ON THE ADEQUACY OF CURRENT AUTHORITATIVE GUIDELINES FOR THE REVIEW AND EVALUATION OF SYSTEMS DEVELOPMENT CONTROLS

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CHAPTER I

INTRODUCTION

Authoritative audit guidelines provide interpretations of generally accepted auditing standards (GAAS) and recommendations as to auditing procedures for American Institute of Certified Public Accountants (AICPA) membership. The basic objective of these guidelines is to shape and coordinate professional thinking in areas in which conflicts and/or ambiguities regarding auditor responsibility and/or acceptable audit procedures emerge. One such area of conflict and/or ambiguity is the study and evaluation of internal control in electronic data processing (EDP) environments.

In an effort to clarify auditor responsibility and auditing procedures to be followed in the EDP internal control evaluation process, the AICPA has issued two authoritative guidelines. The first of these is Statement on Auditing Standards (SAS) No. 3 (AICPA, 1974), which defines areas of EDP internal control over which external auditors are responsible. The second guideline, prepared by the Computer Services Executive Committee (AICPA, 1977), is entitled "The Auditors Study and Evaluation of Internal Control in EDP Systems." This document describes and recommends procedures to be performed by independent auditors in meeting their responsibilities under SAS No. 3.

In their current form these guidelines appear deficient in two respects. First, they do not specify the relationship between controls over systems development procedures and the generation of by-product evidence bearing upon certain audit decisions, although the relationship seems important enough to warrant specification. Cognizance of the relationship on the part of systems reviewers is essential in assessing application integrity and in determining the nature, timing, and extent of audit procedures to be applied in the examination of financial statements.

Second, the guidelines do not contain minimum control standards for the systems development process. Minimum controls are those necessary to assure the generation of essential audit evidence used in conjunction with conventional EDP audit techniques.

Statement of the Problem and Purpose of the Study

Since authoritative EDP audit guidelines appear deficient in the two respects identified above, reason exists to question whether or not practicing EDP auditors are cognizant of the relationship between controls over systems development procedures and the generation of by-product evidence bearing upon certain audit decisions. Likewise, reason exists to question whether or not practicing EDP auditors agree as to appropriate criteria (minimum control standards) for assessing development control adequacy.

This study focused primarily on the second question. In particular, the purpose of this study was to identify empirically and evaluate professional theories-in-use for interpreting and integrating systems development control information in an overall judgment about development control adequacy. However, the two questions are related so closely that to investigate the second is to investigate also the first, at least partially. Minimum control standards addressed by the second question cannot be formulated nor agreed upon, except by chance, without the relational cognizance addressed by the first question. And chance agreement, to say nothing of chance formulation, is difficult to believe.

Importance of the Problem and the Study

Since the questions identified above bear upon certain audit decisions and poor audit decisions may have grave consequences, the questions are nontrivial both from the viewpoint of the individual EDP auditor and the profession at large. For example, assume that in concept, at least, a set of minimum control standards is capable of being formulated. Further, assume that due to professional demands on otherwise intellectual reflective time, individual EDP auditors do not possess the necessary relational congizance to formulate the standards for themselves and hence sometimes judge overall control as adequate when the minimum controls are absent. When and to the extent that this fallacy is detected, the individual EDP auditor may experience loss of client confidence, not to mention legal exposure. The profession may experience one more in the rapidly growing series of quantum losses of societal confidence.

Consider another example. Assume as before that in concept, at least, a set of minimum control standards is capable of being formulated. Also as before, assume that individual EDP auditors do not possess the necessary relational cognizance to formulate the standards for themselves. But now assume that sometimes individual EDP auditors judge overall control as inadequate even though the minimum controls are present and due to the inadequacy judgment decide to supplement cost effective conventional EDP audit techniques. Unlike the fallacy of the first example, this fallacy likely will never be detected. However, its consequence is no less severe. The consequence is wasteful resource consumption.

Finally, the Foreign Corrupt Practices Act of 1977 also provides import for the problem and the study. That

Act requires all public companies (1) to devise and maintain internal control systems sufficient to provide reasonable assurance that assets are safeguarded and transactions are properly authorized and recorded and (2) to keep reasonably detailed records which reflect accurately and fairly financial activities. Moreover, the Act imposes new reporting requirements on both management and external auditors. Beginning in 1980, management must report on and external auditors must attest to management's report on internal control. To the extent that independent EDP auditors do not agree as to appropriate criteria (minimum control standards) for assessing development control adequacy, reason exists to question the quality of the auditors' new reports.

Summary of the Methodology

Again the purpose of this study was to identify empirically and evaluate professional theories-in-use for interpreting and integrating systems development control information in an overall judgment about development control adequacy. To accomplish this purpose, surveys of both the accounting literature and knowledgeable system reviewers were conducted first to identify the domain of relevant activities comprising the systems development process. From the identified domain of controllable activities sixty-four hypothetical cases containing eight variables each were constructed to serve as experimental instruments. The instruments were constructed and tested in a manner appropriate to obtain a reasonable level of confidence regarding face validity, content validity and reliability. The resulting hypothetical cases described the controllable activities of the systems development process in unique combinations of strong and weak control.

The experimental instruments were administered to thirty-two experienced EDP auditors from national public accounting firms in a manner consistent with a 2^8 randomized block fractional factorial experiment (RBFF-2^8). Each auditor evaluated the adequacy of control described in each case administered to him according to "the likelihood that the systems development process described in the case would produce reliable essential information."

An analysis of variance was conducted on the RBFF-2^8 responses to identify the congitive models (professional theories-in-use) which describe the process by which the EDP auditors (judges) interpreted and integrated the hypothetical systems development control information into judgments of overall control adequacy. A set of logically derived minimum control standards in conjunction with statistical tests for model completeness and relative factor importance were used to evaluate the cognitive models.

Contributions of This Study

To the extent that the EDP auditors participating in this study are representative of systems reviewers at large, this study makes the contributions to the literature itemized below. To the extent that the participants are not representative, only the first contribution is questionable and that only in scale.

The contributions are:

(1) Factors which influence system reviewer assessments of development control adequacy have been identified.

(2) The need for development control evaluation guidelines has been demonstrated.

(3) Minimum control standards for systems development procedures have been derived logically.

Overview of Subsequent Chapters

Chapter II contains a discussion of EDP control concepts. The purpose of Chapter II is to trace chronologically the development of internal control principles from their conceptual roots to the current state-of-the art in EDP environments with particular emphasis on the advancement of EDP control concepts by three landmark studies.

A review of conventional EDP audit techniques is contained in Chapter III. These techniques are examined from the perspective of their dependency upon systems development control information. The purpose of Chapter III is to illustrate the relationship between systems development controls and application auditability and thereby dispel any notion that technical developments in EDP auditing have eliminated the need for systems development control information.

Chapter IV contains a detailed description of the methodology of this study.

Chapter V contains the results of data analysis.

Chapter VI contains a summary of the study, a statement of conclusions and implications, a discussion of limitations, and suggestions for future research.

CHAPTER II

REVIEW OF CONTROL CONCEPTS

To date no research has addressed specifically the EDP control problems depicted in Chapter I. The purpose of this chapter is to trace chronologically the development of internal control principles from their conceptual roots to the current state-of-the-art in EDP environments. In this regard the advancement of EDP control concepts is examined through the contributions of three landmark research projects. A review of these studies shows that the problems identified in Chapter I remain unresolved.

Statement on Auditing Procedure No. 29 (AICPA, 1958) was issued to clarify the scope of external auditor responsibility for review of internal control. The all-encompassing definition of internal control advanced by the Committee on Auditing Procedure (1949) was refined in this statement and divided into two subdefinitions: (1) a definition of accounting controls; and (2) a definition of administrative controls. These subdefinitions were codified into SAS No. 1 (AICPA, 1973) and are reproduced below:

1. Accounting controls comprise the plan of or-

> ganization and all methods and procedures that are concerned mainly with and relate directly to, the safeguarding of assets and the reliability of the financial records. They generally include such controls as the systems of authorization and approval, separation of duties concerned with record keeping and accounting reports from those concerned with operations or asset custody, physical controls over assets, and internal auditing.
>
> 2. Administrative controls comprise the plan of organization and all methods and procedures that are concerned mainly with operational efficiency and adherence to managerial policies and usually relate only indirectly to the financial records. They generally include such controls as statistical analysis, time and motion studies, performance reports, employee training programs and quality control (p. 15).

The Committee on Auditing Procedure concluded that accounting controls fall within the scope of the study and evaluation of internal control contemplated by GAAS whereas administrative controls do not. The conceptual underpinnings of this control structure were derived from audit objectives and are independent of the methods of data processing used. Therefore, the foregoing definitions of internal control are considered applicable to manual, mechanical and EDP systems.

Need for Clarification

These definitions of internal control proved difficult to operationalize in EDP environments. Consequently, clarification of auditor responsibility was provided through SAS No. 3 (AICPA, 1974). This document further subdivided accounting control into two categories: (1) general controls and (2) application controls. Figure 1 illustrates the relationship of these control concepts to auditor responsibility. A discussion of each control category is provided in subsequent sections of this chapter.

Application Controls

Within the context of EDP environments accounting applications are defined as one or more computer sensible programs dedicated to accomplishing predetermined sets of accounting tasks. Application controls relate to, and exert influence over, the performance of these tasks. The specificity of application controls limits comprehensive review of them. However, they may be broadly categorized in the following manner: (1) Preventive Controls; (2) Detective Controls; and (3) Corrective Controls. Figure 2 illustrates the general relationship of these control classifications as they apply to EDP applications.

Preventive Control

Preventive controls are passive techniques designed to reduce the frequency of occurrence of causes of EDP exposure. Controls of this sort act as guides to force consistency upon data being processed. Preventive con-

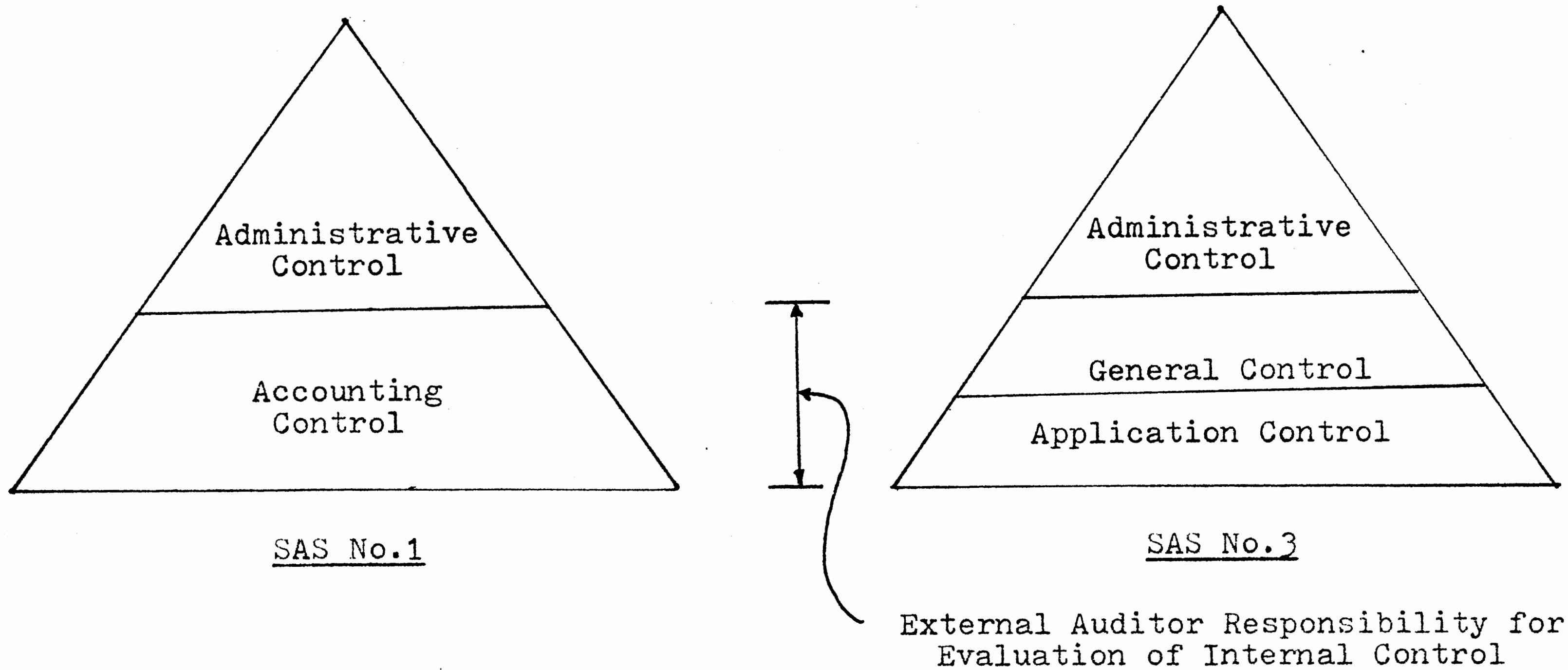
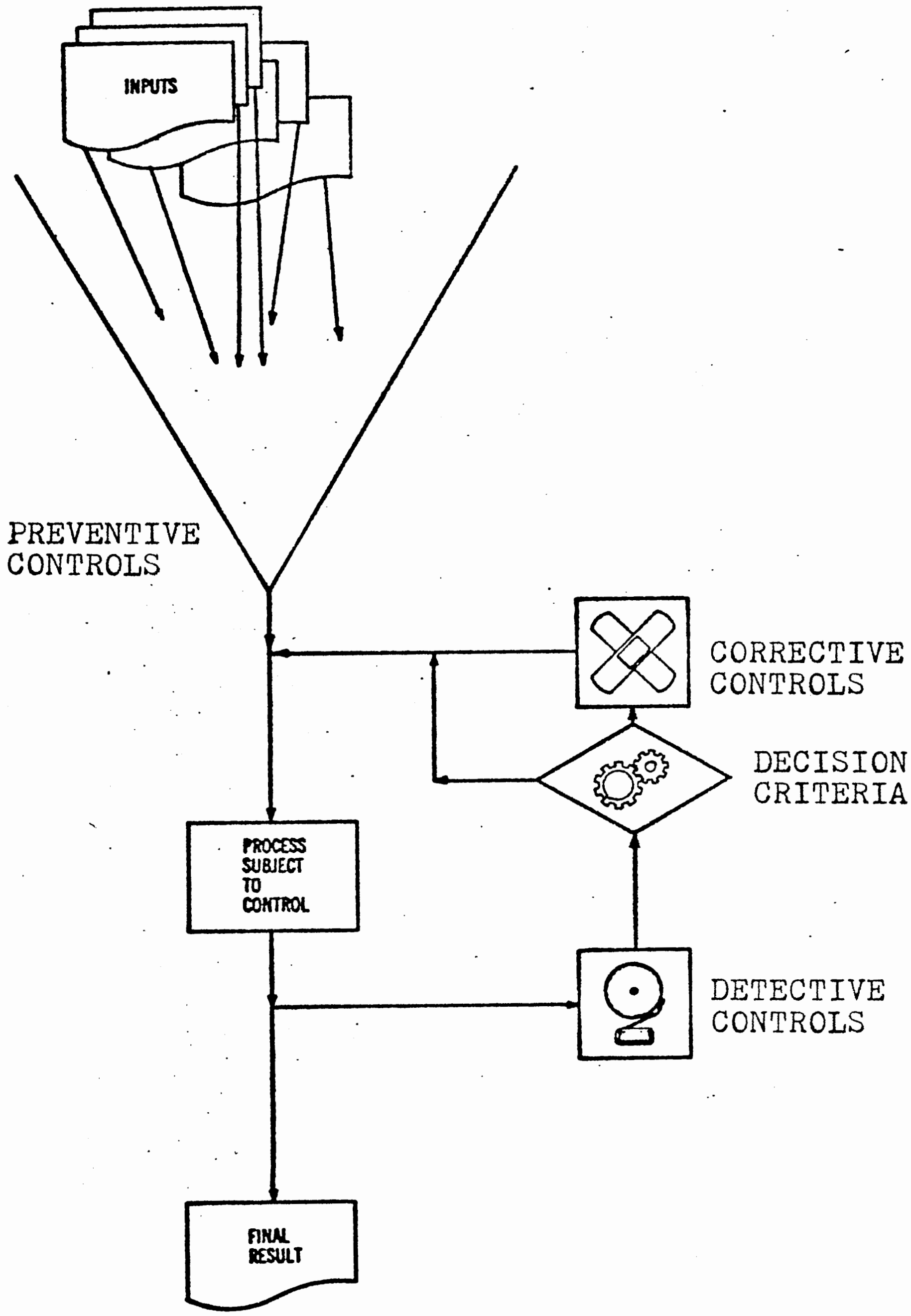


Figure 1. Relationship of Internal Control Definitions Between SAS No. 1 and SAS No. 3.



Source: <u>Computer Control & Audit</u>. New York: Touche Ross & Company, 1972, p. 38.

Figure 2. Functions of Controls.

trols provide standardization over input data necessary for successful computer processing.

Detective Control

The objective of detective control is to identify potential causes of exposure by signaling the occurrence of deviations from programmed expectations. Detective controls support preventive controls by alerting the system to deviations from standard data formats. They also function beyond the boundaries of preventive control structures to detect undesirable conditions too complex or unique to be efficiently prevented. It is difficult to design computer applications with sufficiently comprehensive preventive control systems to ensure compliance with all desired results. Therefore, a feasible and cost effective approach to assure data integrity is to perform rigorous interrogations of data at critical points during computer processing. Detective controls compare results of actual processing with programmed standards of performance and signal discrepancies to predetermined exception processing routines.

Corrective Control

Corrective controls are sets of predetermined decision criteria used to select appropriate corrective action for resolution of detected problems. The decision criteria in use may be simple resulting in standardized and arbitrary corrective action or they may be complex giving rise to various forms of action depending upon the nature of the detected exposure. In either form automated error correction is a costly and error prone process in itself. It is implicit in the selection of corrective action that the action is appropriate for all possible causes of exposure. This is an inherent weakness of all automatic exception handling techniques.

Summary of Application Controls

To summarize, data integrity is assured through three levels of application control working in concert. In general, strong systems of application control rest more heavily upon comprehensive preventive controls than detective controls. Adequate prevention of causes of exposure allows for less reliance upon detection techniques and therefore reduces the need for automatic selection of appropriate corrective action.

Identification and appropriate testing of application controls is an unavoidable step in the process of establishing application integrity. Once established, a basis exists for determining the extent of audit procedures to be applied in the examination of financial statements. Several techniques are available to systems reviewers for determining application integrity. The more common of these techniques are discussed in Chapter III.

General Control

In contrast to application controls, which specifically relate to accounting tasks to be performed, general controls relate to all EDP activities. The Computer Services Executive Committee (AICPA, 1977) identifies and classifies five subgroups of "important" general control. These subgroups are listed below:

1. Organization and Operation Controls
2. Hardware and Systems Software Controls
3. Access Controls
4. Data and Procedural Controls
5. Systems Development Controls.

General control areas (1) through (4) above comprise the plan of the organization and coordinate methods within the organization to promote segregation of duties and to safeguard assets. Descriptions of control techniques over each of these areas are provided by the Computer Services Executive Committee (AICPA, 1977) and need not be reproduced here.

The fifth general control area listed above--Systems development controls--is the area of interest in this study. Hence, this topic is investigated in detail in the pages that follow. The purpose of the remainder of this chapter is to define systems development activities and to examine the contributions made by recent research toward developing standards for system development control.

The Systems Development Process

The systems development process is a multidepartment activity which usually is most highly formalized in organizations with moderate to heavy EDP involvement. The process integrates input from user departments, systems analysts and application programmers. The primary purpose for this coordinated effort is to design and maintain adequately controlled, efficient and user oriented accounting applications. Lack of adequate control over this activity subjects organizations to various financial exposures such as: (1) erroneous record keeping; (2) inappropriate accounting procedures; (3) destruction of financial data; and (4) production of incomplete or unreliable audit evidence. Thus, weaknesses in systems development controls have pervasive effects which reduce both application integrity and application auditability.

The task of assessing the impact of weaknesses in systems development control upon applications falls within the scope of study and evaluation of internal control contemplated by GAAS. SAS No. 3 (AICPA, 1974, S. 321.07) states: "When (systems development controls are weak or absent, the auditor should consider the effect of such weakness or absence in the evaluation of application controls." The importance of this relationship is reaffirmed in the more recent Report of the Special Advisory Committee on Internal Accounting Control (AICPA, 1979). This report is intended to aid business management in considering whether their organizations comply with internal accounting control provisions of the Foreign Corrupt Practices Act of 1977. The Committee concluded that:

> the degree of reliance that can be placed on controls exercised by the EDP system (application controls) is dependent on the degree of control exercised by management over the development, installation, maintenance and use of the computer systems (p. 18).

Therefore, the importance of systems development procedures as a controllable process in the realm of internal accounting control appears to be generally acknowledged. The nature of development control requirements is not.

Systems Development Control Standards

Extant authoritative guidelines fail to specify criteria to be used in assessing systems development control adequacy. Moreover, the guidelines do not in themselves provide the conceptual structure necessary to derive the criteria.

The most recent publication of an authoritative nature related to this subject is the Report of the

Special Advisory Committee on Internal Control (AICPA, 1979). This two and one half page treatment of "EDP Considerations" refers the reader to three sources of information about control concepts: (1) SAS No. 3; (2) The Computer Services Executive Committee Audit Guide; and (3) "current texts and reports on the subject."

SAS No. 3 (AICPA, 1974) suggests that to gain knowledge of assessment criteria and/or the conceptual structure necessary to derive assessment criteria

> an auditor likely need refer to other sources of information. . . . Those sources include continuing education courses, data processing manuals, current textbooks, and current professional literature (S. 321.05).

The Computer Services Executive Committee (AICPA, 1977) disclaims responsibility in this regard altogether. Other "current texts and reports on the subject" are scarce at best. The only three such reports acclaimed as landmark contributions toward the development of control concepts are examined in the remainder of this chapter.

Computer Control Guidelines

The earliest of the three landmark contributions to the advancement of EDP control concepts was "Computer Control Guidelines" published by the Canadian Institute of Chartered Accountants (1970). These guidelines were the product of a study group of the Institute's Accounting and Auditing Research Committee. The research project was embarked upon:

> . . . in recognition of the urgent need for the profession to develop clearly defined standards of internal control and of auditing relative to the use of computers for information processing (Preface).

A significant contribution of this work is the notion that responsibility for systems design no longer resides solely with data processing departments. The guidelines describe development procedures as the combined efforts of four departments: (1) senior management; (2) user departments; (3) systems designers; and (4) programmers. The study group concluded that such activities must be controlled to prevent exposure.

> The manner in which these groups coordinate their activities during the development of the systems and programs, will have a direct impact on the effectiveness and continuing reliability of the systems and programs during operation (p. 35).

Three main objectives for adequate systems development controls were identified:

1. To ensure that an application is converted to the computer only if it will produce greater benefits than any alternatives.
2. To ensure the development of effective systesm and programs.
3. To ensure that system programs are effectively

maintained.

This initial contribution by the Canadian Institute established a basis for growth in EDP control concepts. However, the Institute did not resolve the issues identified in Chapter I. The dual problems of relating systems development controls to the production of audit evidence and the need for minimum control standards are not addressed by the study group.

Computer Control & Audit

The second milestone in the development of EDP control concepts was an internal auditor manual entitled "Computer Control & Audit" (1972). This comprehensive treatment resulted from the joint efforts of the Institute of Internal Auditors International Research Committee and Touche Ross & Co. The motivating force behind this research was candidly revealed by the authors: "It is not intuitively obvious to many auditors what is meant by adequate control in data processing. A prime objective of this manual is to help answer that question" (p. iii).

"Computer Control & Audit" offered two major contributions in the development of EDP control concepts: (1) project structure for the development of EDP systems was formalized; and (2) the notion of internal audit involvement in systems design was advanced as a control technique.

The project structure for systems development is diagrammed in Figure 3. This diagram depicts project activities as a series of steps. Development procedures begin with initial investigation of proposed EDP systems and culminate with the implementation of systems subject to on-going maintenance.

A basic ingredient of the project-technique is that planning and development are handled by project teams composed of personnel from user departments, data processing departments and internal audit departments. User personnel play critical roles in establishing requirements for new applications. EDP personnel serve as project coordinators and provide technical support. Internal audit staff review end-product documentation resulting from each step in the development process in order to ensure the design and inclusion of adequate application controls.

"Computer Control & Audit" develops and expands concepts laid down by the Canadian Institute's Accounting and Auditing Research Committee. This comprehensive manual draws from actual field experience by practicing internal auditors and certified public accountants to outline a methodology for evaluating internal control in EDP systems. However, as with its Canadian predecessor, no attempt is made to link systems development control

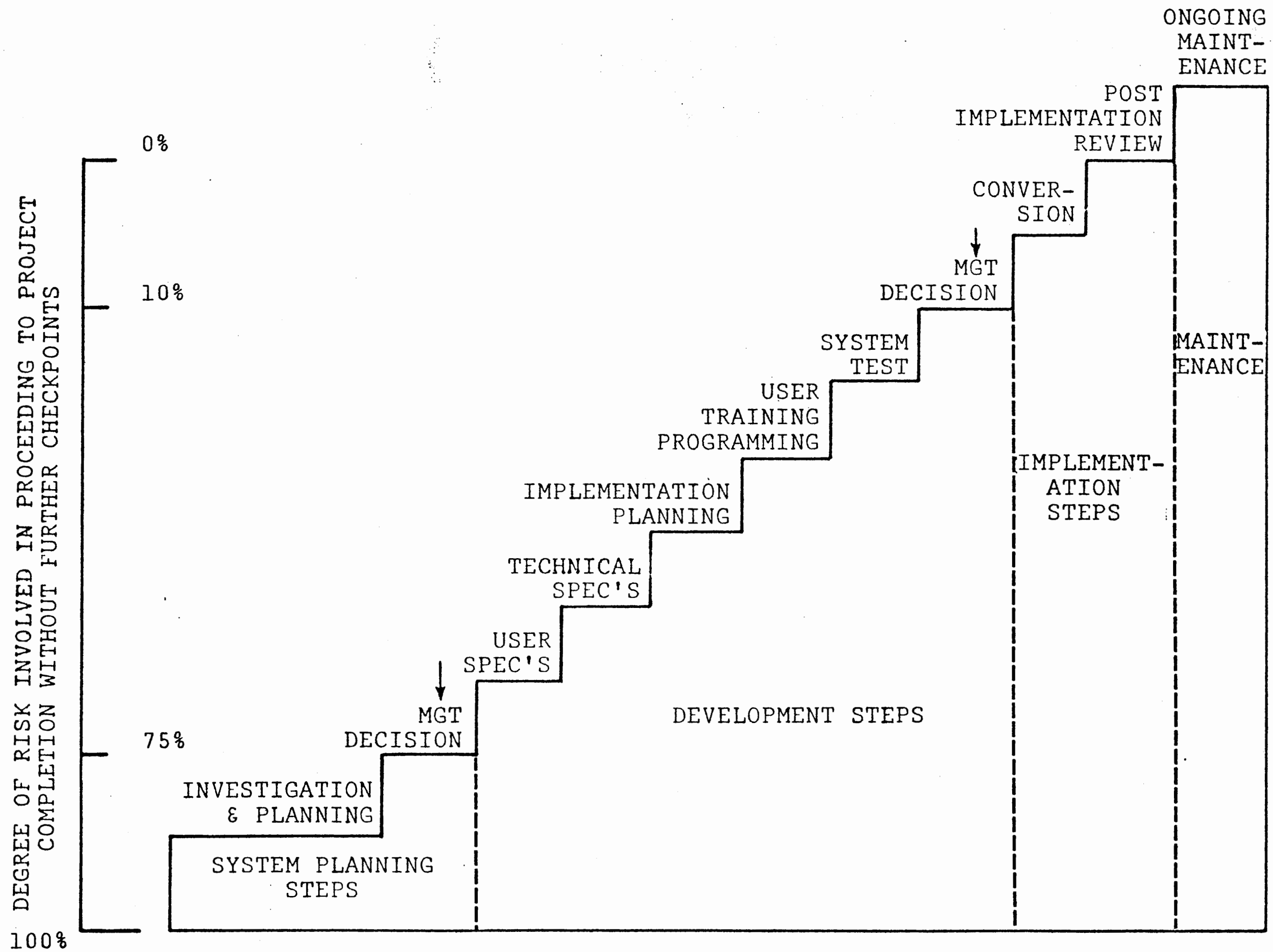


Figure 3. Project Structure for Development of EDP Systems.

weaknesses to application auditability. Hence, the importance of this control relationship is lost to users of these guidelines.

