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GRADUATE COLLEGE

THE IMPLICATIONS OF QUANTITATIVE TOOLS OF DECISION MAKING FOR ACCOUNTING: AN EMPIRICAL INVESTIGATION

A DISSERTATION

SUBMITTED TO THE GRADUATE FACULTY

in partial fulfillment of the requirements for the

degree of

DOCTOR OF PHILOSOPHY

BY

RAJABALI KIANI-ASLANI

Norman, Oklahoma

1975

THE IMPLICATIONS OF QUANTITATIVE TOOLS OF DECISION MAKING FOR ACCOUNTING: AN EMPIRICAL INVESTIGATION

APPROVED BY

DISSERTATION COMMITTEE

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TABLE OF CONTENTS

		Page
LIST OF TABLES		v
Chapter		
I.	BACKGROUND OF THE PROBLEM	1
	Statement of the Problem	8
	Justification of the Research	10
	Objectives of the Study	18
	Scope of the Study	19
	Research Methodology	20
	Organization of the Study	21
II.	THE EVOLUTION AND THE CONCEPTS OF QUANTITATIVE TOOLS OF DECISION MAKING	26
	The Evolution of Quantitative Tools of Decision Making	26
	The Concepts of Quantitative Tools of Decision Making	29
	Problem Solving	32
	Systematic Method	33
	Scientific Management	37
	Operations Research	38
	Management Science	40
	Summary	42
III.	RESEARCH DESIGN AND METHODOLOGY	48
	The Before-Survey Procedures	49
	The Choice of Research Design	49
	Questionnaire Construction and Testing	51
	The Population Scheme	55
	Pattern of Survey Responses	61
	The Problem of Nonresponse Bias	62
	Data Analysis Methodology	65
	Summary	70

Chapter Page

IV. ANALYSES OF FINDINGS OF EMPIRICAL INVESTIGATION 76

Analysis of Research Questions 77
Section I of Controller's Questionnaire--Biographical Data 78
Section II of Controller's Questionnaire--Information Concerning the Quantitative Tools of Decision Making . . 82
Section III of Controller's Questionnaire--The Future Qualifications Necessary To Perform the Controllership Function 101
Additional Comments 110

The Null Hypotheses 113
Testing the Hypotheses 113

Summary 123

V. SUMMARY, CONCLUSIONS, AND RECOMMENDATIONS . . 136

Summary 136
Conclusions 140
Recommendations 146

BIBLIOGRAPHY 150

APPENDICES 162

LIST OF TABLES

Table		Page
III-1.	Research Classified Paradigm Suggested by Green and Tull	50
III-2.	The Nine Categories Considered in Designing the Controller's Questionnaire	53
III-3.	The Population Classified by Size of Firm (Sales)	57
III-4.	The Population Classified by Major Industry Group	59
III-5.	The Population Classified by Size of Firm and Major Industry Group	60
III-6.	Summary of the Population to Size of Firm and Major Industry Group	60
III-7.	Response Patterns/Rates of the Participants to the First and Second Mailings of the Controller's Questionnaire	63
III-8.	The Eight Research Questions Analyzed in the Study	66
III-9.	The Eight Null Hypotheses Tested in the Study	69
IV-1.	Controllers' Highest College Degrees	79
IV-2.	Controllers' College Majors	79
IV-3.	A Summary of Sources of Controllers' Knowledge of Specific Quantitative Tools of Decision Making	81
IV-4.	A Summary of the Overall Levels of Use of Quantitative Tools of Decision Making by Controllers	84

Table		Page
IV-5.	A Summary of Use of Quantitative Tools of Decision Making in Production by Controllers . .	86
IV-6.	A Summary of Use of Quantitative Tools of Decision Making in Marketing and Distribution by Controllers	87
IV-7.	A Summary of Use of Quantitative Tools of Decision Making in Accounting (General, Managerial, Financial)	88
IV-8.	Overall Summary of Use of Quantitative Tools of Decision Making in the Areas of Business Operations by Controllers	89
IV-9.	A Summary of Frequency Use of Quantitative Tools of Decision Making by Controllers	91
IV-10.	A Summary of Importance of Quantitative Tools of Decision Making Weighted by Frequency of Use by Controllers	93
IV-11.	A Summary of Number of Controllers' Opinions Concerning the Overall Results Achieved from Using Quantitative Tools of Decision Making . .	94
IV-12.	A Summary of Importance of Quantitative Tools of Decision Making Weighted by Overall Results Achieved by Controllers	96
IV-13.	A Summary of Number of Controllers Applying Quantitative Tools of Decision Making to Business Operation Problems	98
IV-14.	A Summary of Number of Controllers' Encountering Various Difficulties in Implementation or Use of Quantitative Tools of Decision Making	100
IV-15.	A Summary of Controllers' Attitude Concerning the Importance (Rank) of Selected Areas of the Quantitative Methods for Controllership Function	102
IV-16.	A Summary of Controllers' Attitude Concerning the Importance (Rank) of Selected Areas of the Behavioral Sciences and Communication	104
IV-17.	A Summary of Controllers' Attitude Concerning the Importance (Rank) of Selected Areas of Information Sciences	106

Table		Page
IV-18.	A Summary of Controllers' Attitudes Concerning the Importance of Common Body of Knowledge for Controllership Function	108
IV-19.	A Summary of Number of Controllers' Attitude Concerning the Importance of Professional Certifications for Controllership Function . .	109
IV-20.	A Summary of Number of Controllers' Attitude Concerning the Importance of Minimum Educational Level for an Effective Controller . . .	111
IV-21.	Definition of Ten Variables	114
IV-22.	Means (M) and Standard Deviations (SD) by Group and Variables	115
IV-23.	The Results of Univariate F Tests for Ten Variables on Frequency of Use of Each Quantitative Tool of Decision Making by Size of Firm	117
IV-24.	The Results of Univariate F Tests of Ten Variables on Frequency of Use of Quantitative Tools of Decision Making by Type of Industry	119

THE IMPLICATIONS OF QUANTITATIVE TOOLS OF DECISION MAKING FOR ACCOUNTING: AN EMPIRICAL INVESTIGATION

CHAPTER I

BACKGROUND OF THE PROBLEM

Until recently, accounting has been the most important quantitative reporting aid to managers. However, the quantitative information developed and recommended to managers through the decision analysis techniques as tools of decision making is threatening to displace this importance of accounting.[1] Richard V. Mattessich stated:

> For centuries accounting has dominated the area of practical quantitative problems in business administration. In practice, the accounting department was the major source for quantitative financial information until the emergence of the operations research team challenged this monopoly position. Such a challenge is a serious one. For not only do operations analysts pretend to have solutions for problems which accountants refuse to attack, the OR men even claim the ability to solve less forbidding tasks <u>better</u> and <u>more accurately</u> than accountants do. In consequence, some of the radical members of this new discipline suggest that in time they will replace accountants altogether--a threat that comes close to a declaration of war. This controversy is by no means purely academic; it intimately concerns the welfare of American industry, and an objective look at this problem may be of benefit to practice as well as to theory.[2]

He further states:

The main objections made against accounting may be summed up in four items: First, the cost accounting models (in spite of standard cost systems) are still too closely tied to the approach of historical costing while considerations of alternatives in the form of a variety of opportunity costs are not sufficiently taken care of. Above all, accounting does not reveal the profit which would have occurred had alternative decisions been made.

