Agreement between each group and the other two groups (causes of success of SET's Implementation).

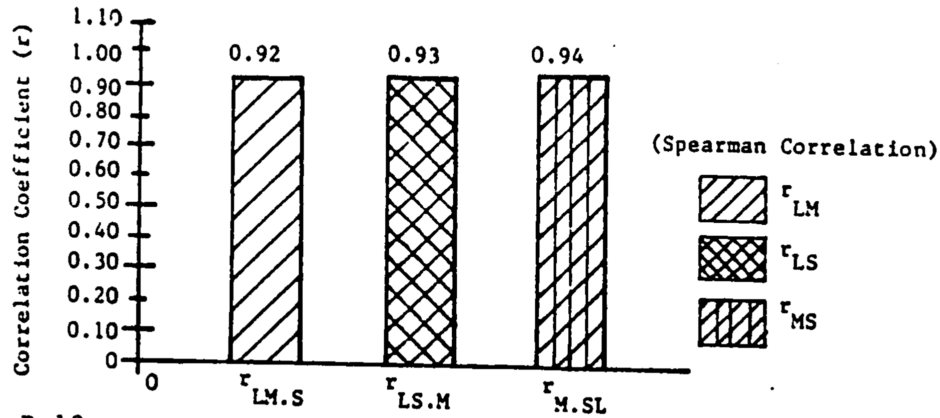

Fig. B-13: The agreement between each two groups as measured by the Correlation Coefficient (Causes of Failure of SET's Implementation).

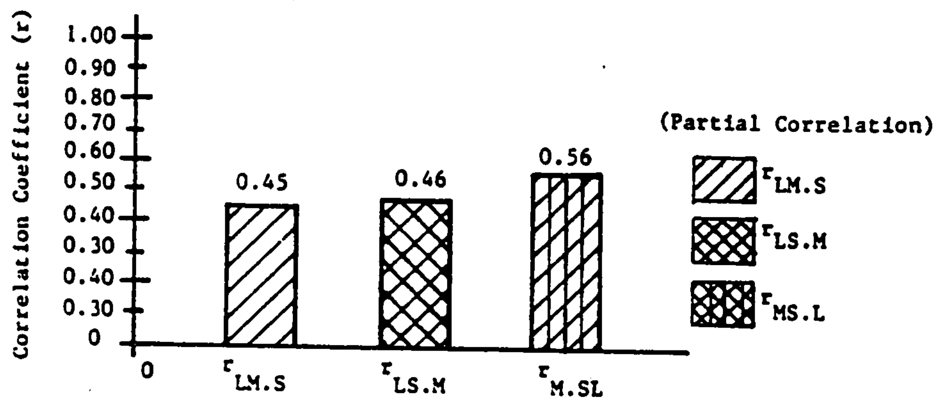

Fig. B-14: The agreement between each two groups when the other one is kept constant (Causes of Failure of SET's Implementation).

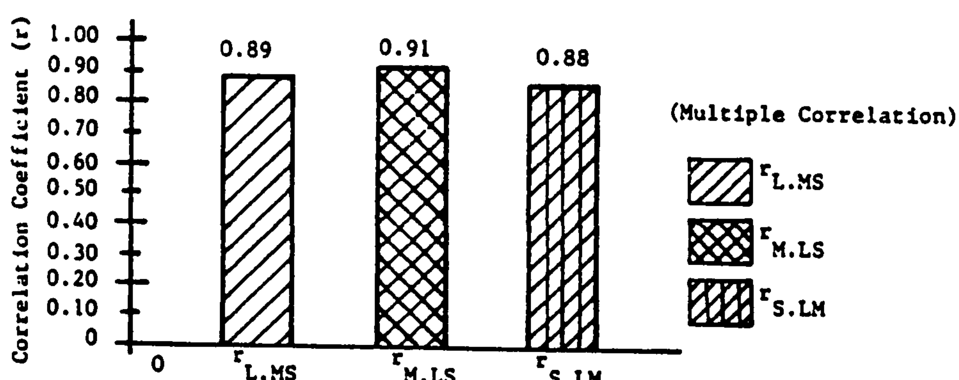

Fig. B-15: The agreement between each group and the other two groups (Causes of Failure of SET's Implementation).