SAC Report

The latest research project to advance the state-of-the-art of EDP control concepts was perhaps the most ambitious of the three discussed in this chapter. For many years the Institute of Internal Auditors (IIA) has been concerned with EDP auditability and control problems. Therefore, in 1975 the Institute sought and obtained a grant from International Business Machines (IBM) for the purpose of "compiling the best known systems control and audit practices in use today." The study was conducted in an attempt to determine current internal audit and control problems and to document successfully applied solutions. Stanford Research Institute (SRI) was contracted to perform the field research in this study which involved visits to 45 organizations in Canada, the United States, Europe, and Japan. SRI produced three reports of which one--Systems Auditability & Control (SAC)--pertains to control concepts per se.

SAC (1977) identified three objectives to be satisfied by "good" systems development control: (1) development control must assist in managing costs and schedules; (2) they should ensure that appropriate application controls are built into systems being developed; and (3) they should ensure that application controls are properly tested before application systems become operational. To satisfy these objectives the SRI survey identified six control areas--collectively defined as the Systems Development Life Cycle (SDLC)--over which control adequacy is "important." These six areas were described as: (1) project management; (2) programming techniques; (3) development and acceptance testing; (4) program change control; (5) documentation; and (6) data base administration.

The primary contribution of SAC was its encyclopedic treatment of tried and tested techniques for establishing EDP control. The report was essentially a description of useful techniques on an ad hoc basis. It made no attempt to provide theories for the construction of control standards. SAC rejected any such responsibility with the following disclaimer:

> These reports are not intended to be used as auditing guidelines or standards, nor do they represent an official position of the Institute of Internal Auditors, its committees, the advisors who consulted with SRI during their preparation, or the IBM Corporation who funded the project (p. xi).

Summary

This chapter contains a review of relevant literature contributing to the development of EDP control concepts. The codification of auditing procedures into SAS No. 1 described internal control as (1) administrative control; and (2) accounting control. However, the broad definition of internal control was inappropriate for EDP environments and was redefined in SAS No. 3 under two categories: (1) general control; and (2) application control.

One area of general control of particular importance pertains to the systems development process. Inadequate control of development procedures has pervasive effects upon application integrity and application auditability. However, extant guidelines do not provide standards by which development control adequacy may be assessed.

Three landmark research studies were reviewed in this chapter. Each was examined in terms of its contribution toward establishing criteria for assessing development control adequacy. The problem of inadequate development control standards remains unresolved.

CHAPTER III

EDP AUDIT PRACTICES

Since the advent of the computer many techniques have been developed which enable system reviewers to gather evidence regarding the state of application integrity. The common objective of all such techniques is to provide information about the accuracy and completeness of application processes and controls. Such information is essential to systems reviewers when determining the necessary extent of substantive testing of data files.

This chapter includes a discussion of EDP audit techniques currently in use. The purpose of this departure is to dispel the notion that technical developments in EDP auditing have eliminated the need to resolve the dual problems defined in Chapter I. Although useful and necessary tools for evaluating application integrity, these developments have not produced a panacea. In fact, their relevance to the process of establishing application integrity is dependent upon the quality of by-product evidence generated by controls over system development activities.

To illustrate this dependency, seven well established

EDP audit techniques are reviewed in this chapter. The techniques selected for illustration vary from the basic "test data method" to more complex, technical approaches such as the "integrated test facility" and "parallel simulation."

Test Data Method

The test data method is used to establish application integrity by processing specially prepared sets of input data through production applications under review. The results of test-processing are compared to predetermined expectations and an objective evaluation of application logic and control effectiveness is obtained. This technique is illustrated in Figure 4.

There are two approaches to the test data method of assessing application integrity. The first of these uses actual transaction data. The advantage of this approach is one primarily of convenience. It is not necessary to design specific test data for each logic path or control. Systems reviewers simply make copies of production master files and transaction files for this purpose. Test files are then processed as actual production data and the results of test-processing are compared to standard results obtained previously through routine operations.

Although this approach has the advantage of convenience, and places little or no demand on the systems de-

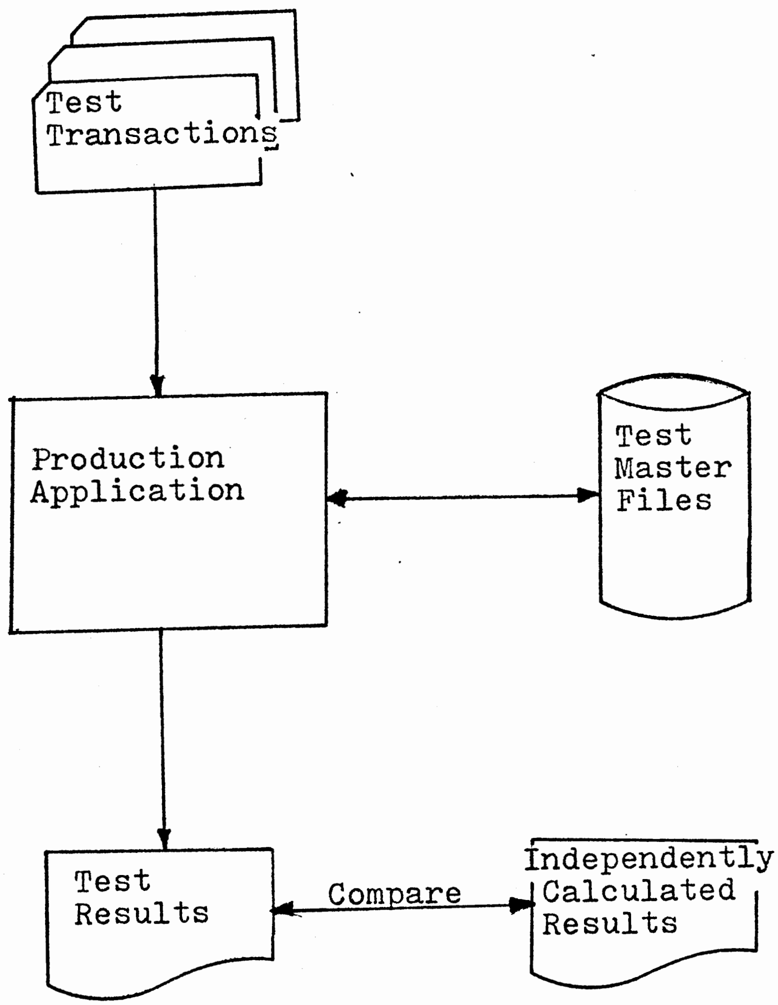


Figure 4. Test Data Method.

velopment process for by-product information it has limitations as a tool for assessing application integrity. The principle limitation arises from the need to process large volumes of data in order to obtain reconcilable results. These huge data requirements preclude independent calculation of expected results. Thus, reviewers are limited to making inferences about application consistency rather than application accuracy.

The second approach to the test data method uses small numbers of specially created transactions to verify specific aspects of application logic and controls. This approach enables systems reviewers to conduct precise tests, with known variables, to obtain results which are compared against independently calculated results. This approach provides more useful information regarding application integrity than does the first approach. However, it places demands for by-product information on the systems development process. Without reliable information regarding transaction types, processing procedures, control functions and exception handling techniques independent calculations of expectations are not possible and no measure of application accuracy can be derived.

Base Case System Evaluation (BCSE)

Base case system evaluations are conducted with a set of test transactions containing all possible transaction types. The data are processed through repeated iterations until consistent and valid results are obtained. These results are the base case. When subsequent changes to applications occur through maintenance or other causes, their effects are evaluated by comparing current results with base case results. BCSE is closely related to the test data method of assessing application integrity. In fact, the test data method becomes a base case when testing procedures are exhaustive.

As with test data methods, systems development by-product information is critical to the success of BCSE methods of assessing application integrity. This approach is a comprehensive audit practice which provides reliable results only if systems development and maintenance procedures are controlled. Weaknesses in system development controls (particularly control over application maintenance) render BCSE results unreconcilable.

Integrated Test Facility (ITF)

Integrated test facilities allow system reviews to be performed under normal operating conditions. These audit capabilities are designed into applications during systems development. The approach is to design fictitious entities (i.e., false vendors or cost centers) into systems and allow them to function within the framework of regular application processing.

During the course of an audit, having selected a certain application process for examination, system reviewers submit specially identified test data along with production data for routine processing. ITF applications are designed to recognize ITF transactions and report the results of processing test transactions separately from production data. The process is illustrated in Figure 5.

There are several advantages to this audit technique. The most obvious is that it promotes on-going system investigations and, consequently, reduces opportunities for undetected application changes during the period. A second advantage is closely related to the first. ITFs allow frequent and unannounced audits without disrupting client operating routines. The approach requires no special test run schedules. This is a distinct advantage over the test-data method which requires systems under review to be immobilized during testing.

However, ITF techniques are not without disadvantages. Primary among them is the potential impact of ITF transactions on data integrity. Steps must be taken to ensure that ITF-test transactions do not materially affect financial statements by being improperly aggregated with actual transactions in the account balances and then subsequently processed as routine data. This potential problem may be remedied in two ways: (1) special adjusting entries may be processed to remove the effects of ITF data

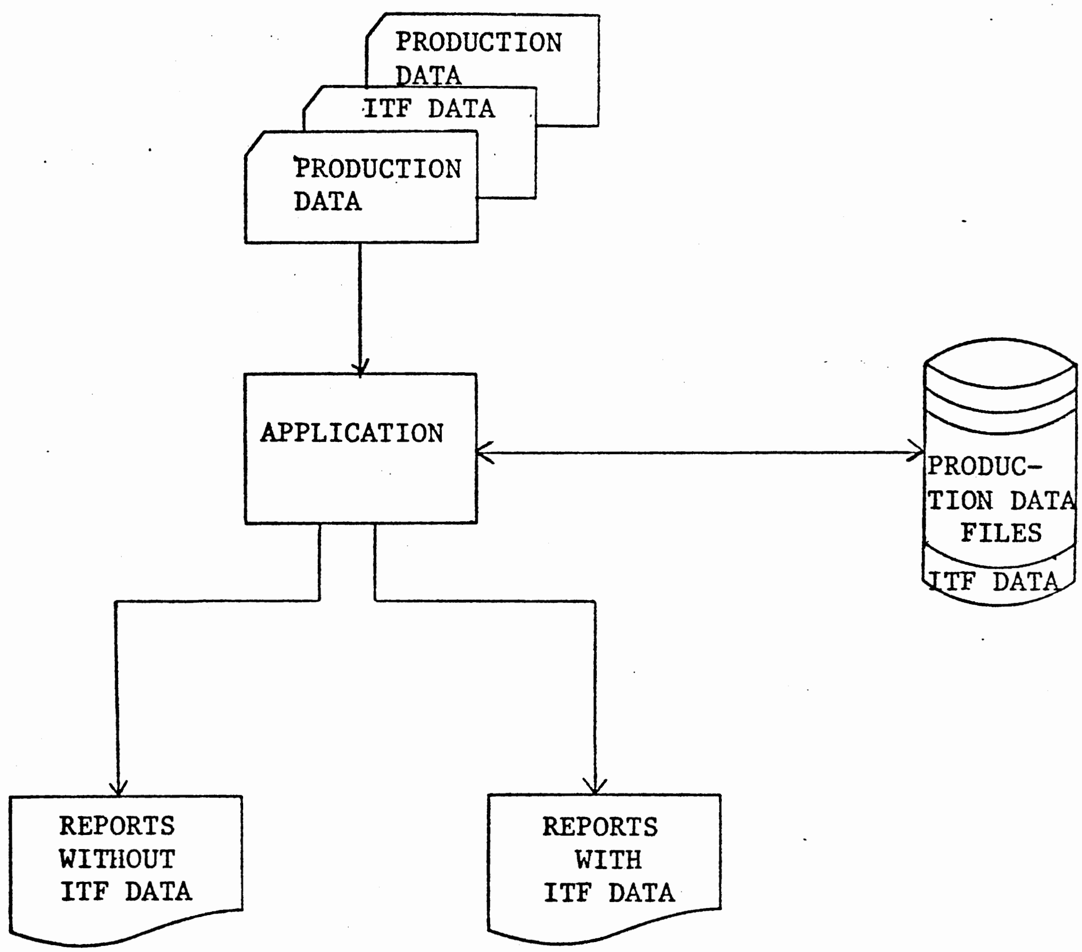


Figure 5. Integrated Test Facility Audit Technique.

from account balances; or (2) data files may be processed through special programs which reverse the effects of ITF transactions from account balances. Both remedies require a thorough understanding of application logic in order to assess the effects of test transactions. Detailed systems knowledge is obtained only through by-product evidence produced in systems development activities. The quality and reliability of this evidence is determined by the nature and extent of system development controls in effect.

ITFs are dependent upon systems development procedures in another way. Successful implementation of ITFs require sophisticated communication channels between user departments, system analysts and application programmers. Specific tests must be conceived and integrated into applications during systems development. Weaknesses in development controls may render ITF tests incomplete and produce unreliable measures of application integrity.

Embedded Audit Data Collection

Embedded audit data collection techniques utilize one or more specially programmed modules embedded in applications to select and record predetermined transactions for subsequent analysis. Data collection modules are positioned in systems during the design phase at points determined according to expected audit requirements. This concept is illustrated in Figure 6.

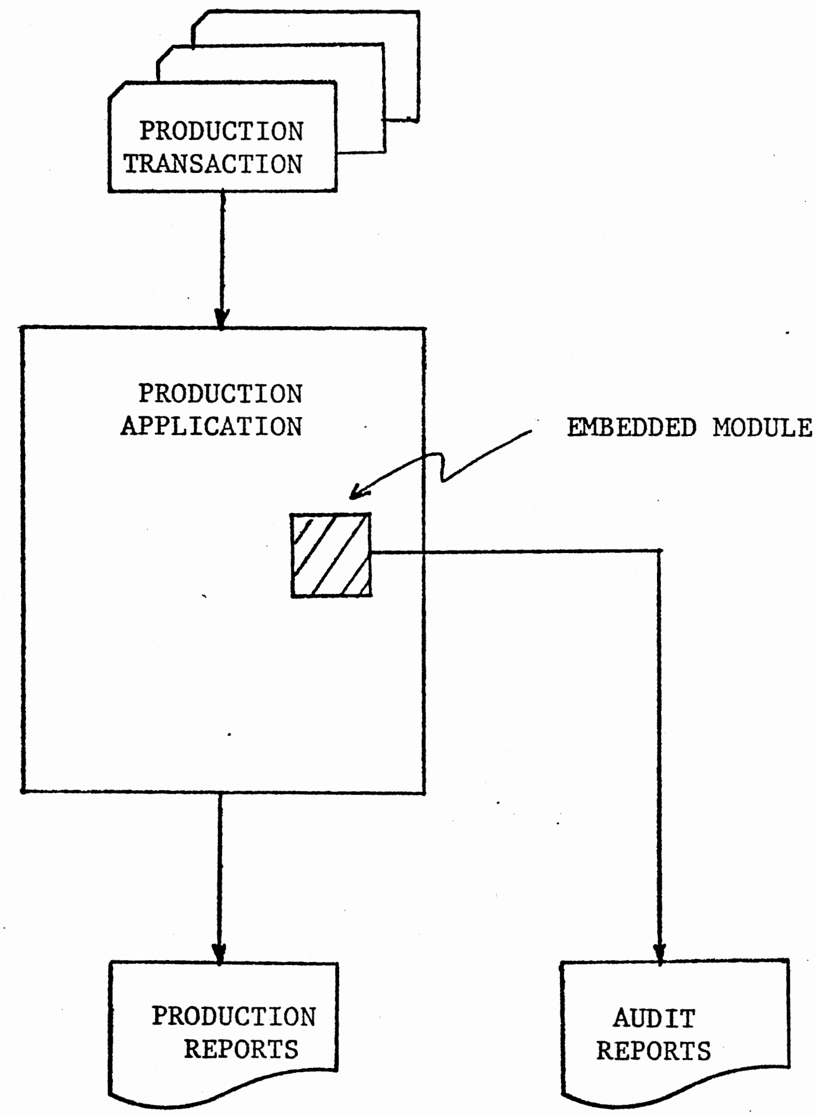


Figure 6. Embedded Audit Data Collection.

Embedded audit techniques are distinguished from other EDP audit approaches by the integration of specialized programmed sampling procedures into production applications. These audit modules perform data collection functions during routine processing of production data. This characteristic has two consequences: (1) stragegically placed modules within applications have access to all transactions processed and permit either comprehensive or specific samples of production transactions to be captured; and (2) once selection and recording criteria are operationalized data selection and analysis are limited to that domain. Therefore, collection criteria must be effectively communicated during system development. Because of these factors successful implementation of this technique is dependent upon adequate systems development control to ensure accurate and complete conversion of audit needs.

Parallel Simulation

Parallel simulation techniques are fundamentally different from other techniques discussed thus far. Whereas most audit procedures process some form of test data through production applications, the reverse is true for simulation techniques. Parallel simulations use one or more test programs to process production data. Results obtained from test-processing are reconciled with the results of production-processing to establish a basis for making inferences about application integrity. The process is illustrated in Figure 7.

Simulation programs are usually less complex than their production counterparts. They contain only application logic, calculations and controls relevant to specific audit objectives. However, this does not imply that less rigorous by-product evidence requirements exist when this technique is employed. On the contrary, high quality evidence of application processes and controls is necessary to adequately reconcile differences between test results and production results. These differences occur for two reasons: (1) the deliberate omission of production conditions from simulation programs; and (2) actual discrepancies between processing procedures employed by production applications and simulation programs. Regardless of the source of difference, reconciliations must be made. To accomplish the reconciliation, adequate systems development evidence must be produced to permit a detailed understanding of application logic and control features. The quality of systems development evidence is a function of system development controls.

Tracing

EDP environments preclude conventional observation of transactions through application processing cycles.

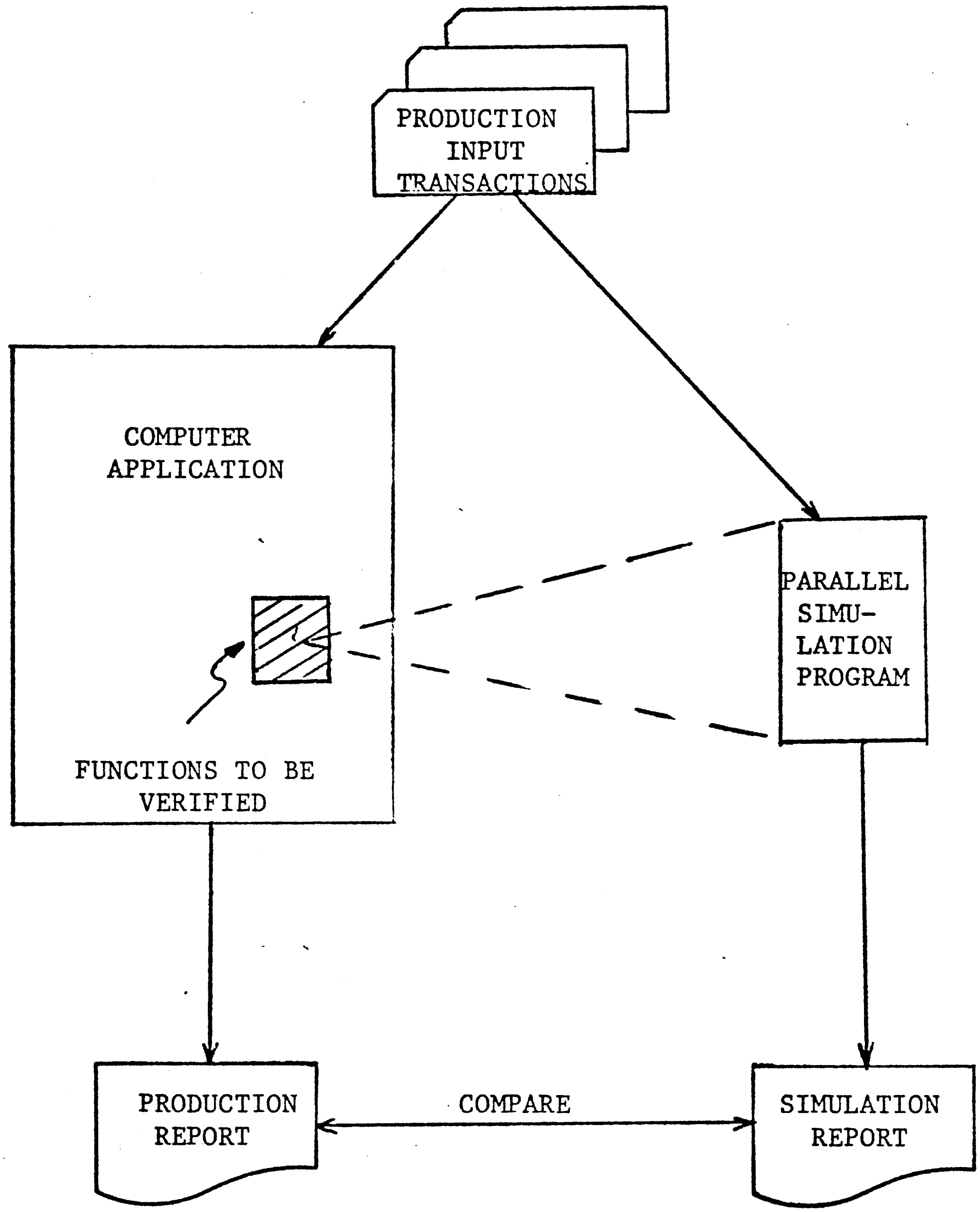


Figure 7. Parallel Simulation.

Many functions once performed by clerks are now performed electronically and utilize inputs and produce outputs which are not easily reconcilable. Therefore, verification of compliance with policy and procedures by substantiating transaction processing paths is a problem inherent in EDP. Tracing is a software option which resolves this problem by performing an electronic walk-through of data processing applications.

This procedure involves three steps: (1) programs under review undergo a special compilation in order to activate the trace option; (2) specific transactions or selected types of transactions are identified (tagged) for tracing; and (3) selected transactions are traced through all processing stages and listings of all programmed instructions executed are produced. Further explanation of this procedure is provided by the example illustrated in Figure 8. The example shows records from two payroll files, a transaction record showing hours worked and two records from a master file showing pay rates. The trace listing at the bottom of Figure 8 identifies the program statements executed and the order of execution. Analysis of trace options indicate that statements 0001 through 0005 were executed. At that point the application transferred to statement 0003. This occurred because the employee numbers of the first file of each record did not agree.

INPUT RECORDS	EMPLOYEE NUMBER	LAST NAME	FIRST NAME	PAY YEAR	PAY WEEK	HOURS WORKED	HOURS EXCUSED
PAYROLL TRANSACTION FILE	12345	SMITH	J	76	30	400	000

PAYROLL MASTER FILE	EMPLOYEE NUMBER	HOURLY RATE	DEPENDENTS	YTD EARNINGS	YTD WITHHOLDING	YTD FICA
# 1	12321	0300	02	0229000	026800	11450
# 2	12345	0450	03	0333300	048000	16565

COMPUTER PROGRAM

STATEMENT NUMBER	STATEMENT
0001	Read Payroll Transaction
0003	Read Payroll Master
0005	If (Payroll Master) – (Employee Number) ≠ (Payroll Transaction) – (Employee Number) Then Go to 0003
0007	Wage = (Hours Worked) X (Hourly Rate)
0009	Print Wage
0011	Go to 0001

TRACE LISTING:

0001-0005, 0005-0003, 0003-0011, 0011-0001, 0001-0011, 0011-0001, etc.

Source: Systems Auditability & Control. Orlando: Institute of Internal Auditors, Inc., 1977, p p. 156.

Figure 8. Tracing.

Tracing, although simple to employ as an audit technique, requires detailed information about application logic and file structure in order to facilitate analysis of results. Information of this sort is a by-product of the systems development process and its reliability is determined by the level of control over that process. Therefore, as a technique for assessing application integrity, tracing rests heavily upon adequate systems development control.

Generalized Audit Program (GAP)

Generalized audit software are the most widely used technique for auditing EDP systems. GAPs allow system reviewers to access electronically coded data files and perform several operations upon their contents. Packages currently available are capable of the following operations:

(1) Footing and balancing entire files or selected data

(2) Selecting and reporting detailed data contained on files

(3) Selecting stratified statistical samples from data populations contained in files

(4) Formatting results of tests into reports

(5) Printing confirmations in standard or special wording

(6) Screening data and selectively including or excluding items

(7) Comparing two files and identifying any differences.

The widespread popularity of these techniaues is due to four factors: (1) GAP languages are easy to use and require little EDP background on the part of the user; (2) GAPs may be used on any form of computer--they are hardware independent; (3) users of GAPs are not dependent upon data processing personnel because there is no need to modify application programs; and (4) GAPs can be used to audit files of many applications (in contrast to embedded audit modules which are application specific).

GAPs have a characteristic which distinguishes them from all other techniques discussed in this chapter. In one form or another, previously discussed audit techniques are used to test application logic and controls in order that an appraisal of application integrity may be made. GAPs make no explicit compliance tests. They do not test logic; they test only results of processing. Therefore, GAPs allow only limited inferences to be made regarding the general state of application integrity.

An example of a typical GAP operation is provided in Figure 9. The example shows an inventory file drawn through a reformatting routine in a generalized audit program. This routine changes the unique file structure of

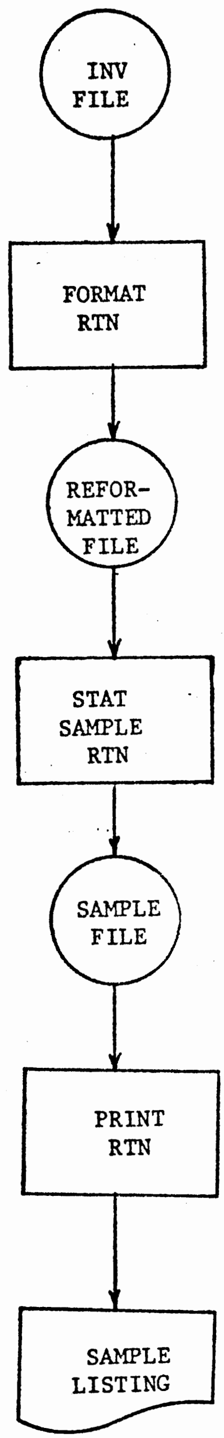


Figure 9. Generalized Audit Program.

the inventory file to a general structure which all other routines in the GAP can recognize. The reformatted copy of the original file is then passed to other specified operations. The first of these is a statistical sampling routine, which selects a sample of the file population for subsequent analysis. This sample is in coded form and must be passed through a print stage to convert it to usable format. The final result (a sample listing) is then available for various conventional audit tests.

Generalized audit programs play an important role in EDP auditing and are widely utilized by system reviewers. However, their role must not be misinterpreted. They are not substitutes for an assessment of the general state of application integrity and hence do not reduce the need for system development control.

Summary

This chapter contained a discussion of seven methods of EDP auditing in current use. Six of the seven techniques have a common thread which links them together; they represent methods of appraising application integrity in order that informed decisions can be made regarding the nature and extent of other audit tests. Successful implementation of each of these techniques was shown to rely upon the quality of evidence generated through systems development controls. One technique--generalized audit program--is an unsatisfactory tool for appraising the general state of application integrity.

CHAPTER IV

RESEARCH METHODOLOGY

In this chapter the methodology employed in this research project is described in detail. The chapter is composed of four related topics: (1) the pilot study; (2) data collection technique; (3) the statistical design; and (4) the development of evaluation criteria.

Pilot Study

In experiments such as this, where attempts are made to draw inferences regarding judge perceptions of the importance of cue relationships, reliability and validity measures of the test instruments influence the methodological soundness of the research. Therefore, in this research project, a pilot study was conducted in order to establish the validity and reliability of the test instrument. The term pilot study in this thesis departs slightly from the generally accepted definition. For the purpose of this research project the term is used to describe an activity comprised of the following two phases:

(1) A phase to identify the domain of relevant observables from which the research instruments were constructed

(2) A phase to measure response consistency of the instrument as an indication of reliability.