Second, the accounting models are chiefly of a quantitative descriptive nature instead of a quantitative analytical nature and are not designed to search systematically for optimal solutions.

Third, on one side the accounting models apply concepts and collect many data which are irrelevant to decisions of the higher echelons of management, but on the other side they do not generate many data urgently needed for decision processes. In this way, accounting ignores goals other than profit and related aims and identifies the profit goal with the goal of the organization.

Fourth, accounting uses allocation procedures that are not based on a knowledge of the optimal organization structure; this distorts the measures that serve managerial decision making.

Thus, accounting does not supply an objective scale of values that can be used for selecting optimal decisions or for evaluating managerial performance. Further arguments and subarguments are that the time over which profits are being calculated is not sufficiently defined; that psychological factors which would seem significant because of the stimulus that costs exercise upon human actions are rarely considered; that the balance sheet is not comprehensive enough and its inclusive criterion of "measurable" is too superficial; that the goodwill of the enterprise, if taken into consideration at all, is incorrectly measured; that the additivity assumption with regard to many assets is unrealistic; that accounting measures are not accompanied by error estimates; and so on.[3]

John A. Beckett stated a similar position:

--accounting does not:

1. Serve as a information system with nearly the precision, speed, and effectiveness of other modern means.

2. Mesh with the new realities of business organization.

3. Relate to the new realities of business management.[4]

W. J. McGuire, criticized accounting as to its ineffectiveness in providing information necessary for business planning and decision process. He explained:

> The problem of setting a policy that affects all functions of business in the best way for the company as a whole is an executive problem. Here the accounting model breaks down as a planning mechanism. Fundamentally, it predicts future costs from past experience and relies on planned operations closely paralleling historical operations. This sort of information puts management in the position of individual trying to drive an automobile forward in traffic with his eyes fixed on the rear-view mirror. We obviously need a model that will more adequately represent the system.[5]

Frank S. Capon, President of Canadian Institute of Chartered Accountants, stated a similar position:

> The stewardship reporting function remains essential because honesty and performance need to be watched and because statements of past transactions are required for tax and legal purposes. But such information is of little real significance to those who must formulate objectives and plan the strategies and policies for attaining these objectives. Forward planning managers who are in fact making the essential decisions today for business, for government, and for all the institutions of society, have long since ceased to spend much time with traditional financial statements and reports that come from the accounting process.[6]

These animadversions would seem to apply not so much to accounting action taken but to action that has not been taken. The general implication of most of these dissatisfactions is that accounting fails to provide meaningful, accurate, and timely information for the planning and decision processes. In other words, the criticisms have

been leveled at accounting and accounting information for the following reasons:

1. The presence of open-ended information.
2. Lack of a broad concept of information development.[7]
3. Lack of an analytical approach.
4. Lack of a sophisticated problem-solving approach.[8]

In the face of these animadversions, and particularly in view of the vast amount of new thinking by other disciplines in this general area, specific changes in accounting education have occurred during the 1960's and 1970's. These changes were manifested in these three major dimensions: faculty, research, and course content.[9]

The content of managerial accounting courses has been changed more drastically than external accounting courses.[10] Increasing attention to the users of accounting information was manifested by the change in the nature of cost accounting courses and by the trend toward requiring all business students to take a management accounting course. The major change in the nature of cost accounting was the emphasizing of information for planning and control by using some of the selective tools of decision making and by deemphasizing of product costing.[11] In addition, the Committee on Courses in Managerial Accounting subdivided the management accounting field into the eight following areas of study:[12] (1) Computer science, (2) behavioral science, (3) quantitative methods, (4) management science, (5) cost

accounting, (6) budgetary control, (7) investment analysis and long-range planning, and (8) systems. As a result, the quantitative techniques and tools became a predominant part of the subject material in managerial accounting courses taught at colleges and universities. For example, Charles T. Horngren stated:

> A body of statistical decision theory had developed during the 1960's, and interdisciplinary work in accounting pivoted increasingly around decision theory as a unifying element. In fact, the decision theory framework strongly influenced both the accounting curriculum and the entire business curriculum. Its major reasons for growth were its universality and its flexibility. Its focus on the decision maker applies to all management functions in nearly any context. Teachers found that its method can be implemented in a gamut of courses from freshman accounting to doctoral seminars; that is, decision models can be framed in the simplest of terms and relationships.
>
> More specifically, decision theory and accounting fit together in the following way. A particular accounting system produces information to a decision maker, who may use the information in choosing an action. This action may influence, at least partially subsequent events. The accountant must predict the relationships between the information system, the decision-maker's prediction and action choice process, and the events that will occur. The best accounting system is that which optimizes the objective function (the payoff) after all costs, including the costs of the information, are considered.[13]

He further states:

> In 1970 management accounting was a diverse collection of techniques that had been useful in directing management's attention and in solving management's problems.
>
> - - - - - - - - - - -
>
> ---The content of management accounting became more systematic, more geared to a fundamental body of <u>decision theory</u> they cemented the field.