APPENDIX (C)

CONSTRUCTION FIRM'S NAMES AND LOCATIONS

NAME OF THE COMPANY	LOCATION
1. Ghater Tahsseen Co. Ltd.	Riyadh
2. Abdullah A. Al-Khodari Ltd.	Al-Khobar
3. Al-Khodari & Sons Co.	Dammam
4. JGC Arabia Ltd.	Jeddah, Riyadh
5. Kirby, Husseini Contractors	Al-Khobar
6. Boremaster (SA) Co. Ltd.	Dhahran
7. Contracting & Trading Co. (CAT)	Al-Khobar
8. Al-Najim Saudi International Co.Ltd.	Dammam
9. Nesma & Alfadl Contracting Co.Ltd.	Al-Khobar
10. Eastern Trading & Construction Co.	Al-Khobar
11. Saudi Arabia Steidle Co. Ltd.	Al-Khobar
12. Al-Barghash Trading & Construction Co.	Thogbah, Turaif
13. Joannou & Paraskevaides Ltd.	Riyadh
14. Belleli Saudi Arabia Ltd.	Jubail Ind.City
15. Saudi National For Trad. & Cont.	Riyadh, Al-Khobar
16. PETCON, Saudi Ele-Mech-Const.Co.Ltd	Dammam
17. Fouad Abdulla Fouad Group	Dammam
18. Flour Arabia Ltd.	Riyadh, Khobar
19. Saudi Conder Co.(SAUCO) Ltd.	Jeddah
20. Abdullah H.Al-Shuwayer Trad.Cont.Co.	Damma, Jubail
21. Nassir Hazza & Brothers	Al-Khobar
22. TEKFEN Const. & Installation Co.Inc.	Riyadh, Jubail

23. Al-Henaki Trading & Cont. Co.	Riyadh
24. Agab Arabian Ltd. Co.	Dammam
25. Kettaneh Brothers Saudi Arabia Co.	Al-Khobar
26. Al-Tamimi Construction Co.	Dammam
27. Salman A. Al-Duhaim Est.	Al-Khobar
28. Al-Fouzan Co. Ltd.	Al-Khobar
29. Al-Abdulrahman (AARTCO)	Al-Khobar
30. REDEC Daelim (SA) Co.	Riyadh, Jeddah, Khobar
31. Modern Arab Const. Co.Ltd	Al-Khobar, Riyadh
32. Civil Works Company	Riyadh, Dammam
33. Hyundai Eng. & Const.Co. Ltd.	Dammam
34. (BETA) A.Zaidan & Partners Co.	Jeddah, Riyadh
35. Allied Engg. Enterprises	Riyadh, Dammam
36. Saudi Arabian Saipem Ltd.	Al-Khobar
37. Al-Derbas Roads & Maint.Co.Ltd.	Al-Khobar
38. Ballast Nedam Co.Ltd.	Riyadh, Dhahran
39. Mitsubishi Consortium Heavy Ind.Ltd.	Al-Khobar
40. Middle East Engg. & Dev. Co. Ltd.	Dammam
41. Ahmed N. Al-Binali & Sons. Co.	Dammam
42. Abdullah B. Al-Khalifah & Sons Ltd.	Riyadh,Jeddah,Khobar
43. King Wilkinson (SA) Ltd.	Al-Khobar
44. EAGLETON (SA) Ltd.	Al-Khobar
45. Al-Oasis Cont. & Trading Co.	Dammam
46. (ATCO) Al-Turki Corporation	Dammam
47. (DCC) Saudi Danish Const.Co.Ltd.	Dammam, Al-Khobar

48. Kirby, Al-Mira For Contracting Ltd.	Dammam
49. Al-Muhana For Trad. & Cont. Est.	Dammam, Arar
50. A.Aziz, Al-Traiki & Partners	Dammam
51. Interedec-Aswd Cons. & Eng.Co.Ltd.	Dammam, Jeddah, Jubail
52. Mohammad Al-Mojil Est.	Dammam
53. (MABCO) Manuf. & Build.Co.Ltd.	Riyadh, Jeddah
54. Consolidated Contractors Co.Ltd.	Riyadh, Al-Khobar
55. Segia Trading & Contra. Co.Ltd.	Dammam
56. Al-Hugayet Trad. & Cont. Est	Dammam
57. Saudi Enterprises Co.Ltd. (SAECO)	Dammam
58. (SST) Sademi Shaker Tamimi Const.Co.	Riyadh, Dammam
59. Contr. & Commer. Dev. Est. (CADO)	Riyadh, Dammam
60. Al-Najim Contr., Trading & Ser. Est.	Dammam
61. You-One Construction Co.Ltd.	Jeddah, Riyadh, Dammam

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