A panel of experts was selected from five national public accounting firms to serve as subjects for the pilot study. The selection of experts was based on the criterion "individuals from national firms who have at least five years experience as reviewers of EDP systems." The need for subjects with that level of expertise was considered imperative for the pilot study. However, this rigorous constraint created subject identification and contact problems. The construction of a panel composed of individuals with appropriate backgrounds involved subject selection from a wide geographic area. Participation came from Tulsa, Oklahoma City, Minneapolis and Saint Louis. The panel was comprised of two audit partners, four audit managers and one senior staff member. All seven subjects participated in phase one of the pilot study. However, because of time burdens which caused conflicts, only five members of the panel were involved in the second phase.

Validity

Before discussing details of the pilot study, concepts of reliability and validity and their relevance to this research are briefly examined. Validity is concerned with what an instrument measures and how well it does so. Two types of validity were considered important in this study: (1) content validity; and (2) face validity.

Establishing content validity involves an examination of the instrument content to determine whether it covers adequately the behavior domain to be measured. Once established, content validity permits one to assert two propositions that are basic to the validity of the instrument: (1) the instrument covers adequately the topics defined to be the relevant dimensions (Emory, 1976, p. 120); and (2) the instrument is relatively free from the influence of irrelevant variables (Anastasi, 1968, p. 115).

Closely related to content validity is face validity (Nunnally, 1978, p. 111), which pertains to the relationship of relevant variables presented by the instrument in use. It refers to whether the instrument "appears" valid to the subject observing it. Face validity is a particularly desirable feature in a policy capturing setting. Clearly, if an instrument's cue content appears to be irrelevant, contradictory or impossible to the judge, then responses to those cues cannot be relied upon to reflect judge-policy in an interpretable sense.

Reliability

Reliability is an important consideration in measurement methodology and represents a significant issue in scientific generalization. Nunnally (1978) states:

> To the extent to which an approach to measurement provides very much the same result . . . then it is reliable; and one can generalize from any particular use of the measurement method to a wide variety of other circumstances in which it might be employed (p. 119).

Therefore, with policy capturing techniques, where researchers attempt to model consistencies of attitudes and values expressed in individual behavior, reliability is an imperative attribute of the research instrument. Since all types of reliability are concerned with the degree of consistency between two sets of independently obtained responses, they can be expressed in terms of correlation coefficients. Anastasi (1968, Chapter 4) discusses three possible alternative techniaues for estimating reliability of measurement instruments. These alternatives are listed below and each is evaluated in terms of its relevance to this research project:

(1) Alternate Form Reliability

(2) Split Half Reliability

(3) Test-Retest Reliability.

Under each technique, measures of reliability are obtained by computing correlations between two sets of responses. Using the alternate form technique, alternate but equivalent forms of the instrument are administered on separate occasions and their responses are correlated. In contrast, split half techniques require only a single administration of a single form of the instrument. The instrument is then divided into comparable halves and responses to each half are scored and correlated. When administering either technique, care must be exercised to ensure that both alternate forms and both halves of the split half approach are truly parallel. This condition greatly restricts the usefulness of these techniques in policy capturing experiments. The criterion of parallelism implies a priori notions regarding "normal" responses to each item in the instrument. In light of the state-of-the-art of control guidelines, the absence of such prior knowledge made it impossible to specify parallel instruments. No basis existed for distinguishing between random fluctuations of performance and possible variations in scores due to perceived substantive differences between test instruments.

On the other hand, the Test-Retest reliability technique is not subject to the parallelism constraint. Under this technique identical instruments are administered on separate occasions and a reliability coefficient is computed by correlating the responses on each occasion. However, this technique is not without limitations. Nunnally (1978, p. 233) identifies the most serious limitations as: (1) a practice or experience effect which produces varying amounts of improvement in the scores of judges over time; and (2) the effect of memory, which allows similar responses to result in situations where judges are uncertain thus driving response correlations higher than they would be otherwise.

With regard to computing instrument reliability measures for this study, the experience effect discussed by Nunnally is negligible. A primary assumption of the Brunswick Lens Model is that judges are familiar with the domain of relevant observables depicted in the measurement instrument. Thus, when presented with logical cue relationships selected from the domain, judges apply unique cue weightings to formulate responses. These weighing schemes, or policies, are unlikely to be influenced over relatively short periods of less than six months (Anastasi, 1968, p. 78).

Likewise, the memory effect on the instrument reliability coefficient was considered to be insignificant for this experiment. The measurement instrument is comprised of unique combinations of eight treatments at one of two levels (strong and weak). Therefore, 2^8 or 256 possible treatment combinations exist. The sheer number of combinations and the nature of the stimuli make remembering specific responses very difficult. Thus, the Test-Retest method of measuring reliability was considered to be the most appropriate under the circumstances.

Pilot Study-Panel Selection

As previously stated, a panel of seven experts were selected from CPA firms in various geographic locations to serve as subjects in the pilot study. The purposes of the pilot study were to ensure that the research instrument possessed content validity and to test the instrument for face validity and reliability.

Members of the panel were selected on the basis of their experience as reviewers of EDP systems controls. No attempt was made at random selection. Rather, each participant was pursued on the basis of his reputation as an expert in the field or by references obtained through contact with knowledgeable associates.

Initial contact with the pilot study subjects was by telephone. Once contacted, each subject was given a brief verbal outline of the research project and asked to participate. All subjects agreed to take part in the study. Four of the subjects communicated their responses to the instruments in personal interviews. Two of the subjects communicated their responses by mail. In the case of one subject, part of the communication was by mail and part by personal interview.

In all cases participants were told that their responses would be solicited on four separate occasions over the period of one month to six weeks starting March 15th, 1979. However, specific details as to the nature of the desired participation was not provided in advance. This precaution was taken to establish control over the experiment and thus prevent the sending of signals which might influence panel member responses.

Pilot Study Phase One

The objective of phase one of the pilot study was to determine that content validity was built into the policy capturing instrument from the outset. Any such determination is unavoidably judgemental. As Emory (1976, p. 121) points out, the process of defining the topic of concern, the items to be scaled and the scales to be used is largely intuitive and unique to the individual researcher.

The process employed in topic definition for this study was direct and pragmatic. The systems development process was reduced to eight principal activities with each defined in terms of strong internal control. These descriptions of controllable activities were chronologically ordered and distributed to the panel members for review. Three questions were asked with regard to descriptive content.

1. Does the composition of activities provide an essentially complete description of systems development procedures?
2. Are the descriptions of control requirements over each of the defined areas complete?
3. Do any of the descriptions contain irrelevant or ambiguously worded information?

No significant conceptual changes to activity descriptions were recommended by panel members. Those minor modifications that resulted were incorporated in the descriptions and redistributed to panel members for approval. The eight activities are listed below and definitions of each are provided in Appendix A.

New System Design

1. System Authorization Procedures
2. User Specification Procedures
3. Technical Design Procedures
4. Internal Audit Participation in System Design
5. Program Test Procedures
6. User Test and Acceptance Procedures

System Change Procedures

7. Authorization, Test and Documentation Procedures
8. Source Program Library Monitor.

This set of descriptions constitutes a definition of the domain of relevant dimensions from which the research instruments draw content. Emory (1976, p. 120) concludes that instruments which adequately cover the "topics which are defined as relevant dimensions" have good content validity. Thus it was contended that the research instruments used in this study possessed content validity.

Pilot Study Phase Two

The objective of phase two of the pilot study was to develop a set of policy capturing instruments which could be shown to possess face validity and reliability. The technique employed to demonstrate the existence of these properties as a Test-Retest procedure. Theoretical justification for this approach was previously presented.

The Instrument

Phase one of the pilot study identified eight separate activities as the relevant dimensions of the systems development process. From that domain 64 hypothetical cases in narrative form were developed. Each case was approximately one typed page in length and described each control area in a binary fashion, as being either strong or weak. Examples of these instruments are presented in Appendix B.

Test-Retest Procedures

Of the 64 policy capturing instruments developed, 16 were randomly selected for pretesting.[1] Since all cases were comprised of identical variables with standard wording it was not considered necessary under prevailing time and resource constraints to attempt to pretest each of them. In addition, to have performed a complete test might have had detremental effects on subject attitude toward the study and, consequently, might have produced unreliable results.

---

[1]The total number of cases possible is 2^8 or 256. The statistical design used for the study was a quarter replicate of a 2^8 factorial experiment. Thus the experiment consisted of 64 of the 256 possible treatment combinations.

Pretest cases were administered to five of the original seven subjects during the period of April 9, 1979 through April 13, 1979. They were informed that each case was a descriptive representation of control over the systems development process for a hypothetical organization. The cases were evaluated according to the following instructions:

(1) View the circumstances of each case independently of the others.

(2) In each case assume heavy involvement in EDP on the part of the organization.

(3) Identify any conditions or relationships depicted in the cases which appear contradictory or irrelevant.

(4) Evaluate each case on the basis of control "adequacy" using an interval scale of zero to ten, where zero is least adequate.

(5) The criterion for determining control adequacy is:

> The likelihood that the systems development process described in the case will produce reliable essential information.

With regard to item (5) in the instructions, no further delineation of the evaluation criterion was provided. The criterion was stated in this somewhat open-ended manner for a reason. The essence of this study was to identify and evaluate the criteria in use by system reviewers in their appraisal of system development controls. By identifying the forms of evidence most important in the appraisal process, it is possible to determine whether the objectives behind the evaluation of systems development controls are generally recognized and thus, whether authoritative guidelines would serve a useful purpose. The key to making this determination is clearly the identification of auditor perceptions of the nature of essential information. To have defined "essential" information in the adequacy criterion was thought to influence the responses of participants. The result would likely have been responses which were artificially consistent across all participants and the purpose of the study would have been destroyed.

During the period of April 23, 1979 through April 27, 1979, the instruments were administered a second time. The instrument content and the instructions for the second test were identical to those of the first. Thus, two separate responses were obtained for each instrument from each of five panel members.

Assessment of Instrument Reliability

Responses obtained on the two test occasions were correlated to obtain reliability coefficients for each instrument. Summaries of the correlations are presented in Table I. The results indicate that the instruments evoked consistent responses over the test-retest period.

TABLE I

SUMMARY OF PRETEST CORRELATION

Case	Mean Score Test 1	Mean Score Test 2	Correlation
1	.05	.1	.10
2	6.40	6.75	.78
3	5.75	6.0	.95
4	6.95	7.65	.78
5	3.59	4.40	.94
6	2.60	3.00	.95
7	7.25	7.60	.85
8	6.80	6.40	.77
9	2.89	3.45	.94
10	4.50	5.00	.90
11	5.20	6.05	.94
12	7.75	8.10	.82
13	2.80	2.60	.80
14	3.55	4.32	.93
15	4.75	5.20	.86
16	6.85	7.56	.95

All correlations exceeded .6 which Nunnally (1978) contends represents adequate reliability in the early stages of research.

Assessment of Instrument Face Validity

As previously discussed, face validity is the extent to which an instrument "looks" as if it measures what it is intended to measure. Face validity is closely related to content validity. Whereas content validity is assured by adequate definition of the domain of relevant variables, face validity concerns judgements about instruments constructed from that domain. In other words, face validity is concerned with the transformation adequacy of content definitions into completed instruments.

Instruction number five in the Test-Retest package requested subjects to identify any irrelevant or contradictory conditions depicted in the case descriptions. Responses to that instruction provided the basis from which a judgement was made regarding instrument face validity.

There were no instances where subjects indicated the existence of irrelevant or contradictory conditions. However, in two cases individuals commented on the unusualness of one case. Their comments are reproduced below.

> Strange to have good control over changes but poor control over development.

> It is unusual to have strong control over changes

> to existing systems but weak controls over new systems. . . . This situation is not the most common one but is not illogical or contradictory.

At this juncture it is appropriate to comment on the ligitamacy of using the same panel of experts for both phases of the pilot study. This was an economic necessity which was not considered to represent a serious limitation. The panel of experts defined the domain of relevant variables; they did not design the instruments per se. Measures of validity and reliability relate to the adequacy of the conversion of domain variables into realistic depictions of real world phenomena. Therefore, phase two of the pilot study is not a test of the completeness of the domain defined by the panel of experts, but rather, it is a test of the completeness of the conversion process and the logical relationships of the values assumed by the instrument variables. Given that different questions and objectives were at issue in each phase of the pilot study, it was considered that material bias was not present and the use of a separate panel of experts was not a critical factor to the integrity of the study.

Sample Selection Process

Judges for the principal study were selected from eight national public accounting firms in the United States. It is common practice among these firms to create EDP service centers in large metropolitan areas and thus geographically consolidate scarce professional resources. From these centralized locations EDP specialists often perform both management advisory services and EDP control reviews for geographically broad based clientele. The pervasiveness of this organizational structure affected the selection of participants for study. Three issues identified as significant in influencing the sample selection decision are discussed below.

The first issue concerned the cost of data collection if random selection of subjects was made from the entire population. The relatively small population of EDP specialists is dispersed in clusters over a large geographic area. The prospect of a random selection from that population, without regard for geographic and economic preferences, threatened to increase significantly expected nontrivial data collection costs. The preferred method of data collection in this project was through personal interviews with selected subjects. From an economic point of view, this was impossible if participants were selected randomly.

The second issue concerned the quality of data likely to result from the study if judges were selected on a purely random basis. As discussed above, radnom selection involves significantly higher costs and thus precludes personal interview as the primary mode of data collection. The economic alternatives to personal interviews are "mail-survey" and "telephone-survey" methods of data collection, both of which are undesirable under the circumstances. The principal defect in telephone surveys is their inherent limitations at gathering sufficiently detailed information. Therefore, it is usually an inappropriate technique in policy capturing experiments. Likewise, mail questionnaires are inappropriate for other well documented reasons. Their most significant limitation is the problem of non-response. According to Kerlinger (1973) typical non-response rates for mail surveys of professional groups range between fifty percent and sixty percent. The effects of bias from this survey phenomenon on one's ability to generalize from the responses obtained are severe, and are discussed at length by Kish (1965).

The third issue concerned whether sample judgements obtained from regionally based EDP specialists necessarily reflect uniquely regional decision criteria and thus prevent generalizations to the more cosmopolitan population. Some evidence to reject this notion of geographic influence in this decision process was advanced by Rittenberg (1975). He found no differences in individual policy which could be attributed to the geographic location of the judge. Furthermore, in actual practise, EDP specialists invariably serve clients in distant locations which are also served by other specialists from different geographically based service centers. Thus, one can argue that informal feedback through this professional interaction mechanism and the universality of the domain of relevant variables renders professional decision processes of judges free of significant geographic components.

In view of the anticipated costs and benefits brought to light by analysis of these issues no attempt was made to randomly select a sample of EDP specialists. Rather, the overriding consideration in sample selection was to ensure sufficient geographic proximity of participants to allow personal interviews to be economically feasible. The metropolitan areas chosen for the study were Saint Louis, Missouri; Tulsa, Oklahoma; Oklahoma City, Oklahoma; and Dallas, Texas. From these locations a total of 32 EDP specialists were selected. The sample was comprised of four individuals from each of the eight largest national public accounting firms.

An axiom of the Brunswick Lens Model requires that only those individuals experienced in decision making within the relevant domain should be selected as judges for experiments which emulate that domain. Thus, care was taken in this study to ensure that judges were selected only from among individuals actively engaged in making relevant decisions. Preliminary screening procedures to identify qualified systems reviewers resulted in the selection of eight judges at the manager level and twenty-four at the level of senior or above.

Data Collection

The experiment was conducted in the four metropolitan areas in the period covering May 7, 1979 through June 3, 1979. Initial contact with participants was by telephone, at which time the nature of the project was briefly outlined and appointments for personal interviews of two hours each were arranged.

Data collection procedures for the principal study differed only slightly from those of the pretest. Instrument format, content and evaluation criteria were essentially unchanged. Judges were interviewed at their business locations and were presented with sets of hypothetical cases similar in format to the sample case in Appendix B. Because of professional time burdens which had a limiting effect on project involvement it was not possible to obtain responses to all 64 cases from each subject. Therefore, the 64 treatment combinations were reduced to four balanced blocks containing sixteen combinations each. Blocked in this fashion, 16 instruments were administered to each judge within a firm. Each firm was viewed as an experimental unit which provided responses to all treatment combinations selected for the experiment.

The instructions illustrated in Appendix C were discussed with judges immediately prior to administering the instruments. When judges indicated they understood the instructions, the instruments were administered in random sequence. Apart from discussing instructions with judges, the experiment was administered without further explanation of the cases. The purpose of this interview technique was to ensure that interviewer bias was minimized.

These procedures applied in all but six instances, where personal interviews of two hours were not possible. On those occasions, short interviews were arranged to explain the instructions and present the instruments to the judges who responded to them at their convenience. Responses were returned by mail. There were two objectives to be achieved by performing personal interviews: (1) to ensure that experiment instructions were understood by judges; and (2) to assure a high response rate among participants. These objectives were met in all instances. Therefore, digression on six occasions, from a pure personal interview setting to a modified personal interview setting was not considered materially detrimental to the experiment.

Experimental Design

The research design used in this study was a 2^8 randomized block fractional factorial (RBFF-2^8) experiment. Fractional factorial designs characteristically depart from full designs, in which all possible treatment combinations appear in experiments. Fractional designs include only a portion of the possible treatment combinations. Their use was proposed by Finney (1945) who outlined methods for developing 2^n and 3^n factorials. His theory was extended by Plackett and Burman (1946) and Kempthorne (1947) who constructed designs of the type p^n where p is any prime number and n is the number of treatments. The chief appeal of fractional designs is that they enable multiple factors to be included simultaneously in an experiment of reduced size.

A single replication of a complete factorial design of the magnitude in this study (2^8) requires observations on 256 treatment combinations. To satisfy this condition would have placed severe limitations on data collection procedures and would have produced a greater degree of precision in estimates of high order interaction effects than was considered necessary. In studies such as this, experiments which consist of a fraction of complete designs provide viable research alternatives through data reduction.

In this study a design was constructed for a one-fourth replication. The number of treatment combinations was thus reduced from 256 to 64. A consequence of using this technique was that all sums of squares were aliased. That is to say, each possessed four designations. However, careful attention was given to alias patterns in the selection of defining contrasts so as to avoid aliasing main effects with other main effects. In the plan selected for this study, no treatments or two factor interactions were lost by aliasing them with lower-order interactions. The plan used for this experiment and the defining contrasts are illustrated in Figure 10.

Benefits from experiment size reduction are not costless. As previously noted, each sum of squares in this design has four alias designations which posed potential ambiguity in data analysis. The problem is one of determining to which alias an effect is to be attributed. This ambiguity was reduced by aliasing treatments with high order interactions, which were assumed to be insignificant. According to Kirk (1968) this is an appropriate technique when experiments meet the following conditions:

> (1) The experiment contains many treatments that result in a prohibitively large number of treatment combinations. Fractional replication is rarely used for experiments with less than four or five treatments.
>
> (2) The number of treatment levels should, if possible, be equal for all treatments. . . . Procedures for experiments involving mixed treatment levels are relatively complex.
>
> (3) An experimentor should have some a priori reason for believing that a number of higher-order interactions are zero or small relative to main effects. In practice fractional factorial designs . . . are most often used with treatments having either two or three levels. The use of a restricted number of levels increases the likelihood that interactions will be insignificant.
>
> (4) Fractional factorial designs are most useful for exploratory research and for situations that permit follow-up experiments to be performed. Thus a large number of treatments can be investigated efficiently in an initial experiment, with subsequent experiments de-

2^8 factorial in 64 units (¼ replicate)

Defining contrasts: *ABCEG, ABDFH, CDEFGH*

Estimable 2-factors: All

Blocks	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	(1)	*adg*	*ach*	*bch*	*eg*	*fh*	*bef*	*acf*
	adefh	*abce*	*bfg*	*abdf*	*bcd*	*ade*	*abdh*	*bgh*
	bcdeg	*efgh*	*cdef*	*cdgh*	*adfgh*	*abcg*	*cdfg*	*cdeh*
	abcfgh	*bcdfh*	*abdegh*	*acefg*	*abcefh*	*bcdefgh*	*acegh*	*abdefg*

	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)
	ab	*ce*	*afg*	*df*	*acd*	*cg*	*dh*	*agh*
	cfgh	*bdg*	*bch*	*aeh*	*abeg*	*bde*	*aef*	*bcf*
	acdeg	*acdfh*	*degh*	*bcefg*	*cefh*	*abfh*	*bcegh*	*defg*
	bdefh	*abefgh*	*abcdef*	*abcdgh*	*bdfgh*	*acdefgh*	*abcdfg*	*abcdeh*

Effects	d.f.
Main	8
2-factor	28
Higher order	27
Total	**63**

Source: William G. Cockran and Gertrude M. Cox, Experimental Designs, 2nd ed. New York: Wiley & Sons, Inc., 1957, p. 287.

Figure 10. Plan for a 2^8 Factorial in 64 Units (1/4 Replicate).

> signed to focus on the most promising lines of investigation or to clarify the interpretation of the original analysis (p. 386).

A brief review of the characteristics of this experiment show that Kirk's conditions were satisfied. The study involves hypothetical cases comprised of eight treatments each. All treatments (controllable activities) had two possible treatment levels (strong or weak control). The research is partially exploratory in nature. That is, this field of investigation is relatively untrodden and results obtained through this experiment are expected to promote subsequent investigation. Thus, in light of these experiment characteristics the decision favoring a fractional study was appropriate.

Blocking Considerations

In behavioral research, variability among subjects may obscure analysis of treatment effects. This masking variable, however, may be reduced by the use of randomized block designs. These designs are based on the principle of assigning subjects to blocks such that subjects within blocks are more homogeneous than subjects between blocks. The assumption was made that where decision situations are codified in organization policy, subjects within the same organization tend toward homogeneity in their selection of decision criteria. Therefore, to the extent that internal guidelines exist within firms (i.e., audit programs and control questionnaires) theories-in-use among subjects are assumed to be structured along intra-organization lines.

The assumption of homogeneity of within-firm subjects provided the basis for construction of a randomized block design. In this design all experimental units--public accounting firms--received all treatment combinations. That is to say, the design was blocked by firm. This arrangement produced eight responses per treatment combination.

The fixed effects linear model for this design is:

$$X_{(abcdefgh)m} = \mu + \beta_a + \beta_b + \ldots + \beta_h + \beta\beta_{ab} + \beta\beta_{ac} + \beta\beta_{ad} \ldots + \beta\beta_{gh} + \pi_m + \epsilon_{(abcdefgh)m}$$

where μ = grand mean of treatment populations

β_a through β_h = effect of treatment a through h, which is a constant for all subjects within treatment populations a through h.

$\beta\beta_{ab}$ through $\beta\beta_{gh}$ = effect, which represents nonadditivity of effects β_a through β_h.

π_m = a constant associated with block m.

$\epsilon_{abcdefgh,m}$ = experimental error which is NID with a mean = 0 and variance = σ_c^2.

The error effect for RBFF designs is smaller than the error effect for completely randomized designs. Therefore, RBFF designs are more powerful whenever block effects account for a significant portion of total variance. As the notation for this model indicates higher order interaction effects were not of interest in this experiment. Those effects were assumed to be insignificant and were aliased to low order effects.

Research Questions

Analysis of variance (ANOVA) on the RBFF-2^8 model responses was the principal analytical tool used to infer answers to the two research questions identified in Chapter I. Those questions are restated below.

(1) What are the cognitive models which describe the process by which EDP system reviewers (judges) interpret and integrate hypothetical systems development control information into judgements of overall control adequacy?

(2) To what extent are the identified models of professional judgement conducive to the promotion of decisions which are in accordance with generally accepted auditing standards?

After control adequacy scores for each of the eight public accounting firms were obtained, the data was blocked by firm and coded to IBM computer cards. There were 64 dependent measures for each firm giving a total of 512 observations. Using the SAS 76 ANOVA package, significant treatment effects at a .05 level of significance were calculated. The significant effects thus calculated constituted the model of professional policy sought for research question number one. Specific results obtained are discussed in Chapter V.

Research question number two is concerned with the extent to which professional use-criteria in the evaluation of general (systems development) controls promotes decisions which comply with GAAS. Answering this question required an analysis of significant treatment effects previously calculated. The criterion used in this analysis is simply stated as:

> Compliance with GAAS is possible to the extent that the professional policy model specifies those controllable activities necessary to establish application integrity.

Couched in this criterion statement is the notion of minimum control requirements for systems development activities. In Chapter II, the systems development process was described as a multidepartmental effort which produces by-product information relevant to assessing EDP application control adequacy. Severe weaknesses in, or absence of, essential controls over these development activities adversely affect appraisals of application integrity in two ways:

(1) Critical by-product evidence needed to establish application integrity is not generated by the systems development process.

(2) Critical evidence produced by the systems development process is unreliably generated or not sufficiently complete to adjudge application integrity.

Minimum control requirements for the systems development process are derived from pervasive EDP-application audit objectives. These objectives must be satisfied before a measure of application integrity is possible. The following five objectives are relevant to the task of analyzing any EDP application:

(1) Identify all application input sources. Examples of input sources are master files and transaction files.

(2) Identify all forms of application output. Examples of outputs are updated master files, various reports, transaction summaries and error messages.

(3) Identify all major processes which act upon items mentioned in 1 and 2 above.

(4) Identify controls which prevent, detect or correct undesirable conditions in order that the interaction of inputs, processes and outputs occurs in the prescribed manner.

(5) Identify the period of time over which application inputs, outputs, processes and controls have been effective.

By-product evidence essential to satisfy these five audit objectives is generated through only four of the system development activities previously itemized. Two of these essential activities relate to new system design and two relate to system maintenance procedures. The impact of each of these essential activities on the generation of audit evidence is discussed in the remainder of this chapter.

The other four activities of the systems development process are nonessential. They are so defined because the by-product evidence produced in those activities is discretionary in nature. The usefulness of this form of evidence in assessing application integrity is characterized as adjunct and is related in a configural manner to essential evidence. Each of the nonessential activities and the relationship between essential and discretionary evidence is discussed in Chapter V.

New Systems Design

User Specification Procedures

This task is oriented toward the development of the business problem to be solved. Once it has been adequately defined, specifications for its resolution are developed through the joint efforts of users and systems personnel. Evidence in the form of documentation produced by this task defines in nontechnical but detailed terms all application parameters such as desired inputs, processes, outputs and control considerations. These specifications, although nontechnical, are essentially complete in their description of the application to be designed.

Technical Design Procedures

Activities associated with this control area convert nontechnical decision rules and control specifications, developed by users, into a detailed and technical set of instructions from which application programs are created. These specifications are expanded into sets of programmed instructions which are compiled into a computer sensible form. At this point the application has been completely converted.

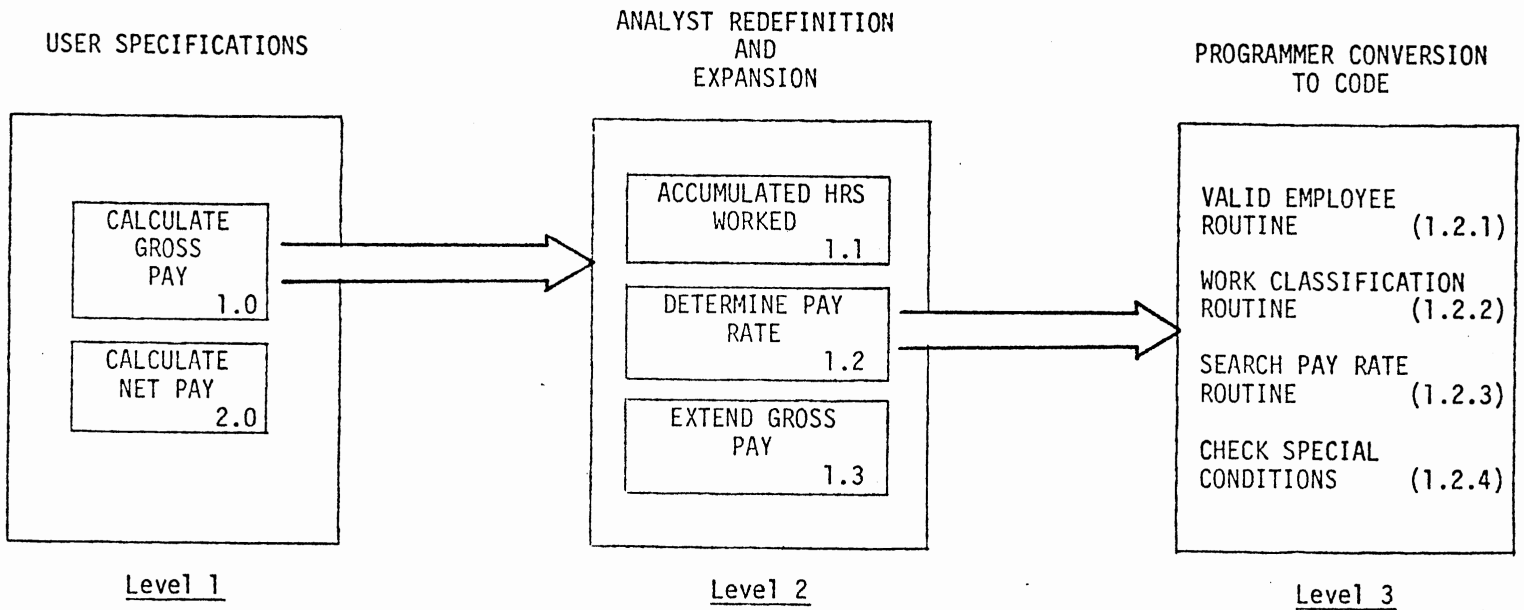
Application integrity rests heavily upon complete and undistorted information flow between user specifications procedures and technical design procedure. If the need for an application control over a process is not communicated then an uncontrolled, undisclosed exposure may be designed into the system. Evidence of adequately defined application parameters is therefore essential to its auditability.