> New textbooks were written that were tied to the decision model and implementation framework. They examined various decisions and explored what information was needed to make choices and implement actions. For example, courses in internal accounting dealt with the problems of designing information systems that would serve management's needs for making capital budgeting decisions, product combination decisions, inventory control decisions, cost center or profit center decisions and their implementation. In addition to economics, quantitative training was routinely applied. Techniques like multiple regression, mathematical programming, and Bayesian analysis for dealing with uncertainty became commonplace. The courses now have a systems design perspective, including the use of the computer.[14]

Some factors which contributed to this development are:

1. The adaptation of the scientific method to the solution of management problems.
2. The development of mathematical methods to the solution of management problems.
3. The advent of the general-purpose digital computer.[15]

The adaptation of the scientific method has brought into the managerial arena concepts, theories, and methods that had developed independently of the business environment. These concepts include systems analyses, communications theory, information economics, measurement theory, cybernetics, and decision theory. Interdisciplinary application of those ideas to the problems of information systems design and decision making in business environment has challenged the authority of the accounting system's structure, contents, and output to serve as the sole or even as the major information network in the firm. Other segments of management have been brought into the field of information

analysis. As the information function evolves, these members of management are frequently thrust into powerful roles.[16]

The impact of mathematical models on operating activities has been cited as having a major influence on the formalization of many routine operating processes. In addition, management scientists have extended the planning and analysis capabilities of management and have produced new and more extensive demands for information. One impetus for the formalization of functional non-financial systems has been the need for data as input to mathematical models being developed and used.[17]

The pace of technical developments in computers and related devices has greatly increased the capabilities of collecting, handling, storing, analyzing, and reporting data and information. Because accounting was already a well-defined information system and had several large data-handling problems readily adaptable to automation, new applications of automatic data-processing methods frequently began there. Quite naturally, the chief accounting officer became the manager most closely related to data-processing methods and equipment. However, as computer applications began to appear with equal frequency in nonfinancial functional areas, the role of the accountant in managing and controlling data processing capabilities began to change. As a result, a mixed situation now exists that has reduced

the accounting function's traditional role as the designer of information systems and as the provider of decision-making information.[18] Moreover, this development facilitated scientific-method studies previously infeasible because of the sheer magnitude of the calculation.

In view of this development, the accountant must obtain the necessary qualifications for playing a larger rather than a smaller role in information systems. However, if accountants are either to maintain or to increase their position, they must understand where quantitative tools of decision making models relate to the planning and controlling functions.[19] Certainly, if this consideration is realized, then accountants can effectively use specific quantitative tools of decision-making models in designing, developing, and implementing a decision-oriented management information system. In doing so, the accountant will then be in a position to provide the informational needs of management.

Statement of the Problem

An examination of the content of recent textbooks[20] in controllership and other managerial accounting courses revealed considerable emphasis on quantitative techniques and behavioral science considerations. Management information systems is another topic receiving increased attention and many times as a separate field of study. On that premise, these and other topics (e.g., present-value concepts, flexible budgeting, linear programming, forecasting techniques,

statistical techniques, and simulation) are valid areas of study because of present and future usefulness to practicing accountants and, therefore, to students who will become practicing accountants.

This is supported in current accounting literature that cites examples of the varied use of most of these concepts and tools. Moreover, the high demand for students specialized in these areas presumably indicates a need for and a use of these managerial concepts and techniques in the business world.

A search of accounting literature revealed no pertinent empirical research:[21] (1) to determine the extent of general usage of quantitative tools of decision making by controllers and the consequential necessity of equipping college graduates in accounting with quantitative-analysis tools; and (2) either to support or to refute the common notion that managerial accounting courses should be more quantitative. If tools of decision making are inappropriate tools for accountants, then colleges and universities are misallocating resources in the accounting curriculum. If they are appropriate, then some colleges and universities need to provide accounting students some background in mathematics, statistics, and perhaps more operations research application in accounting.

With this background, the problems of this study are:

1. There are no empirical studies available to indicate how extensive the application of quantitative methods to controllership has become;

2. There are no empirical studies available to indicate whether controllers are prepared psychologically and/or educationally to utilize these tools;

3. There are no empirical studies available to indicate the reasons for either success or failure of such tools when used by the controllership function;

and 4. There are no criteria available for assessing such techniques for:

   a. importance in accounting curriculum despite lack of present use,

   b. importance in accounting curriculum of present use in practice,

   c. unimportance in accounting curriculum because of fatal faults known to practicing accountants but as yet unknown to academicians.

Justification of the Research

In recent years, drastic changes in the quantitative tools of decision making have occurred. Business enterprises have

increased in size and complexity. Management has ceased to be the function of a few executives in close personal contact with all phases of operations;[22] authority and responsibility have been delegated. More attention is being given to planning, coordinating, and controlling.[23]

As the problems of management become more complex, the need for more and useful information becomes more acute. This need is caused by the nature of executive decision-making that requires accurate and timely information to make a decision concerning acquisition and allocation of scarce resources among competing activities or ends. No longer should plans and decisions be formulated merely on either judgment, hunches, or intuition. With or without scientific-decision analysis, some degree of personal judgment usually is exercised when a final choice is made. Therefore, the main role of tools of decision making is to sharpen the intuition and judgment of the decisionmaker.[24] There is increasing demand for quantitative data to aid in decision making.[25] The manager, in his quest for more facts, is turning to the fields of mathematics, statistics, and perhaps more operations research techniques.[26] Accordingly, the accountant is striving to keep pace with demand for more data and is showing greater interest in these tools of decision making that can be applied to the solution of business problems. In this respect, Rossell and Frasure stated:

> --Improved accounting models have been developed, and the accounting profession has adopted and adapted many of the non-accounting models for its own use. Thus, the requirements for accounting information have increased a pace with the requirements for non-accounting information. Satisfaction of these expanded requirements will require that accountants become knowledgeable of these newer mathematical and statistical models. This does not imply that accountants should be mathematical or statistical sophisticates. It does imply an awareness and a modicum of understanding of these symbolic models to the end that their utilization by accounting practitioners may be enhanced, whenever justified.[27]

The trend toward a wider use of quantitative analysis can be expected to accelerate as new applications are explored and perfected, particularly because computers and high-speed electronic data are making possible calculations that are impossible or impractical to perform manually.

Quantitative tools of decision making have been receiving a significant and rapidly increasing share of attention from the accounting profession. Their importance to accounting is eloquently discussed in the Roy-MacNeill report. They stated:

> --The common body of knowledge for beginning CPAs call for more mathematics, statistics, probability, and decision theory than has been customary in the past and more than is currently required.
> --Accounting seems very likely to remain the basic measurement process for organization decisions; increasingly and inevitably accounting itself will be taught and used with mathematical notation, increasingly and inevitably will be used in conjunction with other mathematical, statistical, and probabilistic methods both for sound accounting and auditing procedures and for enhancement of the organization served by CPAs.[28]

Two years later, the Beamer Committee recommended the following quantitative tools and techniques as a common body of knowledge for a CPA:[29] modern algebra, calculus, statistics and probability, optimization models, sampling,

Markov chains, statistical decision theory, queueing, PERT, and simulation.