The role of evidence here is to provide a map through a maze of specifications, instructions and computer coding. A common shortcoming in the literature with regard to this issue is a tendency to specify the form by-product evidence should take, rather than to treat it conceptually in its relationship to application integrity. It is not important whether certain evidence takes the form of flow charts or decision tables. What is important is that the documentation process satisfies its intended purpose, which is the production of critical evidence to satisfy EDP application audit objectives.

Figure 11 illustrates the concept of mapping processes and associated controls through each level of conversion for a portion of a payroll application. At each level the degree of detail becomes greater and references are produced which point to specific support documentation. For example, in level 2, blocks 1.1, 1.2 and 1.3 provide detailed instructions regarding the calculation of gross pay (1.0 in level 1). Likewise, the elements in level 3 point to specific paragraphs within the application program which support block 1.2 in level 2. This example serves only to illustrate the concept of a vertically and horizontally integrated map which may be used to identify and trace items of audit interest through various states of conversion.

System Change Procedures

The third and fourth control areas of importance in establishing the quality of critical audit evidence relate to system change procedures. Activities in these control areas result from changes in user needs and pose major problems for auditors because if uncontrolled they may render other systems development controls unreliable. Two issues must be resolved through evidence generated by these activities. First, it must be established to what degree applications have been modified during the period.



This is a modification of HIPO - A Design
Aid and Documentation Technique
Installation Management, IBM
May, 1975

Figure 11. The Relationship of Documentation Between Each Level of Conversion.

Second, there must be evidence that modifications to applications have been documented, tested and accepted in a manner consistent with that prescribed for new applications. To resolve these issues two forms of control over system changes are required. The first is preventive and the second is detective in nature.

Authorization, Test and Documentation Procedures

Formal request and authorization of all program changes preserves program integrity and auditability in two ways:

(a) Requiring formal requests for program changes has the effect of restricting sources of program changes to two groups: (1) user management and (2) systems development management.

(b) The requirement that all proposed changes must be authorized establishes responsibility which has the effect of forcing a review and evaluation of each proposed change before it is implemented.

Source Program Library Monitor

Reliance upon preventive control is possible only when a measure of preventive control performance is feasible. This is achieved here, by an on-going detective control to act in a support capacity as well as provide a deterrent to attempts to violate application change procedures. The source program library monitor provides this support and deterrent capability by providing a record of all programs used and all changes made to them. Under this electronic detection system each application program is assigned a version number which is incremented with each program change thus providing a measure of compliance with application change procedures.

In summary, the five pervasive EDP application audit objectives previously defined are satisfied by evidence generated by the essential activities listed below:

(1) User Specification Procedures

(2) Technical Design Procedures

(3) Authorization, Test and Documentation Procedures

(4) Source Program Library Monitor Procedures.

Weaknesses in control over these activities adversely affect application auditability by distorting, or failing to produce audit evidence needed to evaluate application integrity. Therefore, control over these essential activities provides the criteria for determining the extent to which theory-in-use among system reviewers, for assessing development control adequacy, promotes decisions which are in accordance with generally accepted auditing standards.

Summary

Prior to conducting the principal study, a pilot study was performed. The purpose of the pilot study was twofold: (1) to define the domain of relevant variables in the systems development process; and (2) to obtain measures of validity and reliability for constructed policy capturing instruments. The validated instruments were administered to 32 systems reviewers from eight national public accounting firms. The instruments took the form of hypothetical cases which were evaluated on the basis of the "adequacy" of control depicted in each case. Criteria for control adequacy were provided in instructions accompanying the instruments. Responses obtained from subjects were modeled using a RBFF-2^8 design. Judgemental evaluation of the appropriateness of the observed theories-in-use were made according to analytically derived criteria.

CHAPTER V

DATA ANALYSIS

A description of the research methodology was presented in Chapter IV. This chapter contains the research findings relevant to the research questions developed in Chapter I. These questions are addressed individually.

Research Question Number One

What are the cognitive models which describe the process by which EDP systems reviewers (judges) interpret and integrate hypothetical systems development control information into judgements of overall control adequacy?

Selection of the data analysis technique used to answer this question was influenced by empirical evidence regarding judge perceptions of judgement-cue relationships. Slovic and Lichtenstein (1971, p. 659) content that "judges' verbal introspection indicates they believe they use cues in a variety of non-linear ways." However, they point out

> When decision makers state that their judgements are associated with complex, sequential and interrelated rules, it is likely that they are referring to some sort of configural process (p. 659).

Configurality in judge decision processes refers to the existence of significant interactions between cues, i.e., the weighting of one factor (X_1) varies as a function of another factor (X_2). The relationship between essential and discretionary systems development evidence (discussed later in this chapter) suggests that system reviewer judgements should correspond to some complex cue weighting pattern. Therefore, it was deemed important that techniques used to describe the judgement process be sensitive to configurality.

For this reason ANOVA was selected to describe the judgemental process of subjects selected for this experiment. When judgements analyzed in terms of ANOVA provide significant main effects for cue X_1, this implies that judge responses vary systematically with cue X_1, as levels of all other cues are held constant. In contrast, significant interactions between two or more cues (e.g., X_1 and X_2) implies the effect of variation of cue X_1 upon judgements differs as a function of the corresponding level of cue X_2. ANOVA is sensitive to both linear and configural aspects of the judgement process and was considered the appropriate analytical tool. The results of ANOVA procedures applied to data obtained in this study are set forth in Table II.

The results in Table II are based on 512 responses from 32 subjects which were aggregated in a RBFF-2^8 design and blocked according to public accounting firm affili-

TABLE II

SUMMARY OF ANOVA RESULTS FOR ALL FIRMS

Source	df	Sum of Squares	Mean Square	R Square
Model	295	2099.4801	7.1168	.7344
Error	216	759.2335	3.5149	
Total	511	2858.7136		

Source	df	Sum of Squares	F Value	PR < F
Firm	7	63.4765	2.58	.0143
A	1	77.5401	22.06	.0001
B	1	50.7843	14.45	.0002
C	1	109.1964	31.07	.0001
D	1	144.4468	41.09	.0001
E	1	221.0910	62.90	.0001
F	1	454.4170	129.28	.0001
G	1	360.0418	102.43	.0001
H	1	157.9197	44.93	.0001

ation. For the eight firms considered together the results imply a linear, rather than configural, judgement process for assessing control adequacy. A listing of controllable activity (Factor) means A through H is provided in Table Table III.

TABLE III

FACTOR MEANS SUMMED ACROSS ALL FIRMS

Factor	Number of Responses	Level = 0	Level = 1
A	256	4.32109	5.09941
B	256	4.39531	5.03519
C	256	4.24843	5.17207
D	256	4.17910	5.24140
E	256	4.05312	5.36738
F	256	3.76816	5.65234
G	256	3.87167	5.54882
H	256	4.15488	5.26562

Table III contains mean response (control adequacy) scores for each factor at both treatment levels (0 and 1). Differences between mean level scores (e.g., $A_1 - A_0$) represent the average impact of each factor on judge responses. Therefore, an ordering of control factors, in terms of their relative importance to judge responses, may be inferred from the relative magnitude of mean differences (Slovic, 1969). To pictorially illustrate this relationship, factor level means were plotted and are presented in Figure 12. The relative influence exerted upon judge responses, by the absence or presence of control over specific activities, is clearly illustrated. Discussion of the implications of this weighting scheme is deferred to a subsequent section of this chapter.

Returning to Table II, F ratios indicate no significant effects (at $p < .05$ level) upon judge responses due to two-factor interactions. However, F ratios show significant main effects (at $p < .01$ level) for factors A through H and significant effects due to the blocking of subjects by firm. This significant blocking effect indicates differences in experimental unit grand means, implying differences in subject responses due to public accounting firm affiliation. Therefore, a posteriore techniques were directed to explore the experimental results and identify the nature of the difference. This was achieved in part through multiple mean comparison procedures.

The 512 judge responses were categorized by firm, and grand means were computed for each of the eight cells. The means were then ranked in descending order, as illustrated in Table IV. Significant differences between means were derived by applying least significant difference (LSD) tests to the data at the .05 significance level. Results indicate that two firms (Firm 3 and Firm 6) possess sig-

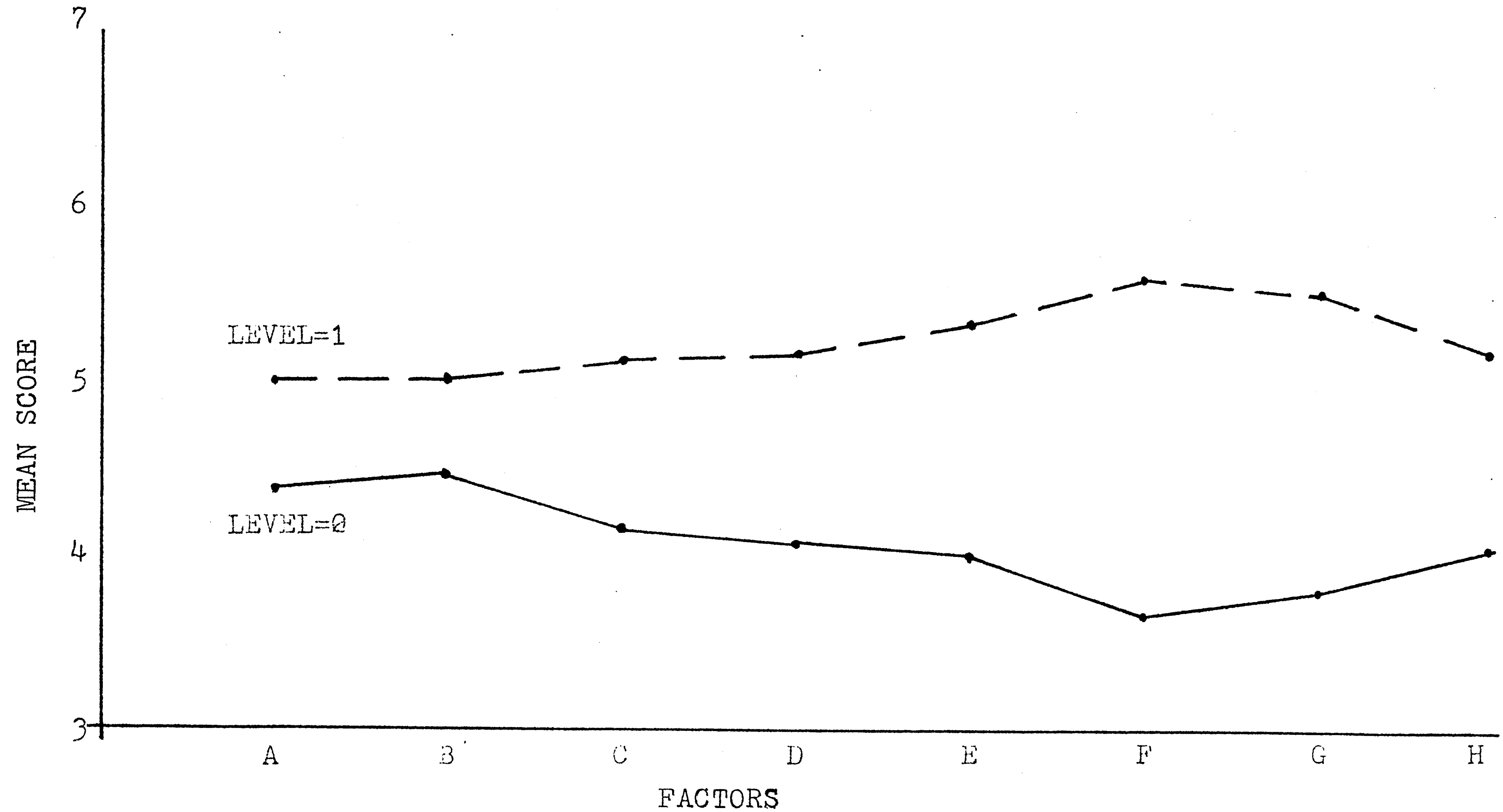


Figure 12. Plot of Factor Means Across All Firms.

TABLE IV

DIFFERENCES AMONG FIRM MEAN SCORES

	$\bar{X}_4$	$\bar{X}_8$	$\bar{X}_1$	$\bar{X}_2$	$\bar{X}_5$	$\bar{X}_7$	$\bar{X}_3$	$\bar{X}_6$
$\bar{X}_4 = 5.109$	-	.027	.066	.359	.399	.555	.709*	1.078*
$\bar{X}_8 = 5.082$		-	.039	.332	.372	.528	.682*	1.051*
$\bar{X}_1 = 5.043$			-	.293	.333	.489	.643	1.012*
$\bar{X}_2 = 4.750$				-	.040	.196	.350	.719*
$\bar{X}_5 = 4.710$					-	.156	.310	.679*
$\bar{X}_7 = 4.554$						-	.154	.523
$\bar{X}_3 = 4.400$							-	.369
$\bar{X}_6 = 4.031$								-

*SIGNIFICANT DIFFERENCES BETWEEN FIRM MEANS AT $P < .05$ LEVEL.

$$LSD = \frac{2\ MS_{ERROR}}{} = .649$$

Where: X = .05
MS ERROR = 3.5149
M = 64
V = 504 df

nificantly lower grand means than other firms in the sample. The generally lower responses are the primary source of between-firm difference depicted in the combined model.

Further explanation of firm differences was sought through analysis of judgement models unique to individual firms. Models (by firm) of judgement processes were obtained through ANOVA procedures and are reproduced in Appendix D. The sources and nature of firm differences were examined on a factor-by-factor basis in subsequent sections in this chapter. Evaluations of individual firm models are addressed in response to research question number two.

Factor A. Systems Authorization

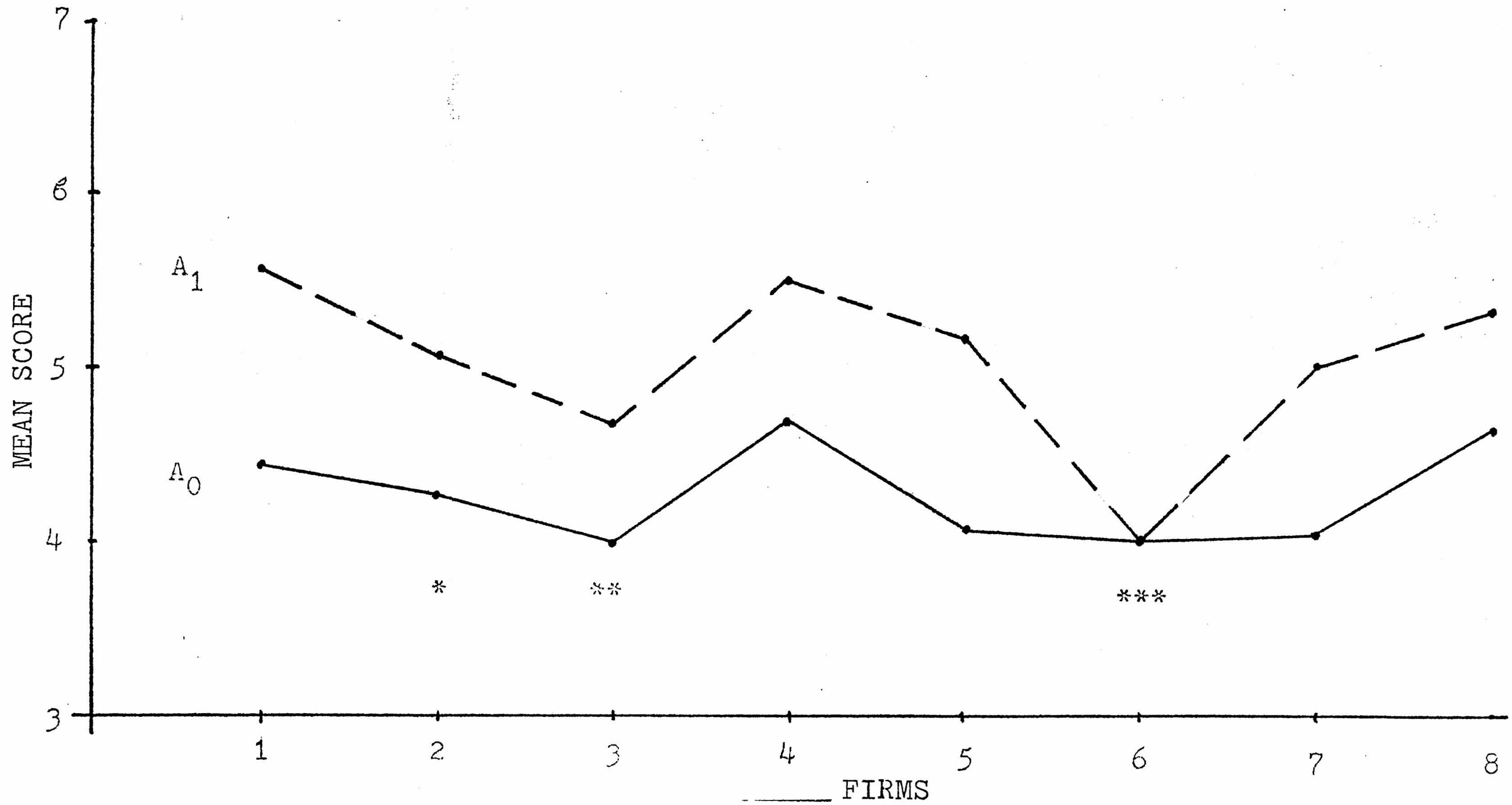
In general, it appears the level of control present over the systems authorization (control factor A) influences judgements regarding control adequacy. This factor is significant (at $p < .05$ level) in five ANOVA's performed on individual firm responses (Firms 1, 4, 5, 7 and 8 in Appendix D). These results suggest a growing awareness among public accounting firms for the need to focus more attention on information requirements of the entire organization prior to system development.

Systems authorization activities involve procedures to critically evaluate espoused merits of proposed project applications before irreversible commitments of resources are made. Project involvements often require long term, integrated participation by many departments and are characterized by major uncertainties regarding the likelihood of successful project completion. The IIA's International Research Committee (Computer Control & Audit, 1972, p. 212) contends that uncertainty of this sort is reduced by 25 percent through adequate systems authorization. Control over this activity is composed of procedures for project evaluation in terms of project scope, objectives, feasibility and costs and benefits in the manner of a capital budgeting decision.

The audit objectives satisfied by reviewing systems authorization activities are exploratory in nature. Reviewers seek to identify areas of weakness and of redundant control. Consequently, management estimates of project costs and benefits are useful in determining the audit procedures to be followed.

In three instances, results of ANOVA procedures indicate no significant effect upon judge responses due to factor A. Figure 13 contains a graph of factor A means for all eight public accounting firms. This graph depicts the relationship of the magnitude of average changes in responses, for each firm, due to changes in level of systems authorization controls.[1] At the $p < .05$ significance

[1]The graphs in Figures 13 through 19 were constructed from data contained in Appendix E. Asterisks on graphs indicate observed significance levels in excess of $p < .05$.



* OBSERVED SIGNIFICANCE LEVEL = $p < .0831$
** " " " = $p < .1075$
*** " " " = $p < .9712$

Figure 13. By Firm Plot of Factor A Means.

level Firms 2, 3 and 6 show no significant effect due to this factor. The results imply that these firms function under conservative interpretations of their audit mandates. Hence, they draw upon alternate sources of evidence in their assessment of control adequacy. In particular, Firms 2, 3 and 6 rest heavily upon control factor F (see Figure 14).

Factor F. User Test and Acceptance Procedures

In contrast to control factor A which represents the first opportunity to detect deficiencies in system applications, control factor F is commonly regarded as the last line of defense against systems exposures. Thus, not surprisingly, results contained in Appendix E support the notion of a concensus among firms with regard to this factor. Seven firms consider factor F significant at the $p < .05$ level and one firm (Firm 6) has an observed significance level of $p < .0794$. Factor means for all firms are plotted in Figure 14, which illustrates the impact on individual firm responses due to changes in factor F.

The relative significance of user test and acceptance procedures in judgements of control adequacy is rationalized by examining the nature of this control. The phase of the systems development process to which test and acceptance procedures pertain is the culmination of design activities and provides a focal point for observing the

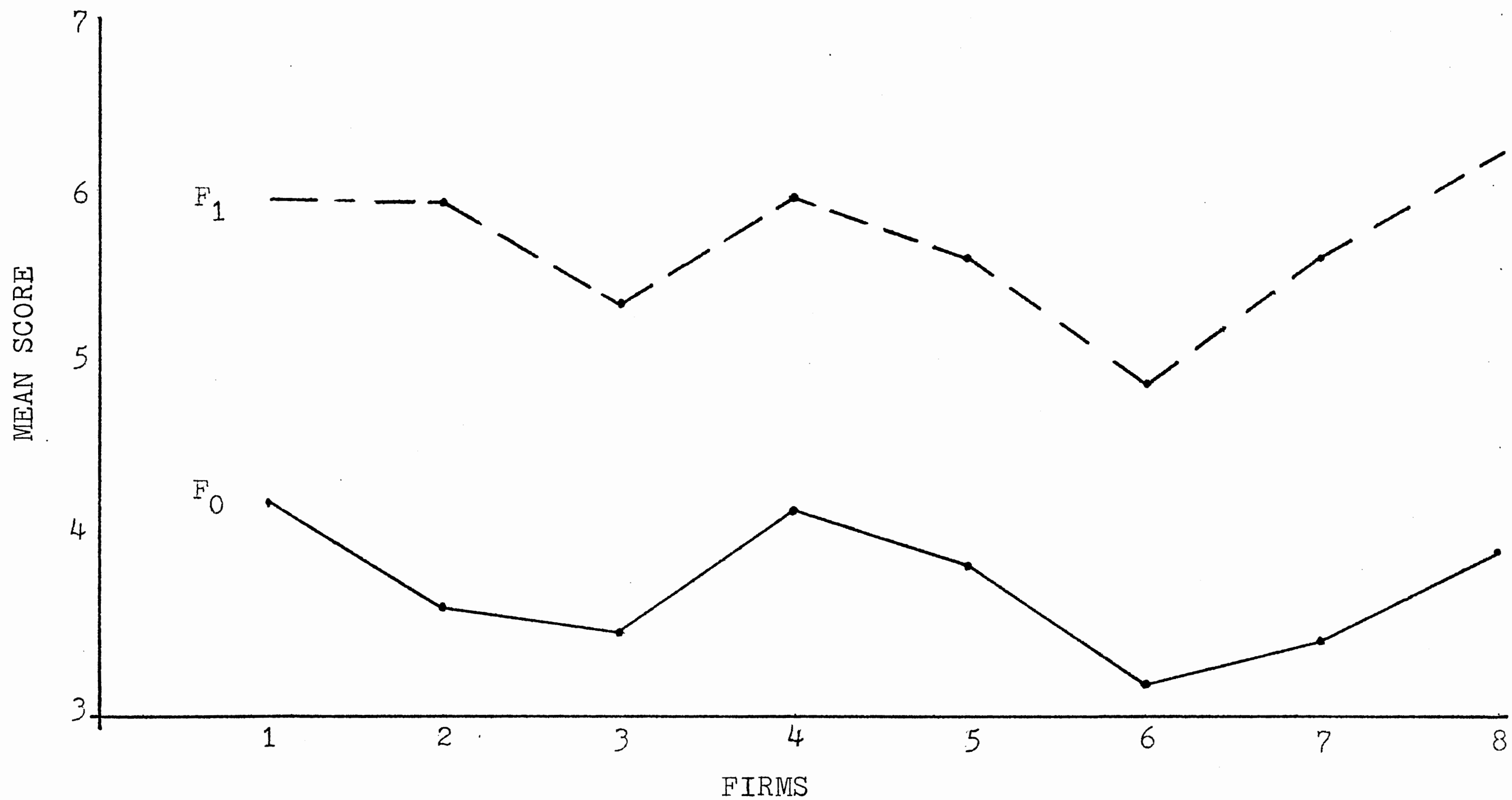


Figure 14. By Firm Plot of Factor F Means.

entire system. At this juncture, all functional system modules are assembled and rigorously tested by special test teams comprised of system users, internal audit staff and EDP personnel. Their objective is to bring about system failure by subjecting each system to a comprehensive range of valid and invalid transactions. These procedures cause significant errors to emerge prior to system implementation. Once system test teams are satisfied that applications meet minimum specifications, they are formally accepted by user departments and are placed into production.

Explanation for perceived importance of control factor F is couched in the notion of auditor pragmatism. Test and acceptance procedures are characterized by a chronology of visible events which produce nontechnical evidence of successful application processing. These formalized acceptance procedures are de facto measures of user satisfaction with new systems. As such they constitute surrogates for assessing application integrity by virtue of user acceptance. Thus, assurance of application control adequacy is inferred by system reviewers because of the existence of formal system test and acceptance procedures.

However, reliance upon results of these procedures as prima facie evidence of application control adequacy is tenuous. The extent to which test results are evidence of application integrity is dependent upon the exhaustiveness of acceptance tests performed. By-product evidence generated in this phase of the systems development process must be reconciled to evidence from essential activities before meaningful conclusions regarding the adequacy of user test and acceptance procedures can be assessed.

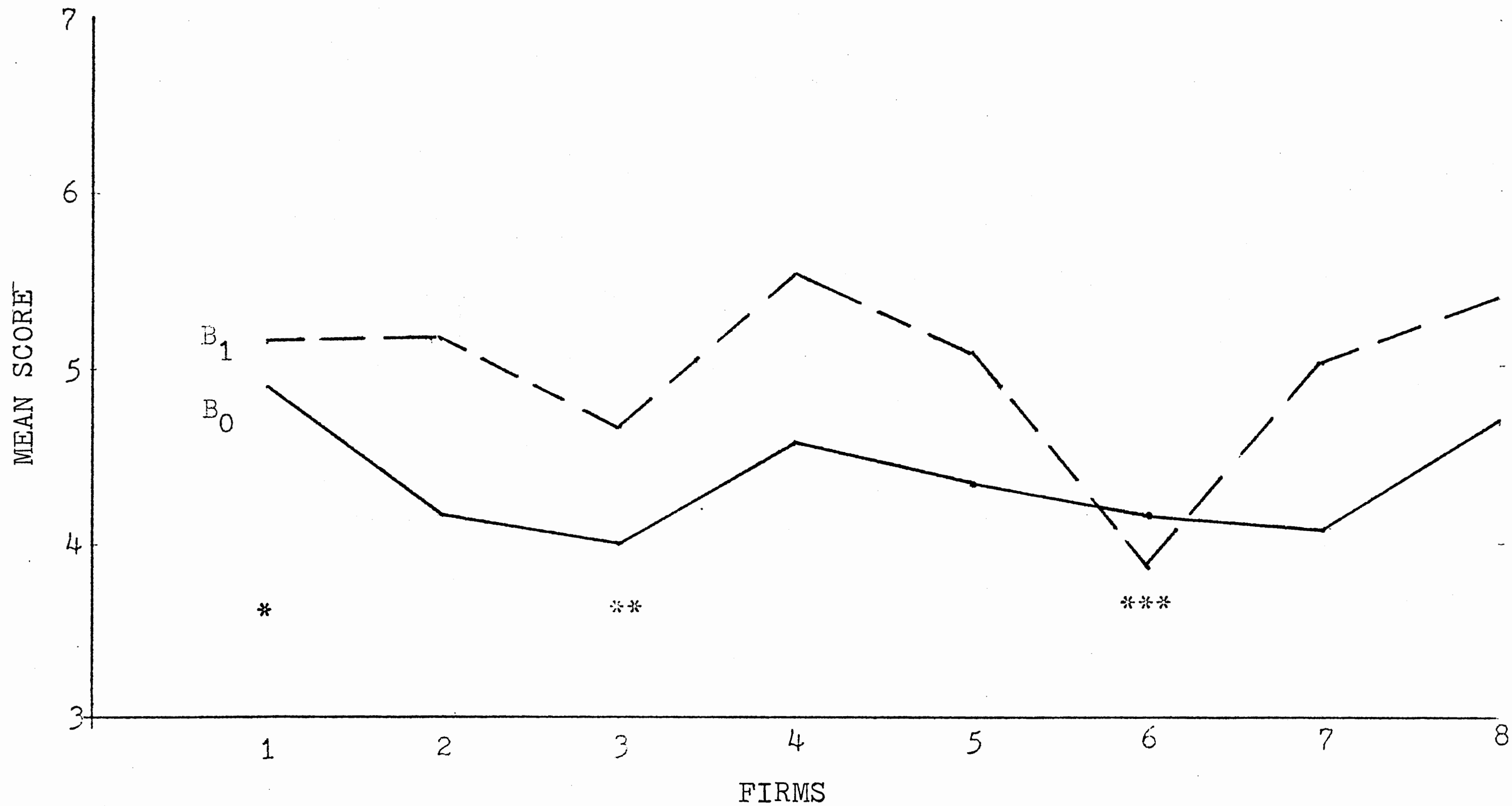
Factor B. User Specification Procedures

User specification procedures (factor B) require users to describe in nontechnical but detailed terms all desired characteristics of proposed systems. These specifications include input, processing and output parameters as well as special control considerations. Although nontechnical, specifications of system requirements should be essentially complete and unambiguous.

Results contained in Appendix D identify this factor to have statistically significant effects on subject responses in five firms. Figure 15 illustrates the relationship of the mean impact on responses due to factor B for all firms in the study.

The conceptual foundations of this control concept were discussed in Chapter IV and are not belabored here. However, a brief overview of some relevant issues is offered as insight into the nature of the significant differences between firms with regard to this factor.

A problem faced by external auditors since the advent of computers has been user abdication of responsibility for system design. Responsibility for design and control



* OBSERVED SIGNIFICANCE LEVEL = $p < .3601$
** " " " = $p < .0794$
*** " " " = $p < .6652$

Figure 15. By Firm Plot of Factor B Means.

of systems was subsequently assumed by data processing departments. This situation gave rise to two undesirable consequences: (1) user management became distally removed from EDP segments of their organizations; and (2) audit trails suffered due to the efficiency orientation (as opposed to control orientation) of typical data processing departments.

In light of these circumstances audit approaches and techniques were forced to change. Electronic data processing functions came to be acknowledged as separate segments, or departments, within organizations and were either ignored (audit around the computer) or reviewed separately. As a consequence, user involvement in accounting application design was steadily de-emphasized.

The current trend in auditing literature expresses EDP control as an integral part of accounting control.[2] Failure to consider user specifications during system reviews runs the risk of compiling incomplete evidence upon which to base appraisals of internal control adequacy. However, results of this study indicate that system reviewers regard this risk to be slight. These findings are comparable across all firms in the study. The relative impact of factor B upon judge responses is consistently low (see Figure 12 and Figures 21 through 28).

Two inferences may be derived from these findings:

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[2]These concepts are discussed in detail in Chapter II.

First, there may exist a general lack of confidence among system reviewers in the ability of user management to effectively participate in systems design and thus any such participation carries relatively less weight than other control considerations; or, alternatively, system reviewers agree in concept with user participation but seek alternate forms of evidence on practical grounds, because of noncompliance by user management. Support for this second inference is suggested by the impact of program test procedures (factor E) upon judge responses. The effects of factor E upon judgements is discussed below.

Factor E. Program Test Procedures

It is noteworthy at the outset to draw a distinction between the concepts of program tests and previously discussed systems tests. Systems tests are directed by user departments as a prelude to system acceptance. They are the culmination of design activities and mark the formal transference of system responsibility from data processing personnel to user departments. Program test procedures, on the other hand, are performed by data processing departments at intermediate steps in the systems development process. Their primary objective is to ensure that all applications are thoroughly tested for such things as efficient program logic, appropriate edit routines and adequate field capacity before they are implemented. In organizations where this activity is adequately controllable, all test results become part of the application's permanent file and thus facilitate subsequent comparison tests.[3]

Summaries of ANOVA results presented in Appendix D imply consensus among subjects with regard to the influence of factor E upon judgements of control adequacy. Observed results indicate significant effects (at the $p < .05$ level) upon responses in seven of the eight firms. Firm 6 had an observed significance level of $p < .1051$. Factor E mean differences for all firms are graphed in Figure 16.

Explanation for this high degree of agreement among system reviewers was partially provided in the discussion of factor B. That is, there is evidence of pervasive user abdication of responsibility for system specification. Therefore, system reviewers seek assurance of application control adequacy through by-product evidence from program test procedures.

However, there is further explanation for the apparent importance of this activity. The rationale is twofold:

(1) Program test procedures produce quantities of test results which may be indefinitely retained by the organization. Results of sufficiently rigorous and comprehensive test procedures constitute a basis upon which subsequent tests of application processing may be evaluated. Therefore, standards of application integrity are created through this development activity which

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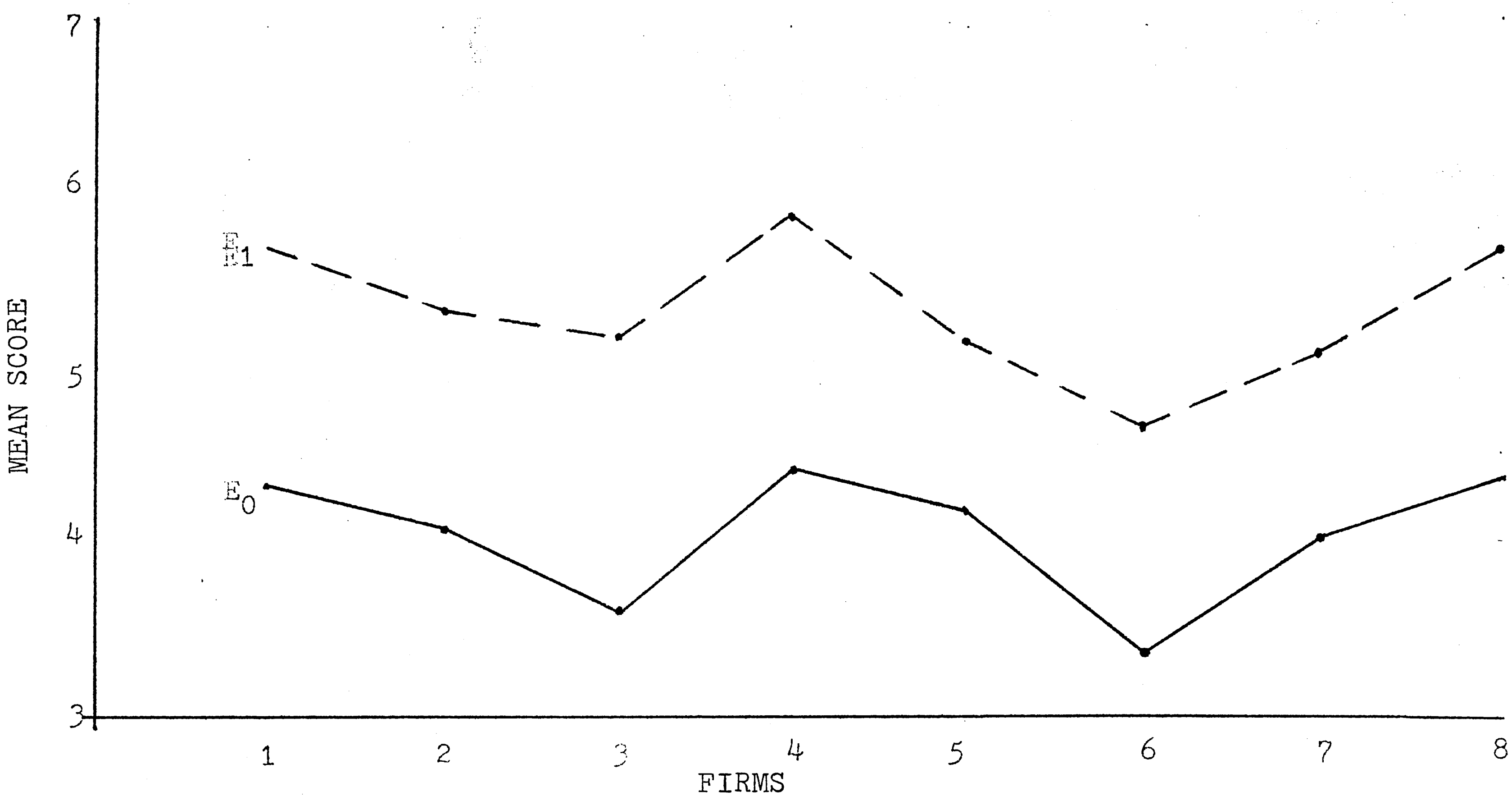
[3]For more detail see the discussion of base case system evaluation (BCSE) in Chapter III.



* OBSERVED LEVEL OF SIGNIFICANCE = $p < .1051$

Figure 16. By Firm Plot of Factor E Means.

serve as guides for subsequent periods.

(2) This activity provides a premise upon which system reviews may be efficiently limited. That is, subsequent to initial implementation, system reviews may be limited to only those areas of accounting applications which undergo major changes (maintenance) during the period of review.

Clearly, strong control over program test procedures creates conditions in which system reviewers perceive opportunities to effectively and efficiently assess application integrity. However, for this purpose, program test results must be viewed with skepticism. If insufficiently supported, evidential content of program tests are incomplete for two reasons:

(1) As reliable application control standards, by-product evidence for program test procedures must be verified through reconciliation with evidence produced in essential systems development activities. Evidence from essential activities is required in order to ascertain the comprehensiveness of the test procedures performed and thus assess their appropriateness as standards.

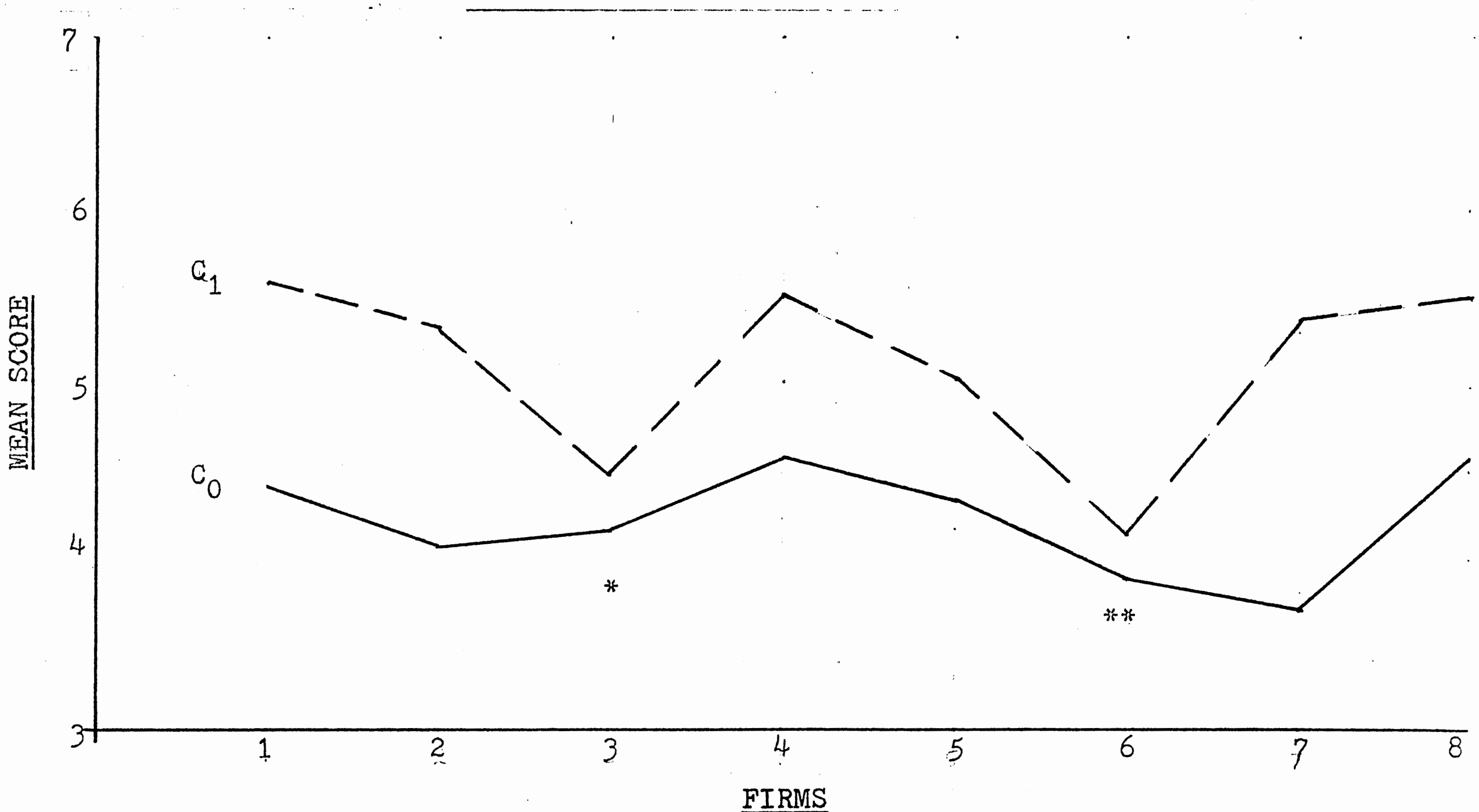
(2) Judgements to limit application reviews are based in part upon evidence of consistent application of accounting procedures during the period of review. In addition to test results of past period application processing, system reviewers must establish that no significant, unrecorded system modifications occurred during the period which materially affect data files.

Evidence of the extent of application maintenance is not produced through program test procedures alone. This form of evidence is produced in the essential control activities identified as factor G and factor H. The impact upon judgements of these factors is discussed following an analysis of the effects of factor C. The influence of factor D is discussed last.

Factor C. Technical Design Procedures

The function of technical design procedures is to convert nontechnical user decision rules and specifications into technical sets of instructions from which application programs may be created. The primary control objective for this activity is to ensure that communication between users and analysts is complete and effective. Failure in this regard may result in varied consequences to organizations. For example, incomplete or distorted communications between user and EDP departments may result in implementation of built-in, undetected exposures which have material financial implications. Alternatively, resulting exposures may be detected prior to implementation during user test and acceptance procedures. However, at that point in systems development procedures it is often too late to rectify major design errors without incurring significant additional costs.

The results presented in Appendix D (illustrated in Figure 17) imply general agreement among subjects as to



* OBSERVED SIGNIFICANCE LEVEL = $p < .4791$

** " " " = $p < .6369$

Figure 17. By Firm Plot of Factor C Means.

the importance of technical design procedures. Significant effects (at $p < .05$ level) due to control factor C were observed in six firms. Observed significant levels for Firm 3 and Firm 5 are $p < .4791$ and $p < .6393$ respectively.

The underlying rationale for these differences is closely akin to that which explains observed differences between firms with regard to user specification procedures (control factor B). In a previous discussion it was suggested that user abdication of responsibility for specifying system requirements forces reviewers to seek alternative sources of assurance of application integrity. Thus, ipso facto, system reviewers perceive little virtue in control techniques designed to effectively capture and translate user specifications into formalized technical instructions (control factor C). These conclusions are not contrary to observed subject responses. Firms which place relatively less weight upon control factors B and C tend to adopt an acid-test approach toward assessing application integrity. Consequently, those firms place considerably more weight upon evidence produced in activities identified as control factors E and F. The problems associated with unsupported reliance upon these factors were addressed previously.

Factor G. Authorization, Test and Documentation Procedures

The impact of systems development activities upon application integrity and auditability does not cease when systems are placed into production. In fact, it is not uncommon for fifty percent of the entire cost os system development to be incurred in system maintenance. This level of maintenance activity is primarily the result of changes in organizational needs for information. If uncontrolled, post implementation maintenance procedures can prove detrimental to application integrity and negate the preimplementation development controls discussed thus far.

The objective of application change controls is to preserve application integrity once it has become operational. This objective is satisfied through two classes of control: (1) preventive control; and (2) detective control. The latter is discussed in the next section.

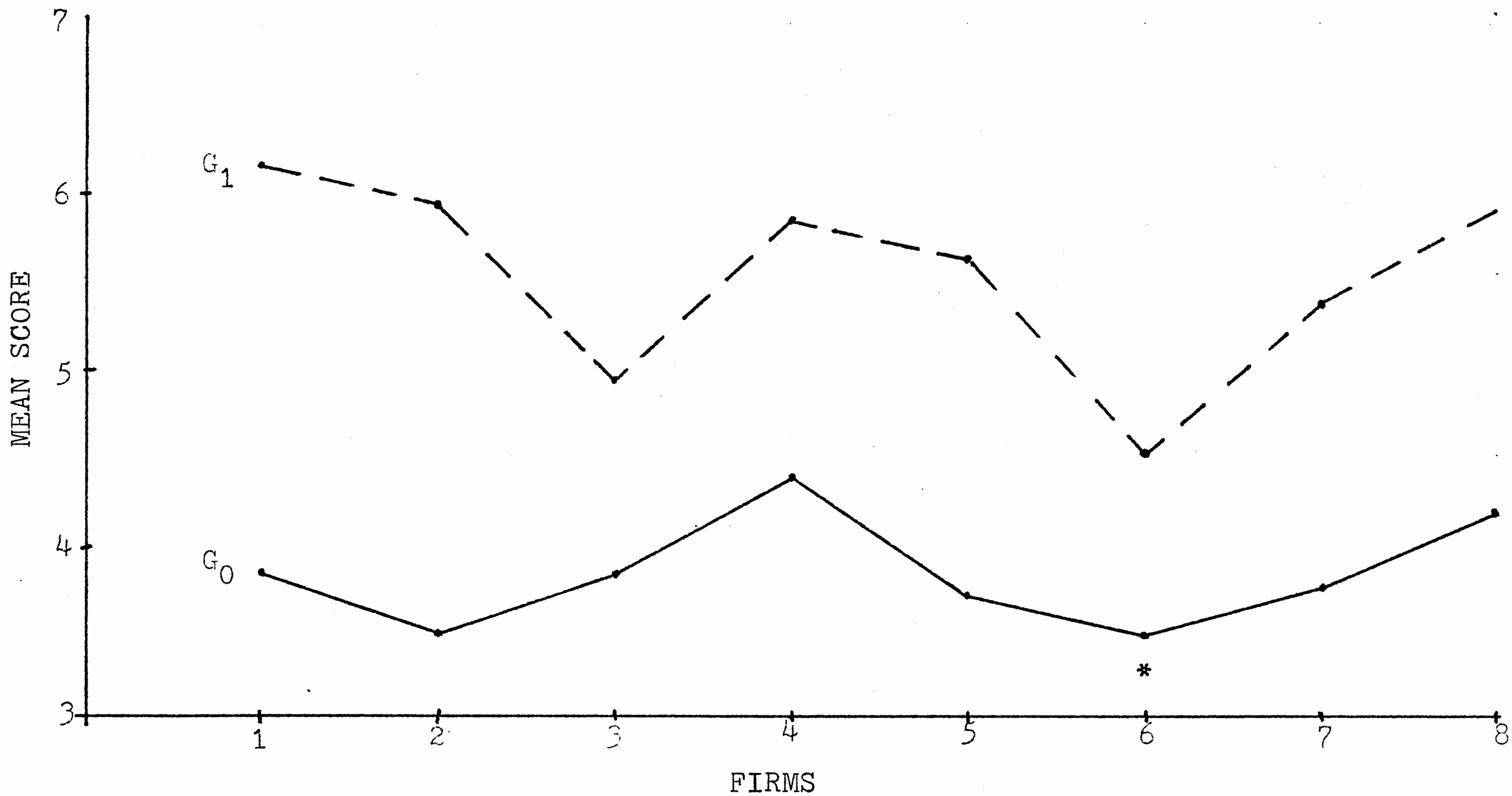
Preventive controls are comprised of formal procedures for requesting, authorizing, documenting and testing application changes in much the same manner as new system development procedures are conducted. By-product evidence produced in these activities serve the same audit objectives as that produced in their pre-implementation counterpart activities. Therefore, a detailed discussion of each activity in this class is redundant.

The results presented in Appendix D indicate general agreement among subjects as to the importance of preventive control of application changes. Significant effects (at $p < .05$ level) due to factor G were observed for seven of the eight firms in the sample. The observed significance level for Firm 6 was $p < .2837$. Figure 18 illustrates the relative influence of factor G upon the mean responses observed for each of these firms.

These observations imply support for the notion that application change procedures are perceived by reviewers as extensions of the systems development process and not independent areas for control consideration. Hence, judgements of system development control adequacy are influenced by control of post-implementation activities.

Factor H. Source Program Library Monitor Procedures

Chapter III contained a discussion of some common audit techniques employed for application control evaluation. They include test decks, integrated test facilities (ITF), tracing and program simulations. These basic EDP audit approaches utilize, to various degrees, detailed data which are generated as by-products of system develop- procedures. The accuracy and completeness of these data affect decisions about application integrity and, consequently, about the nature and extent of subsequent tests. Problems encountered in the quality control of by-product evidence limit the extent to which application review and



* OBSERVED LEVEL OF SIGNIFICANCE = $p < .2837$

Figure 18. By Firm Plot of Factor G Means.

appraisal objectives are satisfied.

As pointed out in the previous section, problems of preserving reliable evidence (once applications are implemented) are confounded by frequent application modifications. Hence, understandably, judges agree that program change procedures must be controlled. However, only partial solutions to these problems are provided through the preventive controls previously discussed. Therefore, in order to derive a complete solution, application change control concepts are expanded in this section to include detective controls.

Detective controls were described in general in Chapter II as procedures designed to detect excessive deviation from established performance criteria. A specific application of this concept relates to the task of detecting deviations from program change procedures. Detective controls for this task are termed source program library (SPL) monitor procedures and are comprised of the following component parts: (1) an on-line source program library; (2) a software library package; and (3) procedures for reconciling output results.

For years source programs were retained by organizations as collections of punched computer cards. Modification of card programs involved creating and hand filing new cards and physically replacing modified or deleted cards. Procedures were slow, error prone and subject to little control. This situation eventually improved when retention of source programs on tapes and disks came into vogue.

Technological innovations in on-line SPLs initiated development of sophisticated software library packages to provide computerized maintenance of stored programs. Library packages are provided through many sources, but their basic characteristics are similar. They possess a number of features to facilitate efficient storage, accurate updating and timely production of useful management reports.

Of primary interest to this study is the expanded capacity for assessing internal control made available through these unique features. Library packages are detective control devices which generate highly accurate evidence, and may be used to establish criteria for evaluating preventive control effectiveness. SPL software features which provide this control are discussed in paragraphs 1, 2 and 3 below.[4]

(1) Source statements are associated with the dates they are placed in libraries. Therefore, programs may be reviewed to determine which statements (instructions) represent modifications to original program code.

(2) Programs are assigned modification numbers within the SPL. When programs are first placed in libraries (at implementation) they are assigned the number zero. Each time modifications occur the number is incremented by one. This feature cannot be easily circumvented and thus provides for positive comparison of library versions of

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[4]Other features provide additional discretionary information and are omitted from this discussion. A comprehensive review of SPL packages in use is provided by Adams (1973).

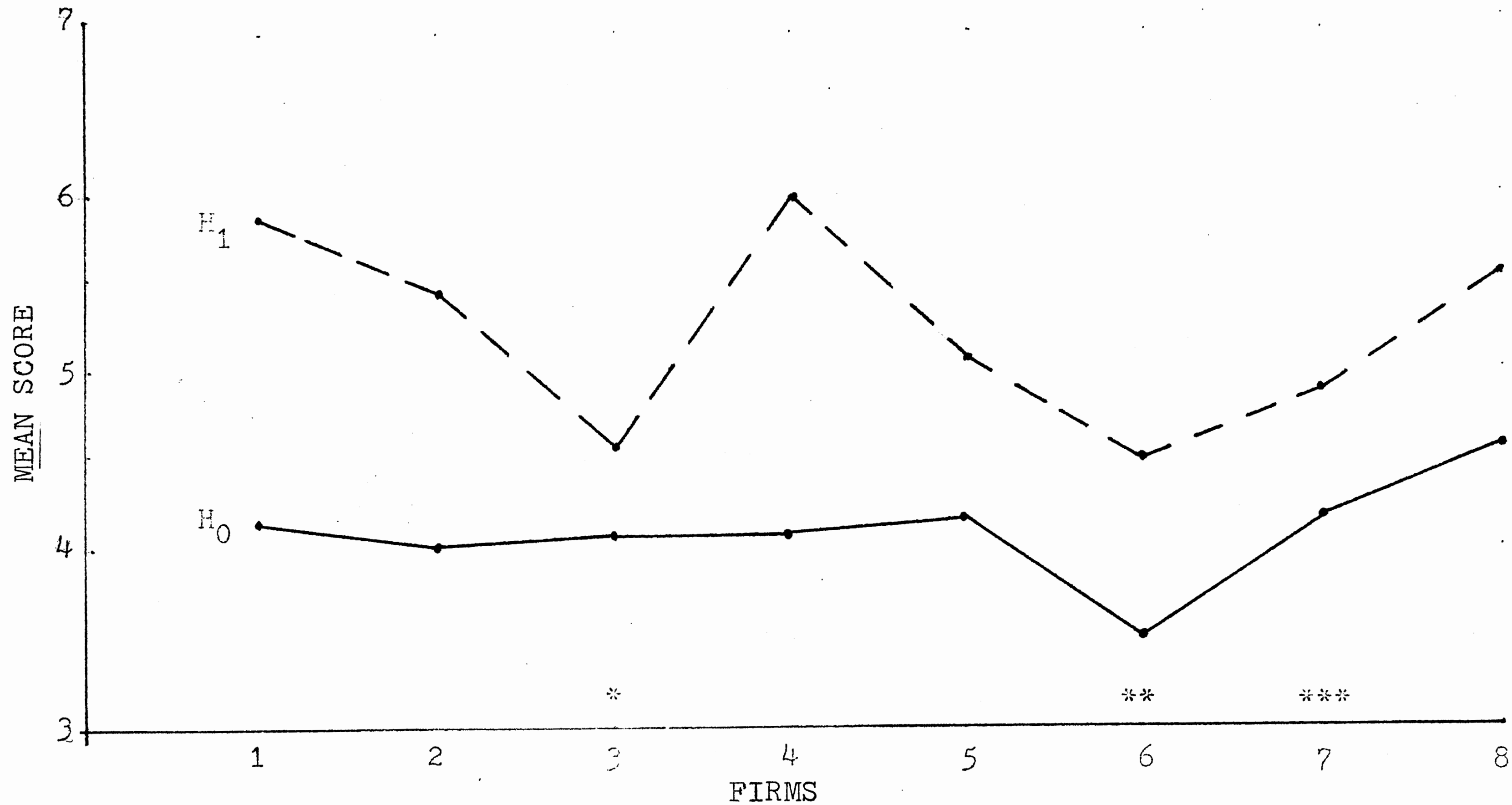
applications against control copies.

(3) SPL packages produce a range of output reports. The most useful of these to system reviewers are change reports which detail every addition, revision, or deletion for each program module. These reports are useful only if they become part of the permanent files of applications and thus provide clear records of modification activity.

Results of subject responses to SPL monitor procedures (control factor H) indicate less reliance, in general, upon these controls than was implied by responses to control factor G. Analysis of judge responses shows significant effects (at $p < .05$) for five of the eight firms in the study. However, observed significance levels for Firm 3, Firm 6 and Firm 7 were $p < .2912$, $p < .2683$ and $p < .0652$ respectively. The impact on subject responses due to this factor is plotted for each firm in Figure 19.