Norton M. Bedford stated this similar position:

> ---The immediate issue is whether or not accounting should expand its scope to include whatever heterogeneous mathematical and statistical techniques which have been developed. Actually, there is considerable reason to assume that it is proper that accounting should do so. In a number of instances, the data provided by mathematical and statistical techniques are merely refined measurements of similar data which accounting has provided management for a number of years.[30]

He further states:

> ---If the administrative process of decision making turns to the area of management science, it is evident that accounting must expand its scope to include operations research, cybernetics, simulation and related methods, if it is not to be absorbed by the broader functions of business management.[31]

Zenon S. Zannetos expressed this view:

> It appears to me that the demands of management for new quantitative criteria of efficiency of operations and decisions both aggregative and partial, are presenting opportunities and pressures that accounting cannot ignore. ---The accountant because of his present functions is in a key position to explore as well as exploit the opportunities afforded by such a technological break-through and become the head of a vast communications network that will provide management with tools and information that are necessary for internal control, planning and decision making.[32] (Underlinings are mine.)

Robert M. Trueblood, former Chairman of American Institute of CPAs Accounting Objectives Study Group, emphasized on potential relevance of quantitative tools of decision making for decision making:

> ---At the least, it is the accountant's obligation to become familiar with these new attitudes and techniques, further, it is the accountant's responsibility to participate in their formulation and development.

> But even more importantly, the accountant must assume responsibility for critically and objectively approving each such development in terms of its potential relevance for managerial purposes. Only by so doing can the accountant fulfill his professional responsibility to continuously improve management's techniques for decision making.[33]

Davidson and Trueblood also expressed a similar perspective:

> As a part of this development, accounting must divert itself from its preoccupation of the past with fiduciary and stewardship responsibilities. Responsibility for fiduciary decisions is a proper and major concern of the accountant. However, if the accountant is to comprehend and contribute to the decision-making, information-flow process within tomorrow's business organizations, he must integrate his stewardship responsibilities with a responsibility for broader management decisions.[34]

Nicholas Dopuch elaborates on the similarities and implementation of these techniques for accounting:

> ---This increased use of mathematical programming techniques should be of interest to accountants for at least two general reasons: (1) There is a definite similarity in the underlying approaches of programming and accounting to a certain type of managerial problem; and (2) the application of programming techniques by the managements of firms will have a growing impact on the accountant's function of supplying data used in making decisions concerning the allocation of resources and also, the data needed for the control and evaluation of these decisions.[35]

E. Leonard Arnoff, National Director of Operations Research of Ernst and Ernst Company expressed the feeling:

> Linear programming is so effective, and often so essential, in developing meaningful costs that I feel safe in saying that, in the not too distant future, it will be firmly established as an integral part of all accounting education and, eventually, accounting practice.[36]

At the 1968 Ernst and Ernst Symposium for Educators (The Impact of Modern Management Techniques on the Accounting Profession), J. William Hemphill partner in charge of Management Service, Ernst and Ernst, made this statement:

> ---Cost Accounting, like other areas of accounting, needs greater emphasis on quantification and organization of results. I think the future cost accountant is going to be well trained in the Operations Research, his work is going to provide management with a full management accounting system rather than the limited system most companies have today.[37]

In the same symposium Dean Peter A. Firmin of the College of Business Administration at the University of Denver, emphasized on education of quantitative tools of decision making:

> ---Now, what does all this mean for accounting education? I think it clearly means that the accounting student has got to be much more familiar with the management process and with operations research and management science than he ever has been before.[38]

Williams and Griffin stated:

> If Accounting practice is in fact a tool of managerial decision making, it must be responsive to current developments in management's disposition toward the factors which influence these decisions. The message of history is that accounting practice will adjust to and meet the challenges of the times; yet, the pace and direction of its movement presently is less than encouraging. This hesitant spirit, if continued, may create a vacuum which will be filled by one of the many new disciplines--or combination thereof--now active in aid of management.
>
> Both the accounting practitioner and theorist are exhorted to reexamine the nature and adequacy of their present methodology; both should consider the degree in which quantitative techniques may more sharply illuminate their methods of analysis and in consequence brighten the future of accountancy.[39]

They further state:

> The traditional adaptability of the accounting function--with its mathematical heritage firmly established over 400 years from Pacilio to DeMorgan--is challenged by the emergence of new quantitative methods for business decision making. This evidence further supports the possible enrichment of accounting methodology by a judicious injection of mathematical methods and techniques.[40]

Regarding quantitative methods, an AAA committee emphasized on the reorientation of the accounting system:

> Mathematical decision models will probably be used increasingly in all types of organizations. These models require the routine collection and analysis of data not previously processed. The accounting system should provide the information required by the models to the greatest extent feasible because the maintenance of separate information systems is likely to be uneconomic, and because accountants are well suited for the task. A fundamental reorientation of the accounting system will be required if accountants are to continue as major suppliers of information for planning and controlling.[41]

From a recent committee report of the AAA came a similar position:

> The accountant is commonly involved in the analysis, design, implementation and monitoring of information systems. His activities occur in the context of increasing use of quantitative and statistical models and procedures by these organizations. Such models provide a basis for the design of information systems, consequently for the performance of the several functions, of the accountant. The kinds of models which are or will be employed provide the foundation of the information system, and highlight the mathematical skills required of accountants.[42]

With regard to quantitative techniques, Charles T. Horngren stated:

> The professional literature and academic meetings in accounting has an influx of quantitative methods. For example, six of the twelve concurrent sessions at the annual meeting of the American Accounting Association in 1970 had a Mathematical accent. Fifteen of the twenty-five articles in the Accounting Review for the first two issues of 1970 and twenty-eight of thirty-two

> articles in The Journal of Accounting Research in 1969 deserved a quantitative label. In contrast, the first two issues of the Accounting Review in 1950 had zero articles out of 22 that could be classified as quantitative; in 1960, the count was 4 out of thirty-six.[43]

In addition, the National Association of Accountants, the American Accounting Association, and the Continuing Professional Education Division of American Institute of CPAs are conducting excellent courses on operations research and mathematics of scientific decision making.