Comparison of these results with previously obtained results for factor G suggest that subjects affiliated with Firm 3 and with Firm 7 employ incomplete control decision models. Results signify their judgements of control adequacy are influenced by control factor G (preventive control) but not by control factor H (detective control).

Judgements influenced by this cue weighting scheme suggest a naive notion of data integrity problems. Reliance upon preventive controls by system reviewers are justified if measures of compliance (detective control) are possible. Therefore, on-going detective controls are essential to data integrity and provide deterrents to the



* OBSERVED SIGNIFICANCE LEVEL = $p < .2912$
** " " " = $p < .2683$
*** " " " = $p < .0652$

Figure 19. By Firm Plot of Factor H Means.

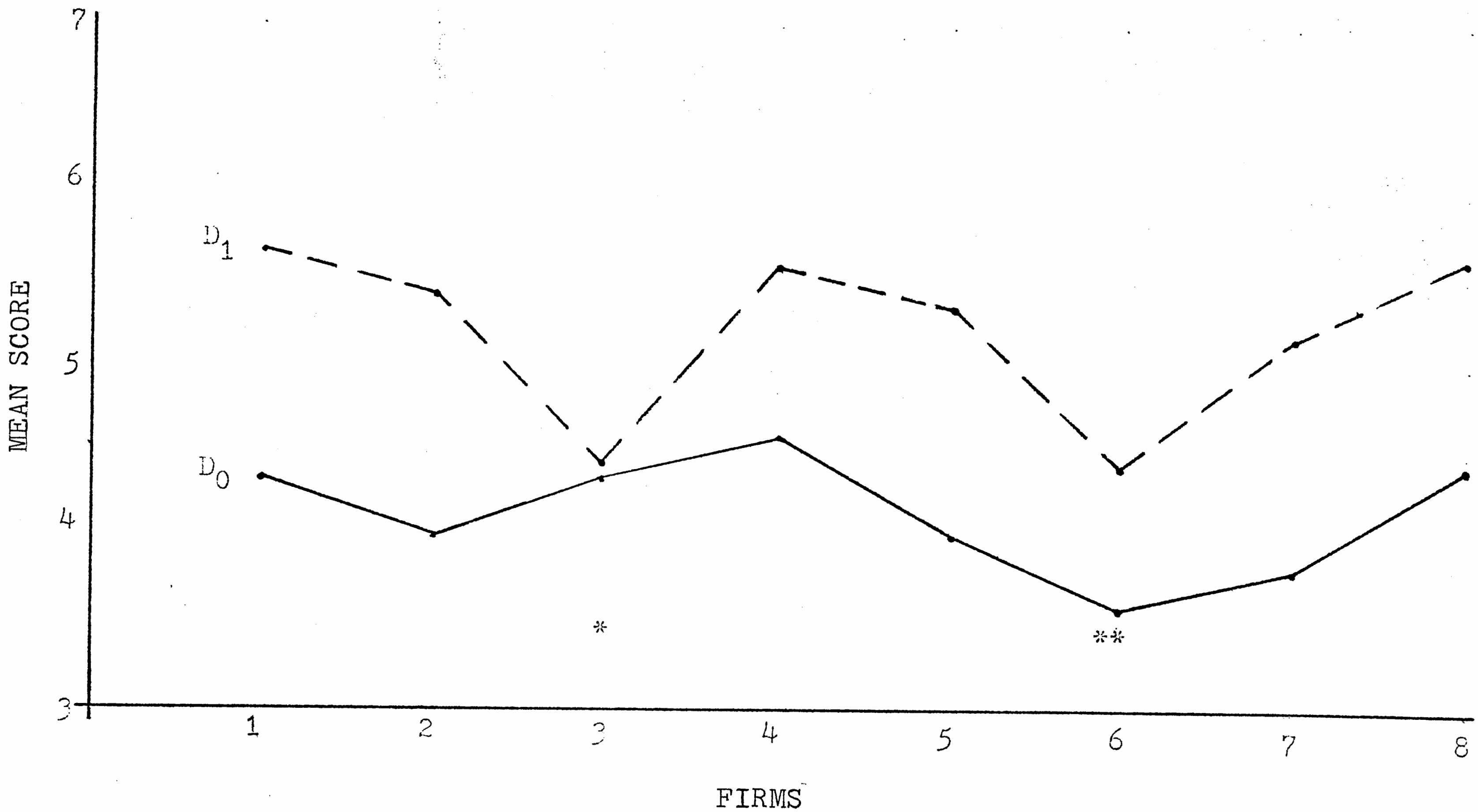
circumvention of application change procedures. Only source program library packages provide this support and deterrent capability in EDP environments. This is accomplished by electronically recording all licit and illicit activity and by producing special reports, which facilitate reconciliation between authorized activity and actual activity. Through this control concept detected discrepancies can be investigated in depth in order to determine the extent and nature of application control tests to be performed. Judgement processes which do not consider control capabilities afforded by SPL monitor procedures may result in incomplete application control reviews.

Factor D. Internal Audit Participation

Internal audit participation (control factor D) is discussed last because it is pervasive to all system development activities. Computer Control & Audit (1972, p. iii) defines internal auditing as "an independent appraisal activity within an organization for review of operations as a service to management." The objective of this function in systems design is to provide liaison to departments involved in EDP systems development and to ensure that adequate controls are designed into applications. The nature of this function necessitates early and continuous involvement. Internal auditors participate throughout pre-implementation phases of system life cycles by assessing control requirements and reviewing test and acceptance procedures. Detailed knowledge gained through design involvement is carried into post-implementation stages and provides the basis for evaluating effects of proposed program changes and for designing application audit procedures.

Rittenberg (1977) examined the influence of audit participation in systems development upon external audit decisions. He concluded (p. 50) that "CPA's strongly agree that the internal auditor should evaluate the adequacy of controls during the design phase of new EDP application developments." It was shown that auditors were willing to adjust the scope of their audits when two criteria were satisfied: (1) internal auditors report to a sufficiently high level (vice president or above); and (2) post-implementation audits are not conducted by the same individuals participating in systems design. During construction of research instruments for this study, care was taken to include these criteria in definitions of strong internal audit participation.

Results obtained tend to support Rittenberg's findings. Subjects in six out of eight firms were significantly influenced by control factor D (at $p < .05$ level). Observed significance levels for Firm 3 and Firm 6 were $p < .7762$ and $p < .3893$ respectively. Factor D means, at high and low levels of control, are plotted in Figure 20.



* OBSERVED SIGNIFICANCE LEVEL = $p < .7762$

** " " " = $p < .3893$

Figure 20. By Firm Plot of Factor D Means.

Findings suggest general approval among subjects for on-going EDP audit functions within client organizations. This form of continuous review of applications and program modifications provides control over a highly dynamic process. Although it is not a substitute for other essential controls, internal audit participation provides useful adjunct evidence of application integrity.

Research Question Number Two

To what extent are the identified models of professional judgement conducive to the promotion of decisions which are in accordance with generally accepted auditing standards?

Research question number one dealt with identification of judgement processes by analyzing observed responses to changes in relevant factor values. Research question number two is concerned with the appropriateness of judgement processes. The philosophical essence of this question is reflected in a statement by Slovic (1969).

> The task of the expert, no matter what his occupation--military officer, detective, businessman, physician, clinical psychologist, financial analyst, etc.--requires him to combine items of information from a number of different sources into a decision or judgement. The key to the expert's success resides in his ability to interpret and integrate information appropriately (p. 255).

To answer research question number two, a two-step technique was employed:

(1) Models were first screened on the basis of completeness, (i.e., those models which include all sources of essential information among significant factors at $p < .05$, are complete).

(2) Complete models were evaluated on the basis of the relative importance of significant factors.

Selection of Complete Decision Models

As with all information systems, the systems development process generates information which falls into either of two fundamental classifications: (1) essential information or (2) discretionary information. Essential information is so labelled because of its indispensibility to the audit task of determining application integrity. Controls over activities which produce this form of information are the minimum necessary. Therefore, the economic criterion in their design is to minimize cost. In Chapter IV, four sources of essential systems development information were discussed and are listed below:

(1) User Specification Procedures (Factor B)

(2) Technical Design Procedures (Factor C)

(3) Authorization, Test and Documentation Procedures (Factor G)

(4) Source Program Library Procedures (Factor H).

In contrast to the concept of essential information, discretionary information is beneficial, but not indispensible to the task of assessing application integrity. Items of discretionary information are not substitutes for essential information but rather adjuncts which greatly enhance system reviews. As such, control over activities which produce discretionary information are provided only when benefits received from additional information exceed the cost of providing it. This classification of information is produced in the following systems development activities:

(1) System Authorization Procedures (Factor A)

(2) Internal Audit Participation (Factor D)

(3) Program Test Procedures (Factor E)

(4) User Test and Acceptance Procedures (Factor F).

The nature of evidence produced in each of these activities is summarized in Table XXIX.

Exclusion of any items of essential information from system reviewers precludes informed appraisals of application control adequacy. Therefore, judgement processes for evaluating development control adequacy, according to the stated criterion[5] must specify controls which ensure the production of critical information. Judgement models

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[5]Subjects were asked to evaluate hypothetical cases according to the criteria: "The likelihood that the systems development process described in the case will produce reliable, critical information."

TABLE XXIX

SUMMARY OF SYSTEMS DEVELOPMENT ACTIVITY CHARACTERISTICS

Activity	Evidence Classification	Nature of Evidence Produced in Activity
Factor A	Discretionary	Evidence of this form serves primarily cost/benefit objectives. It is useful in evaluating the espoused merits of projects and aids in the identification of control redundancy.
Factor B	Essential	System characteristics are defined in a nontechnical but detailed manner. This information provides the starting point for assessing application compliance with management allegations. Absence of control over this activity produced systems which have not been defined by users. Therefore the completeness and accuracy of the conversion of application procedures and controls cannot be determined.
Factor C	Essential	This activity provides evidence of the effectiveness of communications between system users and technical design personnel. The function of technical design procedures is to convert user decision rules and specifications into EDP application programs. When this essential evidence is missing, or incomplete, systems reviewers are prevented from assessing the extent to which user needs and control requirements have been satisfied.
Factor D	Discretionary	The effect of evidence of internal audit participation is to possibly limit the scope of the external auditor's engagement (Rittenberg, 1977, p. 50).

TABLE XXIX (Continued)

Activity	Evidence Classification	Nature of Evidence Produced in Activity
		Internal audit participation in systems design constitutes a liaison between user departments and system designers. The result of this activity is to improve the conversion process by helping to ensure that user needs are effectively communicated. Thus, it provides useful adjunct evidence of application integrity in organizations where essential activities are adequately controlled.
Factor E	Discretionary	The objective of program test procedures is to ensure that all applications are thoroughly tested before being placed into production. However, for the purpose of assessing application integrity, evidence of formal test procedures must be viewed with skepticism and properly verified. This form of evidence is a useful adjunct. It provides a basis for limiting the scope of system reviews only if the comprehensiveness of program test procedures can be ascertained. To do so requires evidence produced in essential activities.
Factor F	Discretionary	The objective of system test procedures is to rigorously test accounting applications with all possible combinations of transactions and thus bring to light errors which could result in exposure. However, reliance upon the results of this activity as evidence of application integrity is tenu-

TABLE XXIX (Continued)

Activity	Evidence Classification	Nature of Evidence Produced in Activity
		ous for two reasons. First, evidence of formal acceptance procedures becomes dated after systems have been placed into service and the inevitable application changes (maintenance) have been performed. Second, system reviewers must determine the comprehensiveness of the tests conducted before an evaluation of test results is possible. This requires detailed evidence of system parameters which is provided only as by-products of essential activities.
Factor G	Essential	The objective of this activity is to preserve application integrity after it has been implemented. Uncontrolled post-implementation maintenance may destroy application integrity, or application auditability or both. Evidence of formal system modification activities provides system reviewers with partial assurance as to the consistent application of accounting procedures during the period of review.
Factor H	Essential	SPL monitor procedures provide reliable and consistent evidence regarding compliance with the organization's maintenance policy. This evidence is essential for detecting departures from acceptable maintenance procedures and provides a permanent record of program changes. Absence of SPL monitor procedures exposes application programs to un-

TABLE XXIX (Continued)

Activity	Evidence Classification	Nature of Evidence Produced in Activity
		authorized modification and thereby destroys both application integrity and auditability.

which show no significant effects (at $p < .05$) due to factors B, C, G and H (critical factors) are deemed inappropriate.

According to this first selection criterion, it is readily observable from the results in Appendix D that subjects affiliated with Firm 1, Firm 3, Firm 6 and Firm 7 utilize incomplete decision models. Models descriging these judgement processes have observed significant levels greater than .05 for at least one essential factor. However, this does not imply that subjects in Firm 2, Firm 4, Firm 5, and Firm 8 necessarily interpret and integrate information appropriately simply because models describing their collective behavior indicate significance at the .05 level. This measure of statistical significance ignores important aspects of the cognitive relationship between essential and discretionary information. The remainder of this chapter contains analyses of the observed relationship between these classes of factors for each firm model.

Evaluation of the Relative Importance of Significant Factors

The question of whether system reviewers appropriately interpret and integrate stimuli in the formulation of judgements is only partially answered by examination of observed significance levels of critical factors. Significant main effects of critical factors provides prima facia evidence of model completeness. However, the philosophical question of appropriate cue-usage involves identification of model structure, i.e., the manner in which sources of audit evidence are differentially weighted. Judge weighting schemes are shown by Slovic (1969) to be appropriate gauges for assessing the relative importance of significant factors in decision processes.

In order to establish a ranking of factor influences on judgements, an index of importance was computed for each factor. This was obtained by calculating the magnitude of factor effects, based upon the degree of change in mean judgements as levels of each factor were varied. These factor effects were summed over all factors and each was divided by the sum of the effects for all factors. Thus, indexes of importance were derived (see Appendix F) percentage scores where the sum of all percentages totalled 100 (Slovic, 1969, p. 260).

Figures 21 through 28 illustrate the relative importance of eight factors in the decision model for each firm. Despite the fact that models for Firm 2, Firm 4, Firm 5 and Firm 8 were adjudged complete, it is apparent that each employs a different cue utilization process. Interpretation and evaluation of these results was based upon the relationship between essential and discretionary systems development information. A discussion of the interactive nature of these information classifications is provided in the subsequent section.

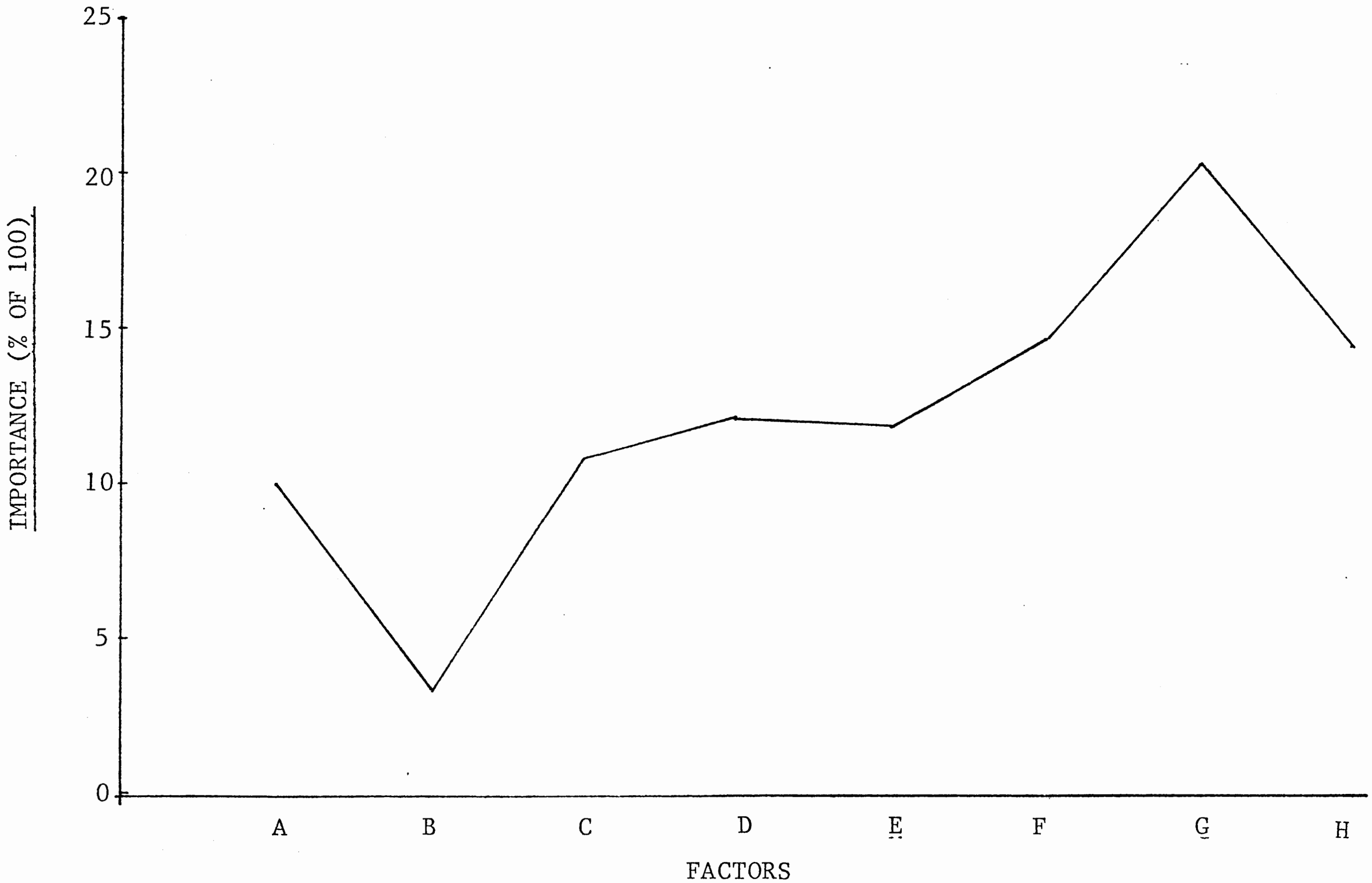

Figure 21. Relative Importance of Eight Factors for Firm 1.

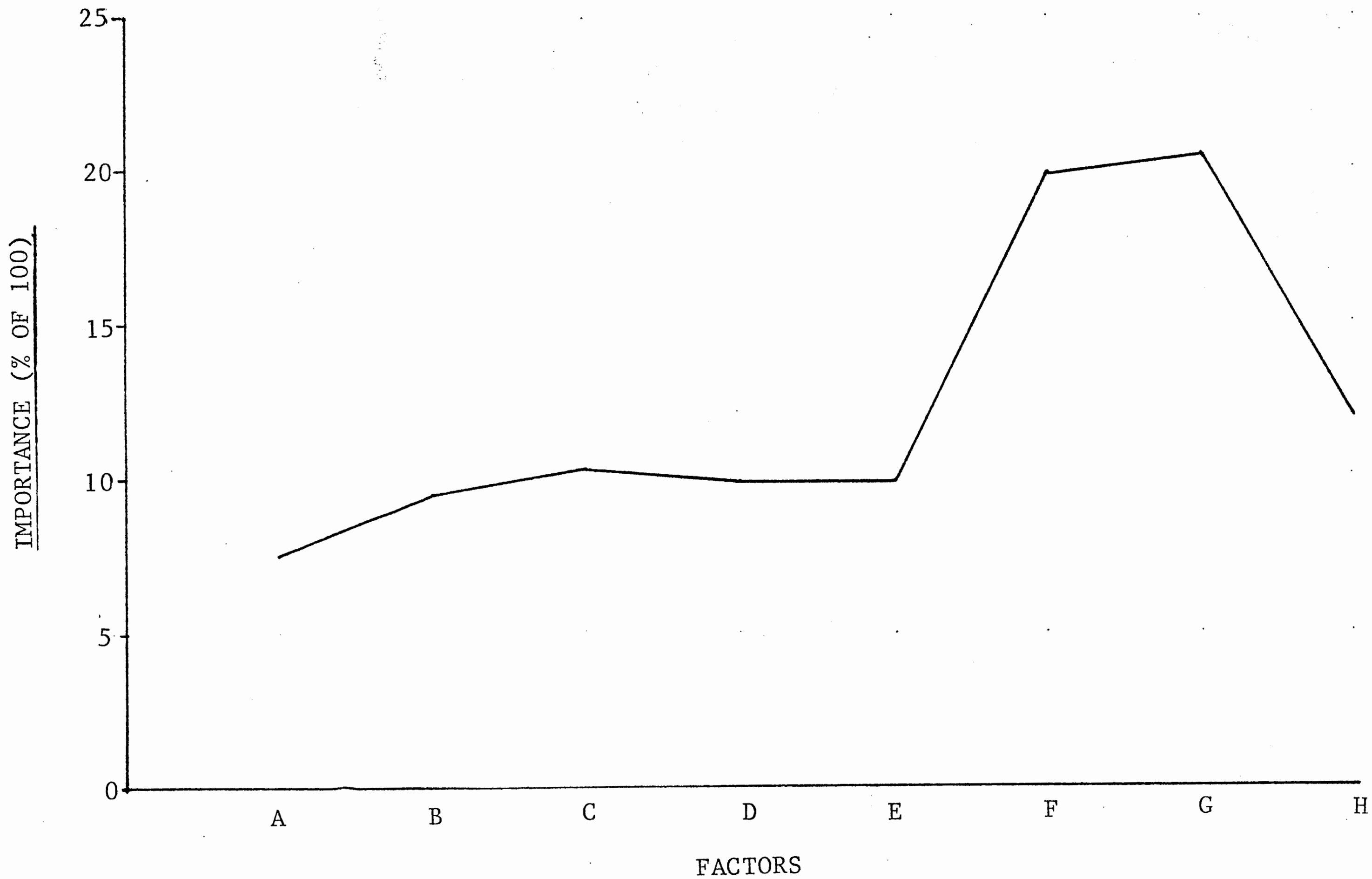

Figure 22. Relative Importance of Eight Factors for Firm 2.

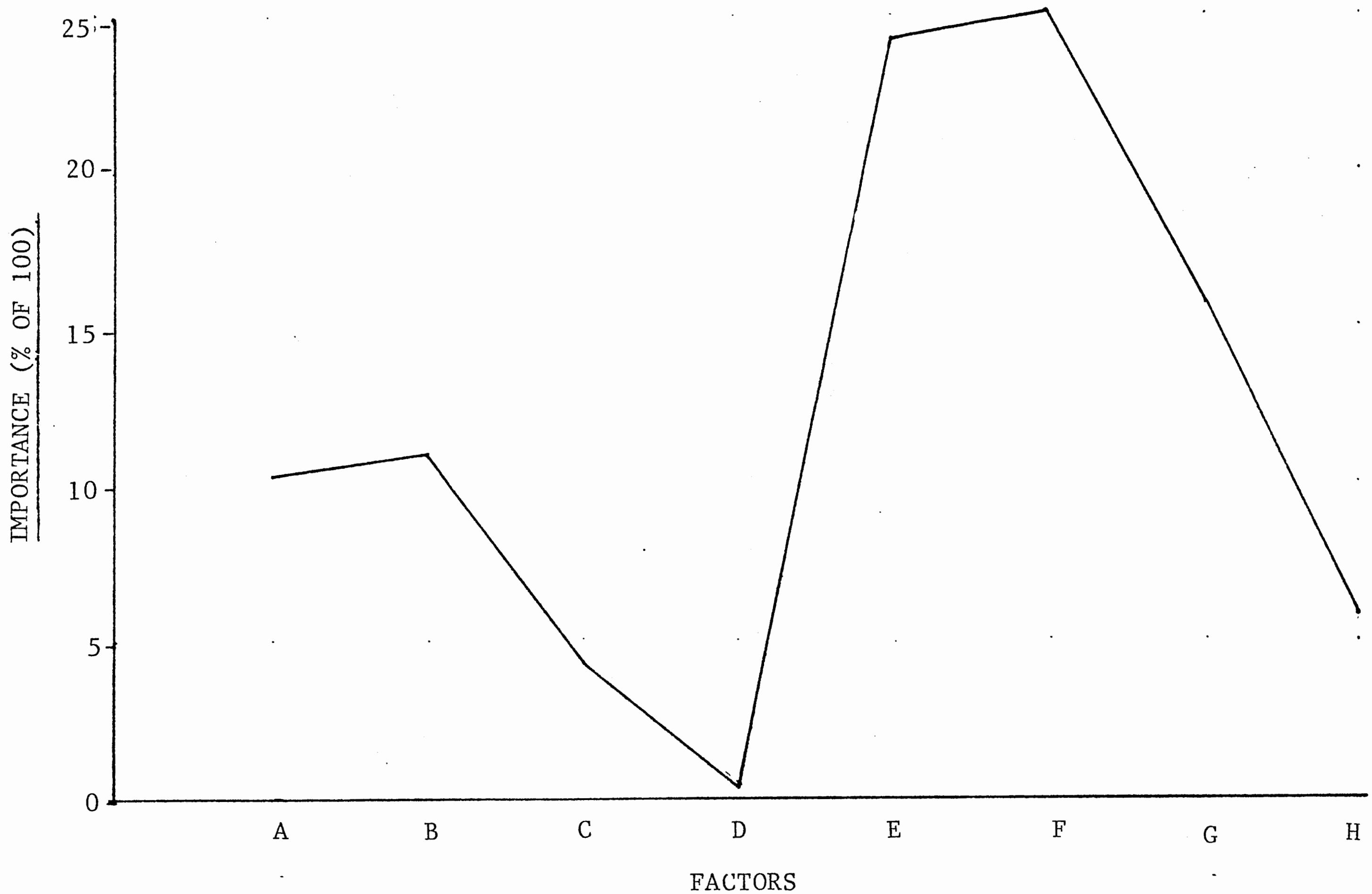

Figure 23. Relative Importance of Eight Factors for Firm 3.

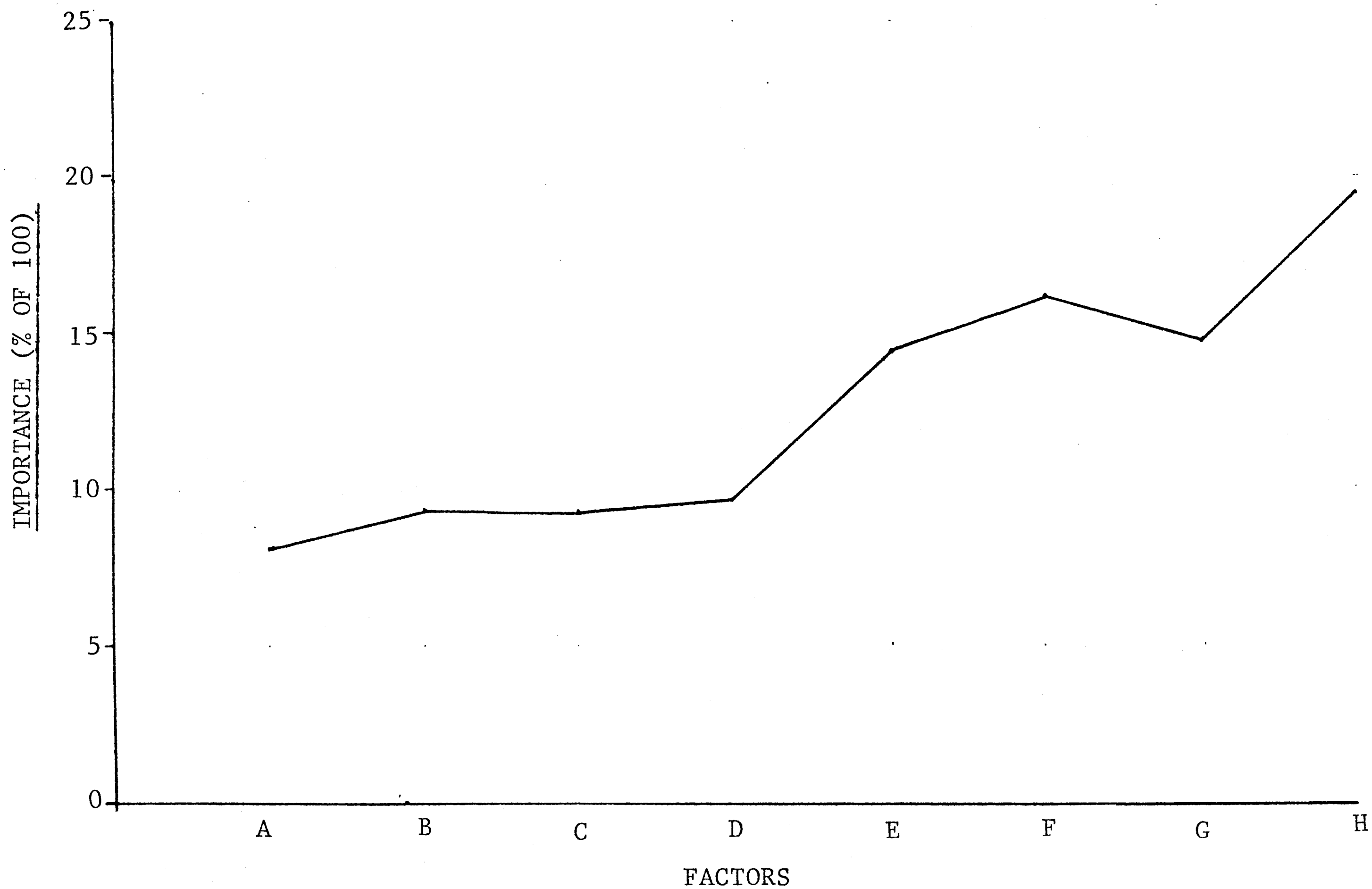

Figure 24. Relative Importance of Eight Factors for Firm 4.

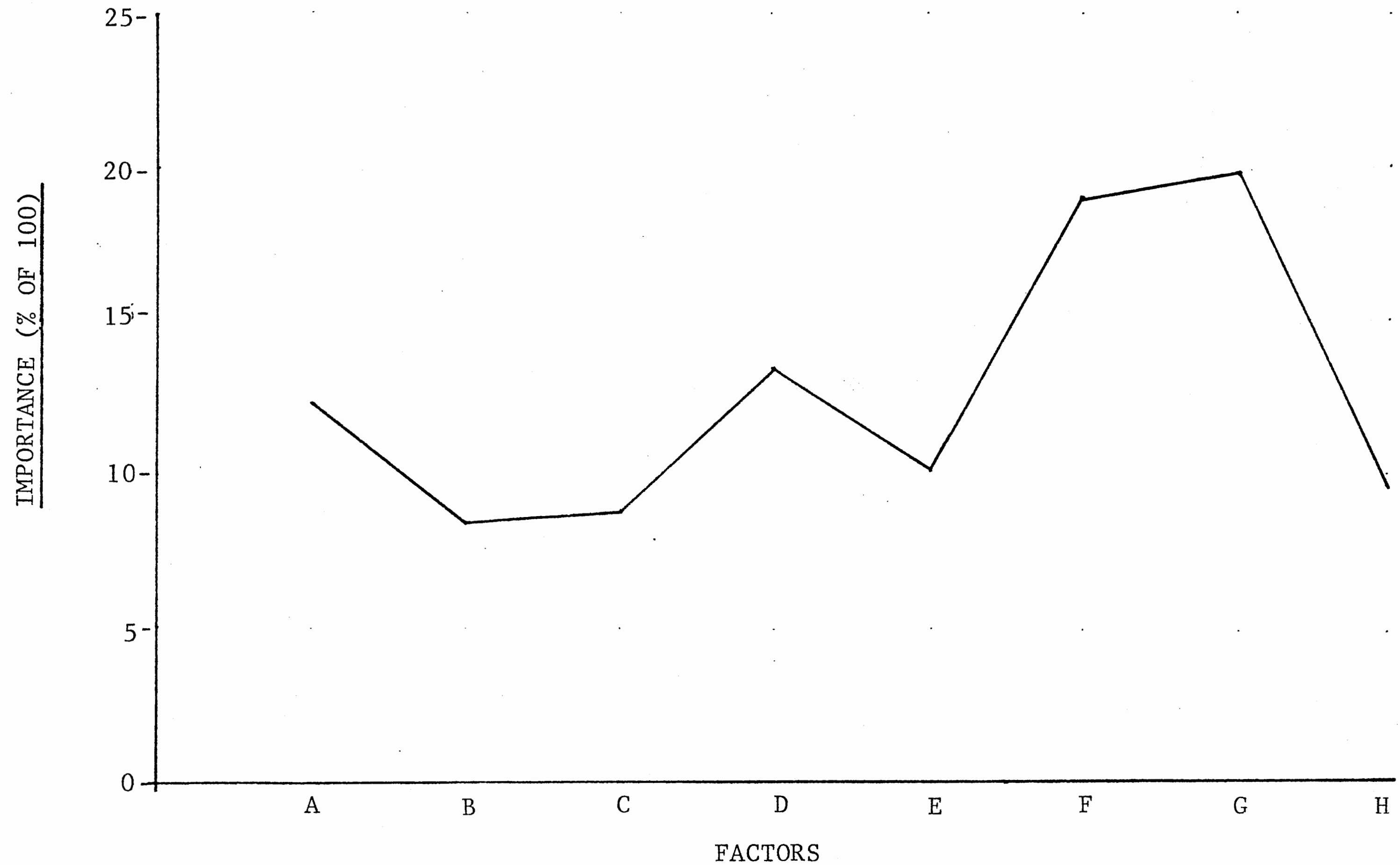

Figure 25. Relative Importance of Eight Factors for Firm 5.

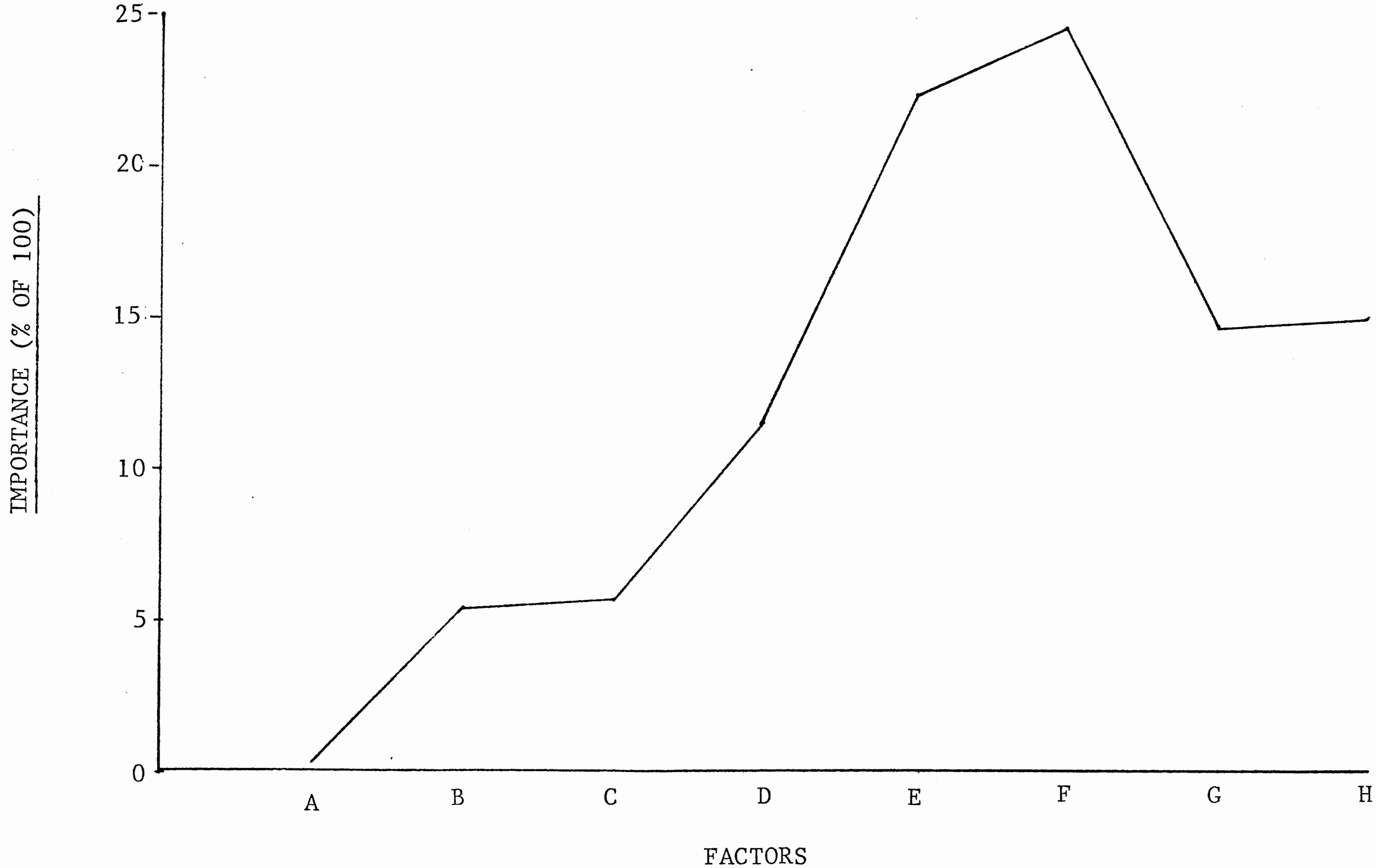

Figure 26. Relative Importance of Eight Factors for Firm 6.

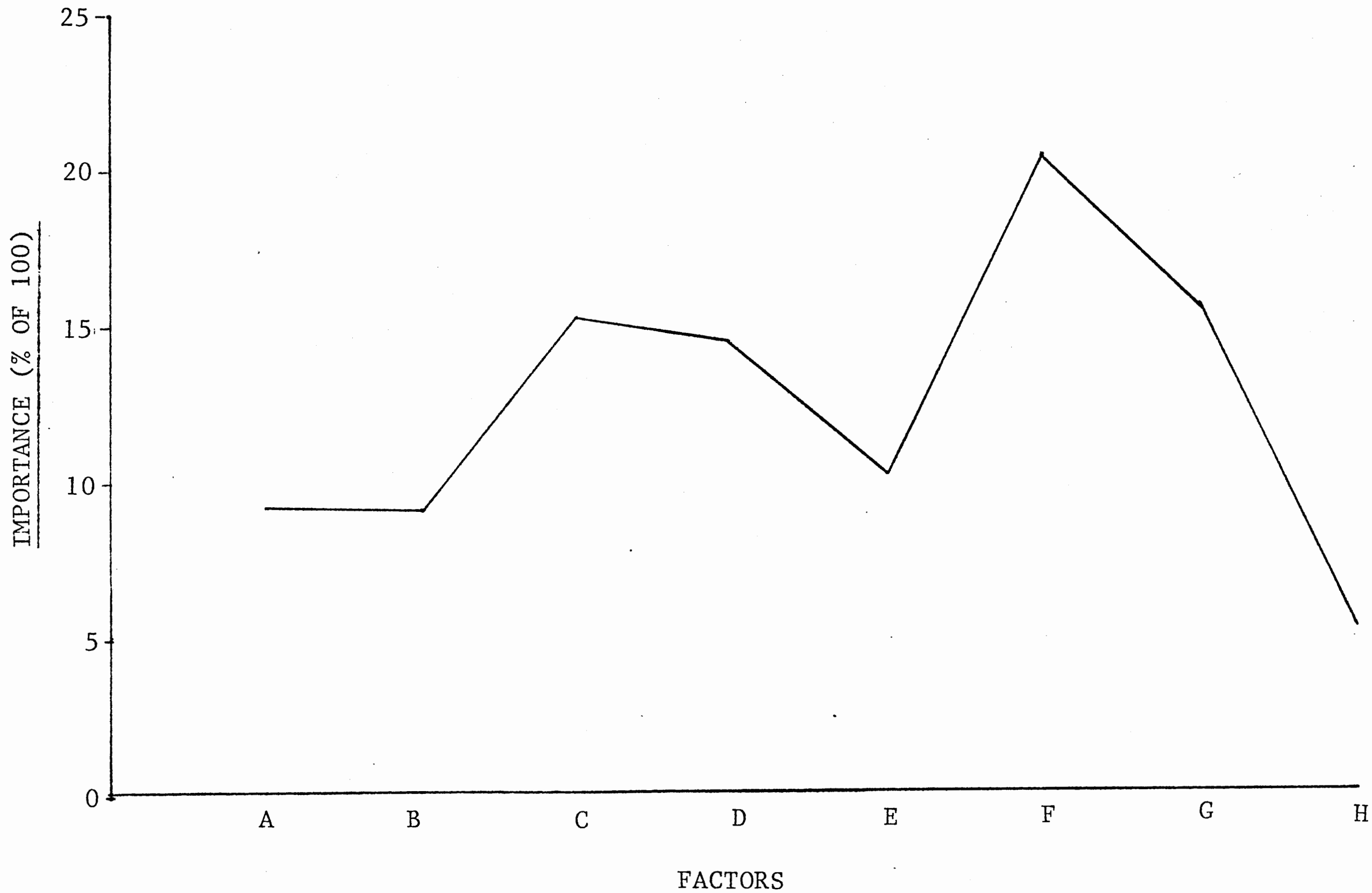

Figure 27. Relative Importance of Eight Factors for Firm 7.

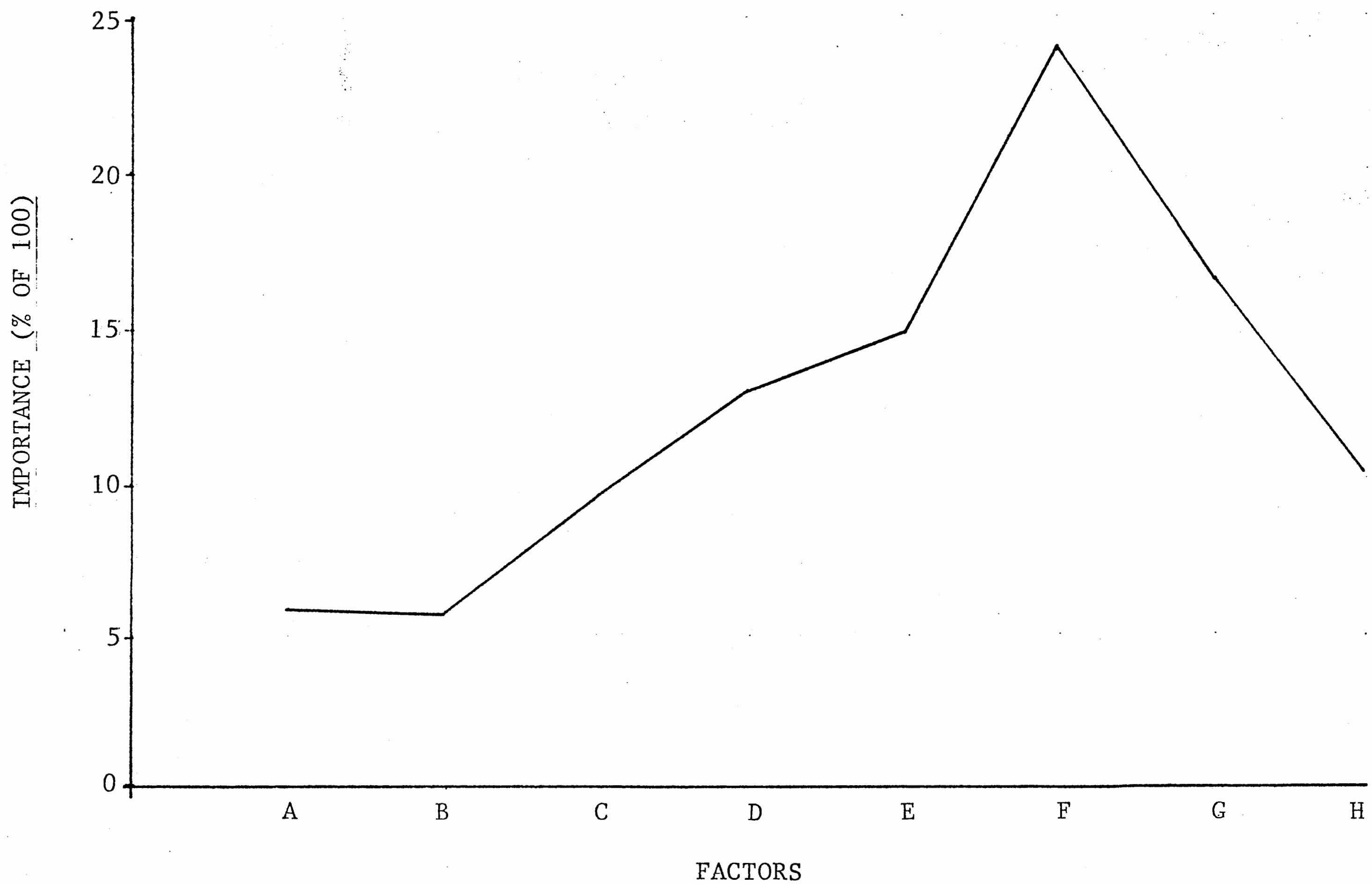

Figure 28. Relative Importance of Eight Factors for Firm 8.

Configurality Between Essential and Discretionary Information

Essential information has no perfect substitute. Therefore, essential information items are assumed independent and additive in providing evidence of application integrity. Discretionary information, although not a substitute for essential information, enhances essential information in a number of ways. In this regard certain types of discretionary evidence are viewed as surrogates for essential evidence. For example, in the absence of technical design procedures (essential information) the presence of program test procedures (discretionary information) may be regarded by system reviewers as a reasonable substitute, from which application control adequacy may be inferred. Results of program tests, however, only reflect the accuracy and completeness of processes actually tested. The accuracy of conversion processes and the extent to which applications solve the business problems for which they are intended, go untested. Therefore, the value of program test procedures alone is marginal. However, the existence of both classes of information provide a basis for evaluating program test procedures and thus for determining the extent to which further compliance tests are required. The value of discretionary information is increased by the existence of essential information.

These characteristics inspire a notion of configurality between essential and discretionary information. This relationship is depicted in Figure 29.

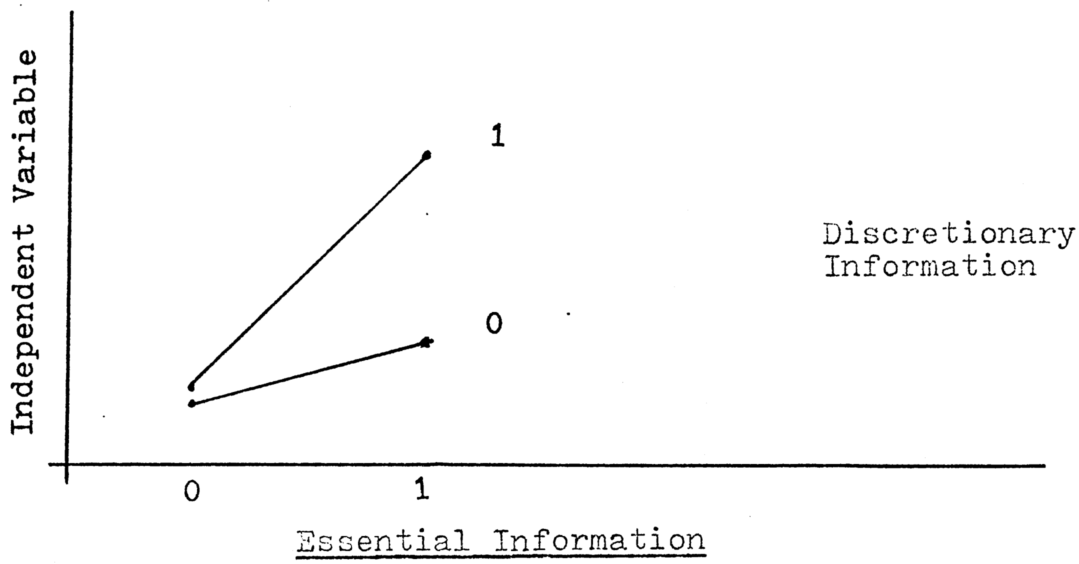

Figure 29. Interaction Relationship Between Essential and Discretionary Information.

Figure 29 depicts an increase in effect due to discretionary information, as the level of essential information is increased from 0 to 1. This cue-usage relationship is an intuitive consequence of the nature of systems development by-product information. Thus, it provides a criterion for evaluation of subject decision models. Judgement processes, which consider the relative importance of these information classes, are likely to result in more complete measures of application integrity; hence, they are conducive to the promotion of decisions in accordance with GAAS.

Interpretation of Observed Results

Relative importance indexes for Firm 2, Firm 4, Firm 5 and Firm 8 were superimposed upon a single graph in Figure 30. Although little commonality of behavior is apparent, two observations regarding appropriate cue-utilization are advanced. First, no significant two factor interactions of the form illustrated in Figure 29 were identified. Results indicate that, in terms of importance to the judgement process, sources of essential information (factors B and C) are perceived as subordinate to, or on a par with, sources of discretionary information (factors A, D, E and F). This implies that system reviewers tend to consider discretionary information independently rather than to weight it in a configural manner with essential information. Second, judge perceptions of relative factor importance suggest significant collective reliance upon surrogates for assurances of application integrity. This proposition is evidenced by the overwhelming influence of control factor F upon subject judgement.

These observations indicate that essential and discretionary evidence is not interpreted and integrated in a

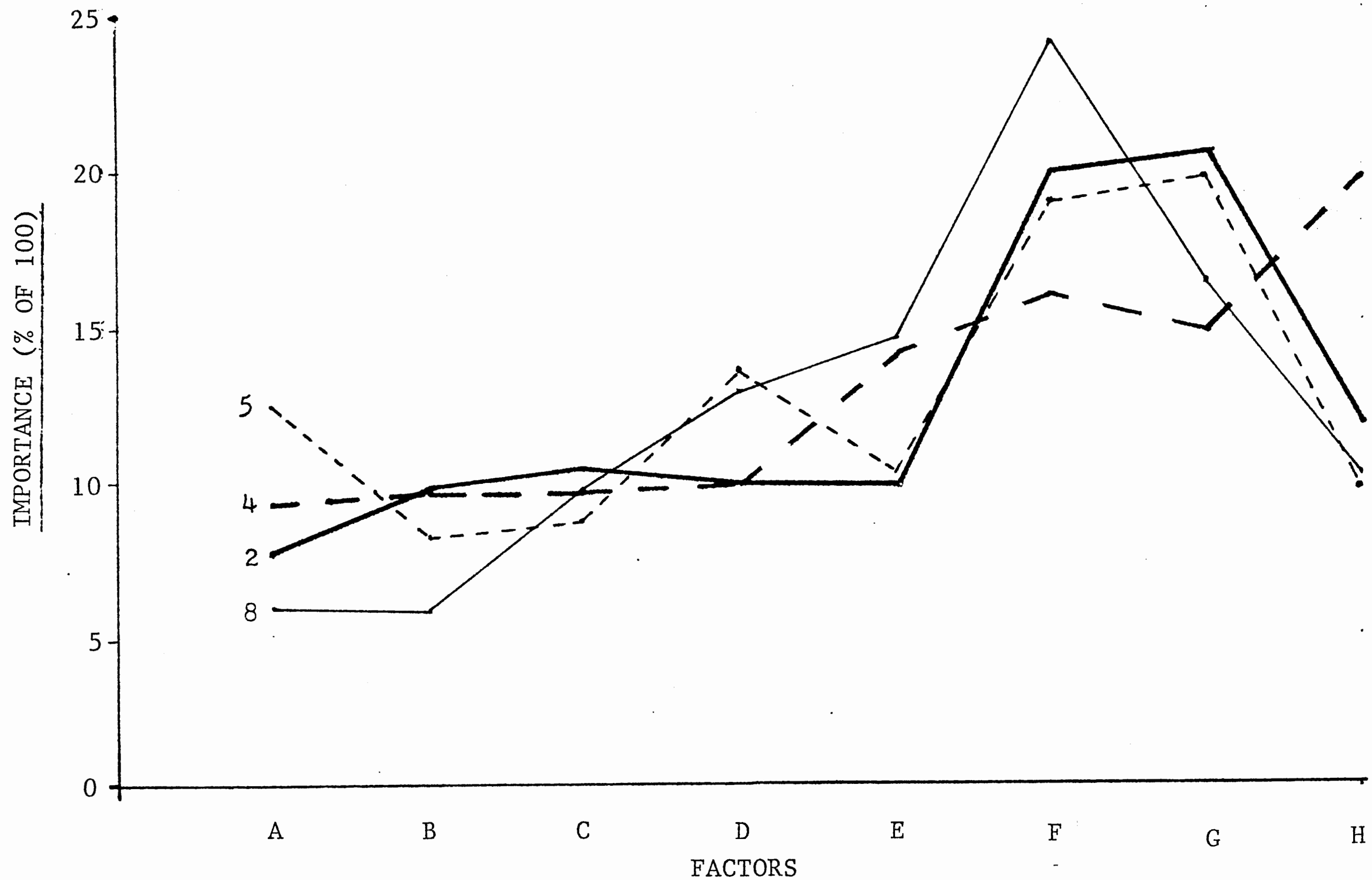

Figure 30. Relative Importance of Factors for Firms 2, 4, 5 and 8.

manner consistent with the established evaluation criterion. Therefore, by this criterion, none of these judgement processes are appropriate for the study and evaluation of internal control contemplated by generally accepted auditing standards.

Conclusions

Judges' integration of information provided by control factors A through F belongs to what may be labelled the surrogate paradigm. In this paradigm, judgement processes are described by models which emphasize sources of surrogate information. In contrast to this notion, the relative importance of systems maintenance activities (factors G and H) is typical of the evidence paradigm, where judgements are influenced most heavily by sources of essential information. These results indicate that judges appear to acknowledge the need to preserve application integrity once systems are placed into production. They acknowledge, to a lesser extent, the importance of SPL monitor procedures. In general, the pattern of cue-usage across all factors is characterized by the following scenario:

Subject perceptions of the relative importance of factors appears to have evolved out of ecological pragmatism. Historically, evidence of user specifications (factor B) and technical conversion (factor C) has been difficult to obtain and to interpret. Therefore, systems development activities which produce this evidence are de-emphasized in importance relative to activities which produce more easily interpretable, but incomplete, evidence.

In a previous section, user test and acceptance procedures (factor F) were characterized as the culmination of all design activities. Therefore, a focal point is provided where systems are viewed in their entirety. These procedures are conducted by the user departments and are de facto measures of user satisfaction with newly designed systems. By virtue of user acceptance, application control adequacy is implied. Hence, test and acceptance procedures are regarded by system reviewers as surrogates for assessing application control.

Although system reviewers rely upon surrogates to provide assurance of initial application control adequacy, they are cognizant of the need to preserve application integrity throughout the period. Consequently, considerable importance is placed upon sources of program maintenance information (factors G and H).

By relaxing the first evaluation criterion slightly, this scenario may be extended to Firm 1 and Firm 7. The cue weighting schemes of subjects in these firms closely corresponds to Firms 2, 4, 5, and 8.

Judges in Firm 3 and Firm 6, however, use information processing models which are characteristic of a purely surrogate paradigm. Their cue-usage patterns imply that they do not seek detailed evaluations of application controls. They seek, instead, reassurance of application integrity through other means (factors E and F). The objective of systems development reviews here is to examine control features which are regarded as good indicators of application integrity.

Summary

This chapter contained analysis of empirical findings relevant to two research questions developed in Chapter I. Research question number one dealt with identification of judgement processes of 32 subjects from eight national public accounting firms. Research question number two was concerned with the appropriateness of judgement processes.

To answer the first question ANOVA procedures were applied to 512 observations in a RBFF-2^8 design. The data was blocked by public accounting firm. Results indicated a significant difference between firms in their cue-usage regarding judgements about internal control adequacy. To identify the nature of these differences, ANOVA procedures were performed on data for individual firms and significant main effects of eight factors were examined for each.

Question number two was answered using a two-step technique. Models were first evaluated statistically for completeness. The second evaluation criterion was based upon the relative importance of significant factors.

Results of the analyses indicated that none of the firm decision models satisfied both evaluation criteria. It was suggested that this was due in part to the historical development of data processing and the problem of user abdication of design responsibility.

Decision models of firms fell into two broad paradigms. The first of these was characterized by strong dependency upon discretionary information for establishing application integrity. However, preservation of integrity was assured through reliance upon systems development control. The second paradigm was comprised of judgement processes which rely solely upon surrogate evidence.