The preceding selected quotations highlight the point that a large body of current accounting supports the need for this particular type of study. In short, the primary need of this study was to establish a benchmark so that practitioners and accounting educators could more objectively:

1. Determine whether management accountants of business enterprises are adequately employing current tools of decision making;
2. Determine how management accountants acquired the knowledge of any of these tools now being used;
3. Determine whether changes need to be made in the current quantitative tools of decision making currently taught in managerial accounting courses;
4. Have available a point of reference for future academic program planning and research activity;
5. Have available a point of reference for trend analysis for similar studies in the future.

In summary, little research on this subject has

been done. In other words, no pertinent empirical research has been done to determine either the usefulness or the appropriateness of including quantitative tools of decision making in managerial accounting courses either by measuring the degree of usage of quantitative techniques in business practice by controllers in general or by surveying the attitudes of controllers about the present and future controller's job qualifications. The preceding points of view need justifications, and this study was aimed in that direction.

Objectives of the Study

The principal objectives of this study are summarized as follows:

1. To investigate the extent and the level of usage of certain tools of decision making in business practice currently taught in managerial accounting courses in colleges and universities. The purpose was
   (a) to determine whether there is a relationship between procedures used in practice and those emphasized in classroom;
   (b) to determine whether there is a relationship between size of firm (sales), industry group (type of industry), and controller's education with the extent and level of use tools of decision making in business practice; in regard to the size of firm, presumably as the organization becomes more complex it is obvious that refined quantitative tools of analysis must be developed in order to facilitate the decision process.[44]
2. To determine how controllers acquired the knowledge of any such tools that they are now being used;[45]
3. To determine in what areas of business operations tools

of decision making are being used and what types of business operations are analyzed with these tools;

4. to determine what overall results have been achieved by using tools of decision making in business operations and what problems are being encountered in using these tools in business practice; and
5. To ascertain the corporate controller's opinions:
   (a) regarding the objectives listed above; and
   (b) concerning the present and future management accountant's (controller's) job qualifications.

Scope of the Study

The scope of this research was limited to:

1. The use of tools and quantitative techniques for managerial decision making. Thus, this study was limited to management accounting on the assumption that a major role of the management accountant is to design and improve information systems for executive decision making and implementation. To do so, the accountant must be aware that accounting systems design has a vital interrelationship with other disciplines, such as engineering, statistics, mathematics, economics, organization theory, decision theory, and social psychology.[45]
2. Certain tools of decision making currently a predominant part of the subject material in controllership and managerial accounting courses. The following most commonly used tools and techniques were selected for this study:

1. Flexible (variable) budgeting.
2. Present-value concepts.
3. Linear programming.
4. Sensitivity analysis (risk analysis).
5. Forecasting techniques (moving average, exponential smoothing, regression analysis).
6. Statistical techniques (sampling and Bayesian statistics).
7. Network analysis (PERT and CPM).
8. Inventory models (under certainty and uncertainty).
9. Simulation models (includes computer simulation).

3. Those facts obtained from mailing a controller's questionnaire to the controllers of all first Fortune 500 major industries in the United States.

Research Methodology

The research methodology employed in this study consisted of (1) the before survey procedures, (2) the survey procedures, and (3) the data analysis procedures.

As a general source of information, a review of the most applicable secondary information and/or relevant literature was made to provide background for the present study. Then a survey questionnaire (see Appendix A) was developed to collect data from the controllers of all Fortune 500 major industrial corporations in the United States. The purpose of the survey was to ascertain the corporate controllers' opinions and attitudes concerning (a) the appropriateness and the inappropriateness of quantitative techniques for accountants, (b) the extent to which these tools are being used in business and (c) the future job qualifications of controllers.

In the third stage the statistical methods were used to analyze the primary data. Descriptive statistics such as means, standard deviations, percentages and rankings were used to analyze and answer the research questions. Multivariate and univariate analyses of variance were utilized to test the null hypotheses of this study.

Organization of the Study

The study consists of five chapters. The first chapter has served to introduce the study by focusing on the background and the statement of the problem, the justification, the objectives, and the scope of the study, as well as research methodology and organization of the study.

Chapter II presents briefly the evolution and the elementary concepts of quantitative tools of decision making, as well as the related terms such as problem solving, systematic method, scientific management, operations research, and management science. Chapter III explains the methods and the procedures used in the conduct of this study. Chapter IV presents a detailed analysis of data with an interpretation of the significant empirical findings. Chapter V summarizes the empirical findings and their implications and concludes with suggestions for additional efforts. In addition, Appendix B provides information concerning the quantitative tools of decision making to be used by today's versatile decision maker and accountant whose expanding horizons require an understanding of these tools.

Chapter I Footnotes

[1]Norton M. Bedford, "Emerging Tools for Managerial Accounting," N.A.A. Bulletin, Vol. 43, October, 1961, pp. 31-37, and Robert M. Trueblood, "Operations Research--A Challenge to Accounting," Journal of Accountancy, May, 1960, pp. 49-51.

[2]Richard V. Mattessich, "Operations Research and Accounting: Competitors or Partners?" William E. Thomas, Reading in Cost Accounting, Budgeting, and Control, ed. (Dallas: South-Western Publishing Co., 1968), p. 412.

[3]Ibid., pp. 417-418.

[4]John A. Beckett, "Management Accounting in the Age of Systems," William E. Thomas, Reading in Cost Accounting, Budgeting, and Control, ed. (Dallas: South-Western Publishing Co., 1968), p. 174.

[5]W. J. McGuire, "Operations Research in Management Planning and Control," The Journal of Industrial Engineering, Vol. 10 (July-August, 1959), p. 309.

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[7]Peter A. Firmin and James L. Linn, "Information Systems and Managerial Accounting," The Accounting Review, Vol. 43, January 1968, pp. 75-77.

[8]N. M. Bedford, op. cit., p. 32.

[9]Charles T. Horngren, "The Accounting Discipline in 1999," The Accounting Review, Vol. LVI, No. 1, January 1971, p. 3.

[10]Ibid., p. 3.

[11]Ibid., p. 3.

[12]American Accounting Association, Report of the Committee on Courses in Managerial Accounting, The Accounting Review, Supp. to Vol. 47, 1971, p. 1.

[13]C. T. Horngren, op. cit., pp. 5-6.

[14]Ibid., p. 7.

[15]American Accounting Association, Report of the Committee on Information Systems, The Accounting Review, Supp to Vol. 46, 1971, p. 293.

[16]Ibid., p. 294.

[17]Ibid.

[18]Ibid.

[19]American Accounting Association, Committee Report on Managerial Decision Models, The Accounting Review, Supp. to Vol. XLIV, 1969, p. 43.