CHAPTER VI

SUMMARY, LIMITATIONS, CONCLUSIONS AND POLICY IMPLICATIONS AND SUGGESTIONS FOR FUTURE RESEARCH

This study has provided empirical insight into the need for definitive EDP control guidelines. The purposes of this chapter are to summarize the study, discuss the limitations of the methodology, present policy recommendations based upon results of the research and discuss implications for future research.

Summary of Research

In their present form EDP audit guidelines leave unresolved two issues of controversy which may limit their usefulness as clarification and coordination devices. First, guidelines do not relate weaknesses in systems development control to application auditability. Second, they disclaim responsibility for establishing minimum systems development control standards. Allowing these issues to go unresolved does not serve the best interests of the profession. This is particularly apparent in light of recent legislative action. New reporting responsibilities mandated by The Foreign Corrupt Practices Act emphasize the need for criteria to assess control "adequacy" over systems development activities.

The principal audit objective to be satisfied by reviews of EDP accounting control is to determine, with reasonable assurance, that accounting applications perform the tasks intended and function in a consistent and accurate manner. In short, the objective is to determine application integrity. This task is often difficult to achieve and requires interpretation and integration of unconventional forms of information. Application auditability is affected particularly by the quality of information produced as by-products of systems development activities. Inadequate control over these activities has pervasive effects upon application integrity and auditability. However, extant guidelines do not provide standards by which development control "adequacy" may be assessed.

Failure on the part of authoritative guidelines to provide a definitive treatise of these issues raises concern regarding the extent of inter-judge agreement as to appropriate criteria for assessing development control. Clearly, an absence of concensus among experts renders the notion of "adequate" control subject to broad interpretation.

The purpose of this study was to identify empirically and evaluate professional theories-in-use for interpreting and integrating essential systems development information. Thus, it provides empirical insight into the need for definitive, authoritative guidance in assessing EDP control adequacy.

The methodology of the study was designed to identify theories-in-use among a group of expert judges selected from the public accounting profession. Prior to conducting the principal study, a pilot study was performed. The purpose of the pilot study was twofold: (1) to define the domain of relevant variables for the systems development process; and (2) to obtain measures of validity and reliability for constructed policy capturing instruments. Once validated, the instruments were administered to 32 systems reviewers from eight national public accounting firms. Instruments were comprised of 64 cases, each of which included the following eight cues:

New Systems Design

(A) Systems Authorization Procedures

(B) User Specification Procedures

(C) Technical Design Procedures

(D) Internal Audit Participation in System Design

(E) Program Test Procedures

(F) User Test and Acceptance Procedures.

System Change Procedures

(G) Authorization, Test and Documentation Procedures

(H) Source Program Library Monitor Procedures.

Each hypothetical case was a description of systems development activities within an organization and depicted the cue set (A through H) in unique combinations of strong and weak treatment levels. Judges were asked to evaluate each case on the basis of control "adequacy" using the following criterion:

> The likelihood that the systems development process described in the case will produce reliable "essential" information.

The principal analytical tool used in the study was ANOVA. The pattern of the data conformed to a 2^8 randomized block fractional factorial (RBFF-2^8) experiment. A one-fourth fractional design was used for data reduction purposes. The total number of possible cases in this study was 2^8 or 256; the actual experiment consisted of only 64 of these combinations. A consequence of this technique was that main effects and low order interactions were confounded with higher order interactions. The design used in this study provided estimates of all main effects and all two-factor interaction effects. An a priori assumption was made that high order interactions were insignificant in the judgement process models.

Two research questions were addressed in this study:

(1) What are the cognitive models which describe the process by which system reviewers interpret and integrate hypothetical systems development

control information into judgements of overall control adequacy.

(2) To what extent is the identified model of professional judgement conducive to the promotion of decisions which are in accordance with generally accepted auditing standards.

Analysis of variance (ANOVA) procedures were used to identify significant (at $p < .05$ level) effects due to specific factors and two-factor interactions. These significant effects constituted the model of professional policy. Thus, research question number one was answered with an identification of judgement processes by analyzing observed responses to changes in factor values.

Research question number two concerned the appropriateness of these judgement processes. To answer this question a two step technique was employed.

(1) The eight firm models were screened on the basis of completeness (i.e., those models which include all sources of essential information among significant factors at $p < .05$).

(2) Complete models were evaluated on the basis of the relative importance of significant factors.

Four of the eight firm models were adjudged incomplete. Each of these had observed significance levels greater than .05 for at least one essential factor. However, the question of whether system reviewers appropriately interpret and integrate stimuli in the formulation of judgements is only partially answered by examination of observed significance levels of critical factors.

The philosophical question of appropriate cue-usage involves identification of model structure, i.e., the manner in which sources of information are differentially weighted. This was achieved by computing an index of relative importance for each significant factor. Results of this procedure indicated little commonality in firm cue-usage processes. However, two conclusions regarding the appropriateness of judgement processes were advanced.

(1) Judgement processes are essentially linear. Discretionary information is considered independently by system reviewers, rather than being weighted in a configural manner with essential information.

(2) Judge perceptions of relative factor importance suggests significant collective reliance upon surrogates for assurances of application integrity.

These observations suggest that essential systems development information is not interpreted and integrated in a manner consistent with the established evaluation criterion. Therefore, none of these judgement processes are appropriate for the study and evaluation of internal control contemplated by GAAS.

Two paradigms were distinguished which describe the judgement processes of the eight firms. Six of them

(Firms 1, 2, 4, 5, 7 and 8) employ decision processes which describe a compromise between the surrogate paradigm and the evidence paradigm. For establishing initial application integrity, subjects in these firms are influenced most heavily by what they perceive as surrogate information. However, their judgements are effected significantly by "essential" system maintenance information. Subjects in Firm 3 and Firm 6 use judgement models which are characteristic of the pure surrogate paradigm. Their judgements are marginally effected by essential information, but they draw heavily upon other sources for assessments of application integrity.

Limitations of the Study

All research methodologies involve trade-offs between the costs and benefits of alternative data collection techniques. This study was not an exception. It involved a sample which was limited in size and geographic dispersion. Conclusions were derived from the responses of 32 judges regarding the "adequacy" of control in 64 hypothetical cases. These subjects were not randomly selected; they were chosen on the basis of the researcher's geographic preference. The relatively small population of EDP systems reviewers is dispersed in clusters over a large geographic area. Therefore, random selection without regard for geographic preference threatened to increase significantly non-trivial data collection costs and preclude personal interviews as the primary mode of data collection.

Alternative methodologies might have been adopted in order to avoid these problems of sample size and non-random selection. The economic alternatives were "mail survey" and "telephone survey" methods of data collection. Such methodologies would suffer from additional limitations not associated with the methodology employed in this study. Furthermore, there is no compelling reason to believe that professional practices in the geographic locations from which the sample was selected uniquely affected subject responses.

A second limitation of this research was the need for simplification in construction of hypothetical cases. Each case was comprised of eight factors which took on binary values of zero or one. Thus, control was depicted to either exist or to be absent in the cases. This is clearly a simplified representation of the situation most auditors face in reality. However, it was necessary to limit treatment levels in this manner for two reasons. First, the number of possible combinations of cases grows exponentially with the number of levels. For example, if three levels were used for each factor, the design would have involved 3^8 or 6,561 combinations. Estimations of main effects and two-factor interactions in a design of this size would have placed a serious data collection burden on the study.

The second reason for simplifying the experiment was to present judges with unambiguous, clear-cut decision situations. As Goodman (1965) points out, this is an important attribute for early research designs to possess.

> . . . science has to isolate a few simple aspects of the world. . . . This, admittedly, is over-simplification. But conscious and cautious over-simplification, far from being an intellectual sin, is a prerequisite for investigation. We can hardly study at once all the ways in which everything is related to everything else (p. xii).

A third limitation to this study is one which affects all policy capturing methodologies; there was a complete absence of a penalty/reward structure. Decisions regarding control adequacy were, in this sense, made in a vacuum. Judges were not subjected to the conflicting pressures from exposure to liability and client expectation. In this regard, the integrity of these findings is dependent upon the degree of professionalism possessed by the participants. However, the likelihood of irresponsible or unconscientious responses was thought to be minimized by selecting experienced and enthusiastic practitioners as subjects for this experiment.

Conclusions and Policy Implications

This research has identified the nature of the contribution of each controllable activity within the systems development process. It has enriched the body of literature concerned with the development of EDP control concepts by integrating essentials of general control, application control and generally accepted auditing standards. It has also provided empirical insight into the interpretative and integrative processes employed by selected subjects in their study and appraisal of systems development control.

A principal objective of this study was to determine the relative importance of factors affecting judge perceptions of control adequacy. It sought to identify sources of confusion and possible misconception fostered by current authoritative guidelines, and thus provide insight for the development of future guidelines. If it may be assumed, in light of previously stated limitations, that sample subjects were representative of system reviewers in general and that hypothetical cases were fair representations of real world phenomena, then this objective was achieved.

The results of this study appear to suggest a need for authoritative guidelines. Research findings support the notion that current guidelines do not effectively delineate professional responsibility for study and appraisal of systems development controls. On the basis of these findings, a large percentage of system reviewers appear to formulate decisions regarding the adequacy of application control from incomplete information sets.

The overall policy capturing model identified in this study may be regarded as an operational description of theories-in-use for interpreting and integrating systems development information. Therefore, as a matter of professional policy, this model provides the nucleus about which a definitive treatise of the relationship between systems development control and application auditability may be concentrated.

A second implication for the development of accounting policy lies in the identification of EDP application audit objectives. This study's analysis of the essential information needs to fulfill those objectives provides criteria for establishing minimum control standards. It is important to note that research to advance EDP control concepts is in an embryonic state. Hitherto, empirical work has not been consistent with normative notions of internal control. The development of control standards based upon normative concepts provides criteria for evaluating theories-in-use for assessing control adequacy. Areas of apparent confusion and misconception identified in this study (particularly the attitudes and beliefs expressed in the collective behavior regarding user specification procedures, technical design procedures and the influence of surrogates on audit judgements) are focal points for future insightful investigation. Such insight will, hopefully, advance the development of guidelines and standards along a vein which is supportive of normative objectives.

Suggestions for Future Research

Future research in the resolution of the EDP control problems studied and reported herein should entail a replication of the present study. Although there appears to be no compelling reason to suspect that the models of judgement processes are seriously biased, some risk of error always exists. Replication can do a great deal to establish the generalizability of the study results. For this reason the findings of this research should be regarded as tentative.

A replication of this study should be undertaken on such a scale as to provide objective evidence of the judgement formulation processes of a massive sample of the practicing profession. This sort of input would best be conducted by an authoritative body (such as the American Institute of CPAs, Computer Services Committee) with resources sufficient to access large numbers of subjects.

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APPENDIX A

DEFINITIONS OF SYSTEMS
DEVELOPMENT ACTIVITIES

(A) System Authorization

Development of new systems is authorized in accordance with management criteria. An example of strong control over this function involves procedures which insure that new-system requests are submitted by authorized users to a development steering committee for preliminary review and evaluation. Formal approval by the sterring committee is given for all systems prior to commencement of subsequent system development activities.

(B) User Specification Procedures

Strong control here requires users to describe in a nontechnical but detailed manner all aspects of the required system in terms of its inputs, processes, outputs and special control considerations. These specifications, although nontechnical, are essentially complete in their description of the system to be designed.

(C) Technical Design Procedures

Standards exist which guide the activity of converting nontechnical user specifications into detailed and technical program instructions. Strong control over this function involves standards for designing and coding programs in order that fully documented applications are produced. The role of documentation here is to provide an audit trail which establishes a link between user specifications, technical specifications, and coded application instructions.

(D) Internal Audit Participation

Strong control requires the internal auditor to become involved early in the development process. His concern is that controls are designed into the system. He therefore makes recommendations as to control requirements, assesses security standards, reviews testing procedures and uses this knowledge of the application design to develop post-implemenetation audit procedures. (It is assumed that the auditor has a high degree of personal integrity, honesty, competence and reports to a sufficiently high level to maintain independence.)

(E) Program Test Procedures

Procedures exist to insure that all programs are thoroughly tested before implementation. Strong control over this process requires that test transactions, test master files and test results are documented and maintained as part of the permanent system documentation file.

(F) User Test and Acceptance Procedures

Formal procedures for testing and accepting the completed system are carried out before it is placed into production. Strong control over the testing process is achieved by the assignment of a test team comprised of user personnel, EDP personnel and internal audit personnel which subjects the system to rigorous testing. Test results are then analyzed and reconciled and all test data are retained as part of the documentation file. Once the test team has satisfied itself that the system meets minimum requirements, it is formally accepted by the user department.

(G) Authorization, Test and Documentation Procedures

Procedures exist which insure that changes to existing financial systems are made in accordance with management criteria. Strong control over this process requires formal authorization, documentation, testing and acceptance procedures similar to those discussed for new systems development.

(H) Source Program Library Monitor

The source program library monitor provides a record of all programs used and all changes made to them. Under this electronic detection system, each application program is assigned a version number which is incremented with each program change, thus providing a measure of compliance with systems change procedures.

APPENDIX B

EXAMPLES OF HYPOTHETICAL CASES

CASE 6-4

No formal procedures for system authorization exist.

Users are required to describe in a nontechnical but detailed manner all aspects of the requested system in terms of its inputs, processes, outputs and special control considerations.

Standards exist for designing and coding programs. The technical design process produces fully documented applications and provides an audit trail which links technical specifications and program code to user specifications to the extent that such user specifications exist.

The internal auditor becomes involved early in the development process. He makes recommendations as to control requirements, assesses security standards, reviews testing procedures and uses this knowledge of the system to develop audit procedures.

Programs are thoroughly tested before implementation. All test data such as transactions, master files and test results are documented and retained as part of the permanent documentation file. The auditor is technically competent and reports to the president of the organization.

Rigorous testing of completed systems is carried out by a test team comprised of user personnel, EDP personnel and internal audit personnel. Test results are analyzed, reconciled and retained as part of the permanent documentation file. Minimum standards of performance by the system must be achieved before it is formally accepted by the user department.

All changes to existing systems (maintenance) are formally authorized, documented, tested and accepted by the user prior to the implementation of the change.

A source program library monitor is used to record all changes made to applications. This is accomplished by incrementing the version number of each reconcile which results from a program change.

Adequacy Rating________________

CASE 6-3

New system requests are submitted by authorized users to a systems development steering committee for preliminary review and evaluation. Formal approval by the steering committee is given for all new systems prior to commencement of subsequent development activities.

Users are required to describe in a nontechnical but detailed manner all aspects of the requested system in terms of its inputs, processes, outputs and special control considerations.

Standards exist for designing and coding programs. The technical design process produces fully documented applications and provides an audit trail which links technical specifications and program code to user specifications to the extent that such user specifications exist.

The internal auditor does not participate in the development process.

No formal procedures exist which insure the testing of programs before their implementation.

No formal user test and acceptance procedures are in effect.

All changes to existing systems (maintenance) are formally authorized, documented, tested and accepted by the user prior to the implementation of the change.

No source program library maintenance system is in use.

Adequacy Rating_______________

APPENDIX C

INSTRUMENT INSTRUCTIONS

This research project is designed to gain insight into factors which affect your evaluation of the adequacy of EDP System Development Control. You are asked to review and evaluate sixteen independent, hypothetical situations (cases) in which various levels of control over systems development processes are depicted. In order to establish a common frame of reference among participants in this study, each case is described in terms of the eight systems development activities (A through H) listed below:

New Systems Development

A System Authorization Procedures
B User Specification Procedures
C Technical Design Procedures
D Internal Audit Participation in systems design
E Program Test Procedures
F User Test and Acceptance Procedures

Systems Change Procedures

G Authorization, Test and Documentation Procedures
H Source Program Library Monitor Procedures.

In reality there are multiple levels of control possible for each of these activities. However, for the purpose of this study only two levels of control (STRONG and WEAK) are considered.

You are asked to evaluate these cases independently of each other. Indicate your evaluation of the adequacy of the system of control described in each case on an interval scale of zero to ten (where ten is the most adequate system) using the following criterion:

The likelihood that the systems development process described in the case will produce reliable essential information.

APPENDIX D

TABLES V THROUGH XII

SUMMARIES OF ANOVA

RESULTS

TABLE V

SUMMARY OF FIRM 1 ANOVA RESULTS

Source	df	Sum of Squares	Mean Square	R-Square
Model	36	328.2965	9.1193	.8216
Error	27	71.2459	2.6387	
Total	63	399.5425		
Source	df	ANOVA SS	F Value	PR F
A	1	20.5889	7.80	.0095
B	1	2.2876	.87	.3601
C	1	26.5225	10.05	.0038
D	1	32.6326	12.37	.0016
E	1	31.2201	11.83	.0019
F	1	44.8900	17.01	.0003
G	1	89.5389	33.93	.0001
H	1	42.4126	16.07	.0004

TABLE VI

SUMMARY OF FIRM 2 ANOVA RESULTS

Source	df	Sum of Squares	Mean Square	R-Square
Model	36	331.8750	9.2187	.7646
Error	27	102.1250	3.7824	
Total	63	434.0000		
Source	df	ANOVA SS	F Value	PR F
A	1	12.2500	3.24	.0831
B	1	18.0625	4.78	.0377
C	1	22.5625	5.97	.0214
D	1	27.5625	7.29	.0118
E	1	20.2500	5.35	.0285
F	1	81.0000	21.41	.0001
G	1	90.2500	23.86	.0001
H	1	30.2500	8.00	.0087

TABLE VII

SUMMARY OF FIRM 3 ANOVA RESULTS

Source	df	Sum of Squares	Mean Square	R-Square
Model	36	189.7812	5.2717	.6985
Error	27	81.8987	3.0332	
Total	63	271.6800		
Source	df	ANOVA SS	F Value	PR F
A	1	8.4100	2.77	.1075
B	1	10.0806	3.32	.0794
C	1	1.5625	.52	.4791
D	1	.2500	.08	.7762
E	1	43.8906	14.47	.0007
F	1	49.0000	16.15	.0004
G	1	20.7025	6.83	.0145
H	1	3.5156	1.16	.2912

TABLE VIII

SUMMARY OF FIRM 4 ANOVA RESULTS

Source	df	Sum of Squares	Mean Square	R-Square
Model	36	258.5937	7.1831	.7938
Error	27	67.1406	2.4866	
Total	63	325.7343		
Source	df	ANOVA SS	F Value	PR F
A	1	10.5625	4.25	.0491
B	1	13.1406	5.28	.0295
C	1	12.2500	4.93	.0350
D	1	15.0156	6.04	.0207
E	1	31.6406	12.72	.0014
F	1	43.8906	17.65	.0003
G	1	34.5156	13.88	.0009
H	1	60.0625	24.15	.0001

TABLE IX

SUMMARY OF FIRM 5 ANOVA RESULTS

Source	df	Sum of Squares	Mean Square	R-Square
Model	36	224.8281	6.2452	.8487
Error	27	40.0742	1.4842	
Total	63	264.9023		
Source	df	ANOVA SS	F Value	PR F
A	1	21.9726	14.8	.0007
B	1	10.1601	6.85	.0144
C	1	10.9726	7.39	.0113
D	1	24.3789	16.43	.0004
E	1	15.5039	10.45	.0032
F	1	49.8789	33.61	.0001
G	1	55.3164	37.27	.0001
H	1	13.5976	9.16	.0054

TABLE X

SUMMARY OF FIRM 6 ANOVA RESULTS

Source	df	Sum of Squares	Mean Square	R-Square
Model	36	190.0312	5.2786	.3745
Error	27	317.4062	11.755	
Total	63	507.4375		
Source	**df**	**ANOVA SS**	**F Value**	**PR F**
A	1	.0156	.00	.9712
B	1	2.2500	.19	.6652
C	1	2.6406	.22	.6393
D	1	9.0000	.77	.3893
E	1	33.0625	2.81	.1051
F	1	39.0625	3.32	.0794
G	1	14.0625	1.20	.2837
H	1	15.0156	1.28	.2683

TABLE XI

SUMMARY OF FIRM 7 ANOVA RESULTS

Source	df	Sum of Squares	Mean Squares	R-Squares
Model	36	275.1406	7.6427	.8637
Error	27	43.4179	1.6080	
Total	63	318.5585		
Source	df	ANOVA SS	F Value	PR F
A	1	13.5976	8.46	.0072
B	1	12.6914	7.89	.0091
C	1	41.2539	25.77	.0001
D	1	35.2539	21.92	.0001
E	1	19.6914	12.25	.0016
F	1	75.4726	46.93	.0001
G	1	44.7226	27.81	.0001
H	1	5.9414	3.69	0.652

TABLE XII

SUMMARY OF FIRM 8 ANOVA RESULTS

Source	df	Sum of Squares	Mean Square	R-Square
Model	36	237.4570	6.5960	.8685
Error	27	35.9248	1.3305	
Total	63	273.3818		
Source	df	ANOVA SS	F Value	PR F
A	1	6.0947	4.58	.0415
B	1	5.4931	4.13	.0521
C	1	12.4697	9.37	.0049
D	1	22.8603	17.18	.0003
E	1	31.2900	23.52	.0001
F	1	80.4384	60.46	.0001
G	1	41.0400	30.84	.0001
H	1	15.2587	11.47	.0022

APPENDIX E

TABLES XIII THROUGH XX

FACTOR MEANS BY FIRM

TABLE XIII

FIRM 1 FACTOR MEANS

Factor	Number of Treatments	Level 0	Level 1	Change due to Factor
A	32	4.4765	5.6109	1.1344
B	32	4.8546	5.2328	.3782
C	32	4.4000	5.6875	1.2875
D	32	4.3296	5.7578	1.4282
E	32	4.3453	5.7421	1.3968
F	32	4.2062	5.8812	1.6750
G	32	3.8609	6.2265	2.3656
H	32	4.2296	5.8578	1.6279

TABLE XIV

FIRM 2 FACTOR MEANS

Factor	Number of Treatments	Level 0	Level 1	Change due to Factor
A	32	4.3125	5.1875	.8750
B	32	4.2187	5.2812	1.0625
C	32	4.1562	5.3437	1.1875
D	32	4.0937	5.4062	1.3125
E	32	4.1875	5.3125	1.1250
F	32	3.6250	5.8750	2.2500
G	32	3.5625	5.9375	2.3750
H	32	4.0625	5.4375	1.3750

TABLE XV

FIRM 3 FACTOR MEANS

Factor	Number of Treatments	Level 0	Level 1	Change due to Factor
A	32	4.0375	4.7625	.7250
B	32	4.0031	4.7968	.7937
C	32	4.2437	4.5562	.3125
D	32	4.3375	4.4625	.1250
E	32	3.5718	5.2281	1.6563
F	32	3.5250	5.2750	1.7500
G	32	3.8312	4.9687	1.1375
H	32	4.1656	4.6343	.4687

TABLE XIV

FIRM 4 FACTOR MEANS

Factor	Number of Treatments	Level 0	Level 1	Change due to Factor
A	32	4.7031	5.5156	.8125
B	32	4.6562	5.5625	.9063
C	32	4.6718	5.5468	.8962
D	32	4.6250	5.5937	.9687
E	32	4.4062	5.8125	1.4063
F	32	4.2812	5.9375	1.6563
G	32	4.3750	5.8437	1.4687
H	32	4.1406	6.0781	1.9375

TABLE XVII

FIRM 5 FACTOR MEANS

Factor	Number of Treatments	Level 0	Level 1	Change due to Factor
A	32	4.1250	5.2968	1.1718
B	32	4.3125	5.1093	.7968
C	32	4.2968	5.1250	.8282
D	32	4.0937	5.3281	1.2344
E	32	4.2187	5.2031	.9844
F	32	3.8281	5.5937	1.7656
G	32	3.7812	5.6406	1.8594
H	32	4.2500	5.1718	.9218

TABLE XVIII

FIRM 6 FACTOR MEANS

Factor	Number of Treatments	Level 0	Level 1	Change due to Factor
A	32	4.0468	4.0156	-.0312
B	32	4.2187	3.8437	-.3750
C	32	3.8281	4.2343	.4062
D	32	3.6562	4.4062	.7500
E	32	3.3125	4.7500	1.4375
F	32	3.2500	4.8125	1.5625
G	32	3.5625	4.5000	.9375
H	32	3.5468	4.5156	.9688

TABLE XIX

FIRM 7 FACTOR MEANS

Factor	Number of Treatments	Level 0	Level 1	Change due to Factor
A	32	4.0937	5.0156	.9219
B	32	4.1093	5.0000	.8907
C	32	3.7500	5.3593	1.6093
D	32	3.8125	5.2968	1.4843
E	32	4.0000	5.1093	1.1093
F	32	3.4687	5.6406	2.1719
G	32	3.7187	5.3906	1.6719
H	32	4.2500	4.8593	.6093

TABLE XX

FIRM 8 FACTOR MEANS

Factor	Number of Treatments	Level 0	Level 1	Change due to Factor
A	32	4.7737	5.3906	.6169
B	32	4.7890	5.3750	.5860
C	32	4.6406	5.5234	.8828
D	32	4.4843	5.6796	1.1953
E	32	4.3828	5.7812	1.3984
F	32	3.9609	6.2031	2.2422
G	32	4.2812	5.8828	1.6016
H	32	4.5937	5.5703	.9766

APPENDIX F

TABLES XXI THROUGH XXVIII

RELATIVE IMPORTANCE OF FACTORS

TABLE XXI

RELATIVE IMPORTANCE OF FACTORS FOR FIRM 1

Factor	Change due to Factor	Index of Importance
A	1.1344	.1000
B	.3782	.0334
C	1.2875	.1139
D	1.4282	.1264
E	1.3968	.1236
F	1.6750	.1483
G	2.3656	.2094
H	1.6279	.1441
Total change due to factors	11.2936	

TABLE XXII

RELATIVE IMPORTANCE OF FACTORS FOR FIRM 2

Factor	Change due to Factor	Index of Importance
A	.8750	.0768
B	1.0625	.0933
C	1.1875	.1043
D	1.1312	.0993
E	1.1250	.0988
F	2.2500	.1976
G	2.3750	.2086
H	1.3750	.1208
Total change due to factors	11.3812	

TABLE XXIII

RELATIVE IMPORTANCE OF FACTORS FOR FIRM 3

Factor	Change due to Factor	Index of Importance
A	.7250	.1040
B	.7937	.1138
C	.3125	.0448
D	.1250	.0179
E	1.6563	.2376
F	1.7500	.2511
G	1.1375	.1632
H	.4687	.0672
Total change due to factors	6.9687	

TABLE XXIV

RELATIVE IMPORTANCE OF FACTORS FOR FIRM 4

Factor	Change due to Factor	Index of Importance
A	.8125	.0808
B	.9063	.0915
C	.8962	.0891
D	.9687	.0963
E	1.4063	.1398
F	1.6563	.1647
G	1.4687	.1461
H	1.9375	.1927
Total change due to factors	10.0525	

TABLE XXV

RELATIVE IMPORTANCE OF FACTORS FOR FIRM 5

Factor	Change due to Factor	Index of Importance
A	1.1718	.1225
B	.7968	.0833
C	.8282	.0866
D	1.2344	.1290
E	.9844	.1029
F	1.7656	.1846
G	1.8594	.1944
H	.9218	.0963
Total change due to factors	9.5624	

TABLE XXVI

RELATIVE IMPORTANCE OF FACTORS FOR FIRM 6

Factor	Change due to Factor	Index of Importance
A	.0312	.0048
B	.3750	.0579
C	.4062	.0627
D	.7500	.1159
E	1.4375	.2222
F	1.5625	.2415
G	.9375	.1449
H	.9688	.1497
Total change due to factors	6.4687	

TABLE XXVII

RELATIVE IMPORTANCE OF FACTORS FOR FIRM 7

Factor	Change due to Factor	Index of Importance
A	.9219	.0880
B	.8907	.0850
C	1.6093	.1537
D	1.4843	.1417
E	1.1093	.1059
F	2.1719	.2074
G	1.6719	.1597
H	.6093	.0582
Total change due to factors	10.4686	

TABLE XXVIII

RELATIVE IMPORTANCE OF FACTORS FOR FIRM 8

Factor	Change due to Factor	Index of Importance
A	.6169	.0649
B	.5860	.0616
C	.8828	.0929
D	1.1953	.1258
E	1.3984	.1472
F	2.2422	.2360
G	1.6016	.1685
H	.9766	.1028
Total change due to factors	9.4998	

VITA

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Candidate for the Degree of

Doctor of Philosophy

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