[20]Charles T. Horngren, Cost Accounting: A Managerial Emphasis, third edition (New Jersey: Prentice-Hall, Inc., 1972); Adolph Matz, and Othel J. Curry, Cost Accounting, Planning and Control, fifth edition (Cincinnati: South-Western Publishing Co., 1972); John L. Livingstone, Management Planning and Control: Mathematical Models (New York: McGraw-Hill Book Co., 1970); Nicholas Dopuch, Jacog G. Birnberg, and Joel Demski, Cost Accounting: Accounting Data for Management's Decisions, second edition (New York: Harcourt Brace Jouanovich, Inc., 1974); Harold Bierman, Jr., and Thomas R. Dyckman, Managerial Cost Accounting (New York: The MacMillan Co., 1971); James H. Rossell and William W. Frasure, Managerial Accounting (Ohio: Charles E. Merrill Publishing Co., 1972); Gerald R. Crowningshield and Kenneth A. Gorman, Cost Accounting: Principles and Managerial Applications, third edition (Boston: Houghton Mifflin Co., 1974); Thomas H. Williams and Charles H. Griffin, Management Information: A Quantitative Accent (Homewood: Richard D. Irwin, Inc., 1967); Hector R. Anton and Peter Firmin, Contemporary Issues in Cost Accounting (Boston: Houghton Mifflin Co., 1966); William E. Thomas, Jr., Readings in Cost Accounting, Budgeting and Control, third edition (Dallas: South-Western Publishing Co., 1968).

[21]In this regard N. Dopuch in his unpublished article "Financial Models vs. Managerial Models," presented to American Accounting Association's symposium: Researching the Accounting Curriculum--Strategies for Change--which was held in Chicago on May 19-21, 1974, stated:

> We need more definite methods of evaluation in managerial accounting, including various criteria which could be employed in empirical studies of different information proposals. Unfortunately, empirical work in managerial accounting is practically nonexistent. (p. 25)

[22]Robert F. Vandell, "Management Evolution in the Quantitative World," Harvard Business Review, Vol. 48, January-February, 1970, p. 83.

[23]Robert N. Anthony, "Framework for Analysis," Management Services, Vol. 1, March-April 1964, p. 18. W. W. Cooper, "Some Implications of the New Analytic Approaches to Management," California Management Review, Vol. IV, Fall 1961, p. 57.

[24]David Novick, "The Mathematical Content of Business School Curriculum," California Management Review, Vol. 8, Spring 1966, p. 6. Sang M. Lee, "Goal Programming for Decision Analysis of Multiple Objectives," Sloan Management Review, Vol. 14, 1972-1973, p. 1.

[25]James H. Rossell and William W. Frasure, Managerial Accounting (Ohio: Charles E. Merrill Publishing Co., 1972), p. 567.

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[28]Robert H. Roy and James H. MacNeill, Horizon for a Profession (New York: American Institute of Certified Public Accountants, Inc., 1967), pp. 256-257.

[29]American Institute of CPAs, Report of the Committee on Education and Experience Requirements for CPAs. March 1969, p. 58.

[30]N. M. Bedford, op. cit., p. 33.

[31]Ibid., p. 35.

[32]Zenon S. Zannetos, "Mathematics as a Tool of Accounting Instruction and Research," The Accounting Review, Vol. 38, April 1963, p. 326.

[33]Robert M. Trueblood, "Accounting and New Management Attitudes," The Journal of Accountancy, October, 1958, p. 38.

[34]H. Justin Davidson and Robert M. Trueblood, "Accounting for Decision-Making," The Accounting Review, XXXVI, 1961, p. 582.

[35]Nicholas Dopuch, "Mathematical Programming and Accounting Approaches to Incremental Cost Analysis," The Accounting Review, Vol. 38, October 1963, p. 745.

[36]E. Leonard Arnoff, "Operations Research and Decision Oriented M-I-S," Management Accounting, June 1970, p. 16.

[37]J. William Hemphill, "The Impact of Modern Management Techniques on the Accounting Profession," Ernst and Ernst, 1968 Symposium for Educators, p. 129.

[38]Peter A. Firmin, "The Impact of Modern Management Techniques on the Accounting Profession," Ernst and Ernst, Symposium for Educators, 1968, p. 155.

[39]Thomas H. Williams and Charles H. Griffin, The Mathematical Dimension of Accountancy (Dallas: South-Western Publishing Co., 1964), p. 23.

[40]Ibid., p. 235.

[41]American Accounting Association, Report of the Committee on Managerial Decision Models, The Accounting Review, suppl. to vol. 44, 1969, p. 57.

[42]American Accounting Association, Report of the Committee on the Measurement Methods Content of the Accounting Curriculum, The Accounting Review, Suppl. Vol. 46, p. 223.

[43]C. T. Horngren, op. cit., p. 3; "The first three issues of the Accounting Review in 1974 had 26 articles out of 32 that could be classified as quantitative." (researcher)

[44]Richard A. Johnson, Fremont E. Kast and James E. Rosenzweig, The Theory and Management of Systems, 2nd ed. (New York: McGraw-Hill Book Company, 1967), p. 281, Robert F. Vandell, "Management Evolution in the Quantitative World," Harvard Business Review, Vol. 48, Jan.-Feb., 1970, pp. 87-88, and William J. Vatter, "The Use of Operations Research in American Companies," The Accounting Review, October 1967, p. 722.

[45]The source of knowledge of tools of decision making are considered to be: formal training, executive training programs, professional development programs, self-studies through professional journals and/or current textbooks, working with consultants and practical training.

[46]Charles T. Horngren, Cost Accounting: A Managerial Emphasis, third edition (New Jersey: Prentice-Hall, Inc., 1972), p. 766.

CHAPTER II

THE EVOLUTION AND THE CONCEPTS OF QUANTITATIVE TOOLS OF DECISION MAKING

As the complexity and the specialization in an organization increases, effective allocation of available limited resources to various activities becomes more and more difficult. These problems and the need for relevant and accurate information to help resolve them provide the environment for the emergence of quantitative tools of decision making.[1] This chapter presents briefly the evolution and the elementary concepts of quantitative tools of decision making, as well as the related terms such as problem solving, systematic method, scientific management, operations research, and management science.

The Evolution of Quantitative Tools of Decision Making

Churchman, Ackoff, and Arnoff stated, "No science has ever been born on a specific day."[2] Smiddy and Naum feel that the "Science of Managing" can be classified into three time periods:[3] (1) before the nineteenth century in which management was practiced without systemization and on a personalized basis (i.e., rule of thumb), (2) the early nineteenth century in which management was practiced as a

quasi-science, and (3) the twentieth century that saw "the beginning of the work of investigating the principles of management along lines which provide statistical validity."[4] During this period, because of the ever-increasing complexity of business activities and competitive atmosphere, the simplified techniques and mathematical models were considered essential.

In retrospect, effective analytical quantitative tools of decision making have been developed and vastly improved since World War II.[5] During this era, the military management in England called upon a team of scientists to study the strategic and tactical problems associated with air and land defenses of the country. The team's main objective was to decide upon the most effective utilization of limited military resources. The applications were studies of the way to use the newly invented radar and the new types of bombers. The establishment of this scientific team marked the first formal operations research activity.[6]

Since its birth, this new decision-making field has been characterized by the use of scientific knowledge through interdisciplinary team effort to determine the best utilization of limited resources.

The encouraging results achieved by the British operations research teams motivated the United States military command to start similar operations.[7] Successful

applications of the United States teams included the study of complex logistical problems, the invention of new flight patterns, the planning of sea mining, and effective utilization of digital computer.

After World War II, the success of the military teams attracted the attention of business and industrial managers who were seeking solutions to their complex management problems. Such problems were becoming more acute because of the introduction of functional specialization into business organizations. Despite the fact that specialized functions are established primarily to serve the overall objective of the organization, the individual objectives of these functions may not be always consistent with the goals of the organization. This specialization has resulted in complex decision problems that ultimately have forced business organizations to seek the utilization of the effective analytical tools of decision making.[8]

The impressive progress in the field of quantitative operations research techniques is due in large measure to the parallel development of the modern digital computer with its tremendous capabilities in computational speed and information storage and retrieval.[9] In fact, without the digital computer, quantitative operations research techniques with their large-scale computational problems, would not have acquired the present promising status in all kinds of operational environments.

Levin and Lamone indicated the following two reasons for the developments in this area:

> (1) Writers and researchers in the field increased their emphasis on the study of the firm as a whole, i.e., an integrated unit where each decision made takes into effect the total operating environment /optimization/ instead of concentrating in a specific functional field /suboptimization/, and (2) the increased development of mathematical tools /and development of the modern digital computer/ to aid management in decision making.[10]

The Concepts of Quantitative Tools of Decision Making

A preferred approach in constructing a sound definition is to start from the commonly accepted view about the content of subject, refine and clarify certain aspects of this view, and then draw boundaries as tightly as possible. Unfortunately, as of today, there is no generally accepted definition by the writers on the subject. However, for the purpose of this study, the quantitative tools of decision making defined as the systematic approach for organizing, summarizing, and analyzing individual elements of a problem that can be measured and by which management intuition is minimized through reliance on analytical techniques whose results are independently reproducible and whose degree of congruence with organizational goals can be explicitly defined. These tools are essentially quantitative in nature and can be utilized by decision maker for coping with the complexity, the variability, and the lack of information during the entire decision-making process.

Quantitative tools of decision making involve mathematical model building to develop communication (descriptive) and evaluation (optimizing) models. Mathematical models are useful because they provide a conceptual representation of realities and enable the decision maker to anticipate and measure the effects of alternate courses of actions.

Decision making or choosing among alternatives occurs as decision makers conduct their planning and controlling functions. A mathematical decision model is one which, in effect, performs management's planning and control functions--but only to the extent that management decides when the model is constructed and implemented. For example, management may decide that inventory levels should be regulated by a system based on a mathematical decision model that specifies when to order, how much to order, how much safety stock to carry, and so forth. From that point on, the system can fully perform the delegated inventory planning and control functions unless management explicitly intervenes.

In mathematical decision models, the following steps are usually taken:

1. Determination of an organizational objective which can be expressed quantitatively. This objective can take many forms. For brevity, assume that the objective is either to maximize profit or

to minimize cost.

2. Identification and description of the mathematical relationships among the relevant variables which affect the profit (or cost).
3. The necessary mathematical operations are performed using the values identified in (2). The solution consists of finding a combination of values for the independent variables that maximizes profit (or minimizes cost) for the given values of the external variables.

The mathematical models help to describe and solve management problems and will become more and more important in business. The application of mathematical models requires managerial judgment, understanding, and skill. The decision maker should be alert to these three factors during his course of action: (1) importance of problems, (2) relevance of model to problem, and (3) sensitivity of solution to subsequent input information.

An important advantage of mathematical model building is that it provides a frame of reference for consideration of the problem; that is, the model may indicate gaps which are not apparent immediately. After a mathematical model is tested, the character of the failure might give a clue to the mathematical model's deficiencies.[11]

The dysfunctional aspect of the increased application of mathematical decision model is sometimes criticized

because the process of abstraction may drastically simplify the problem and overlook significant underlying factors.

The concept of tools of decision making is broad because the tools themselves range from simple financial analysis to complex mathematical analysis and computer models used in operations research and/or management science. However, it is highly probable that the reader has been exposed to a number of confusing references to tools of decision making. Thus, the remainder of this chapter briefly identifies the other terms related to tools of decision making concerned with managerial analysis. The general heading of these tools includes such items as problem solving, systematic method, scientific management, operations research, and management science.

Problem Solving

Throughout history, man has approached problem solving in a number of ways. Stuart Chase identified the following ways:

1. Appeal to the supernatural
2. Appeal to worldly authority--the older the better
3. Intuition
4. Common sense
5. Pure logic
6. The scientific method [systematic method].[12]

The list implies a gradation leading toward more careful, searching, and rational approaches. In reality, combinations of several of these are utilized in many problem-solving efforts.

In business enterprise, the problem-solving activity often is termed decision making. Herbert Simon described the process of decision making as follows:

> The first phase of decision making process--searching the environment for conditions calling for decision--I shall call intelligence activity.
> The second phase--inventing, developing, and analyzing possible courses of action--I shall call design activity.
> The third phase--selecting a particular course from those available--I shall call choice activity.[13]

Henry Lucas, Jr., writes, "it is useful to add another stage to Simon's scheme, that of implementation. Implementation involves developing a program to see that the particular alternative chosen is executed."[14]

The decision-maker in business is involved simultaneously in intelligence, design, choice, and implementation. Thus, as the business organization becomes more complex, refined tools of decision making and analysis must be developed in order to facilitate the decision process or problem solving. The fundamental framework of operations research, as for any other science, is the systematic method.

Systematic Method

Systematic method apparently means different things to different people. The basic premise underlying the systematic method is a simple and abiding faith in the rationality of nature that leads to the belief that phenomena have causes.[15] Therefore, the systematic method is an

approach that deals with problems such as conflicting objectives, policies, and alternatives and has as its primary goal the development and the application of quantitative methods to specific problems. Quite often, however, the systematic method involves the following steps:

1. observation /search for problems/
2. definition of the real problem
3. development of alternative solutions
4. selection of optimum solution using experimentation
5. verification of optimum solution through implementation
6. establishment of proper controls.[16]

The specific steps in the systematic method are followed to avoid bias and make complete disclosure in the final recommendations. The adaptation of the systematic method requires systematic investigation of the totality or system with which the decision maker is concerned. This systematic approach assures the decision maker that he has considered all necessary factors in reaching his ultimate decision. When some factors are ignored, they must be clearly identified, and the conclusions drawn must clearly state those factors have been ignored.

Thierauf and Grosse[17] have prepared a diagram that compactly illustrates (Figure 1) the entire process of the systematic method for defining, formulating, implementing, and controlling business problems.[18]

Figure 1 shows that the first step in a scientific method is to obtain the basic facts, ideas, opinions, and so forth of the problem needed to define the problem clearly.

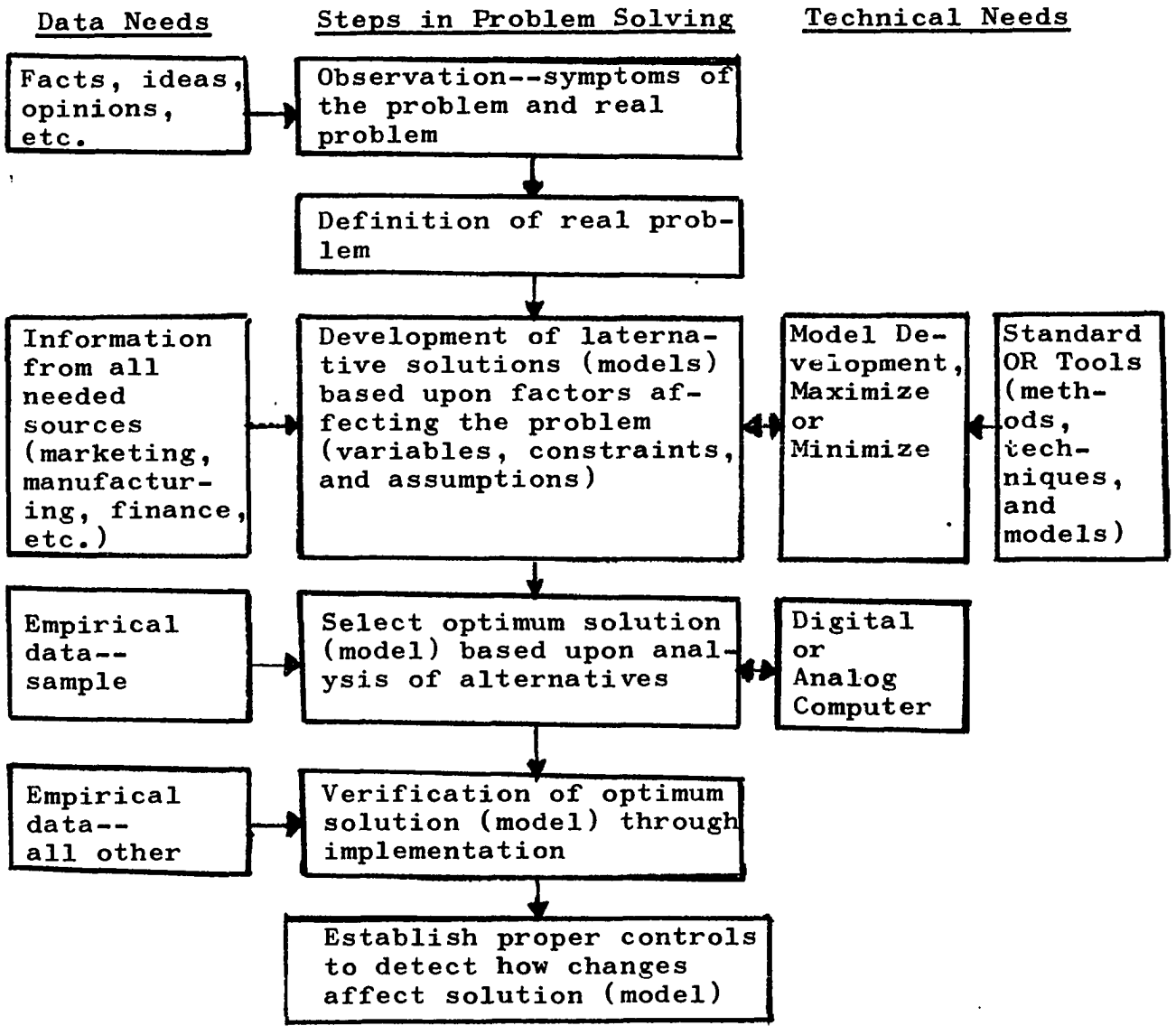


Figure 1. Steps in systematic method.

Next, the factors affecting the problem (variables, constraints, and assumptions) must be determined. The variable factors are those on which decisions have to be made, such as level of inventory, production rate, and amount and character of promotional effort. Problem solving is also affected by such constraints as specific

out-of-stock criteria, a constant employment policy, and a cash requirement.

The next important step in the systematic method is the development of alternative courses of action or possible solutions to the problem and a clear statement of objectives by which the alternatives can be analyzed. The following alternatives are then evaluated to select the optimum solution; i.e., the course of action, the plan, or the rule that will best achieve the objective. The next step is, of course, implementation.

Finally, controls must be established to indicate (a) the limits within which the mathematical model and its solution can be considered as sufficiently reliable, and (b) the future conditions and manner in which either the model or the solution would have to be modified.

These steps represent a formal approach to problem solving applicable to the solution of any problem whether mathematical or nonmathematical techniques are used. As Figure 1 illustrates, the "technical needs" of the tools of decision making are concerned with developing alternative solutions and analyzing them to determine the optimum solution. A mathematical model is usually developed by using appropriate tools of decision making to allow a computer to calculate the optimum solution. The important factor to consider when using the "technical needs" of tools of decision making is that the optimum solution of

the model may not be the course of action that decision makers should take to solve their business problem. The model solution must be interpreted and evaluated in the context of the assumptions used in the total business environment so that a complete course of action can be developed.

Scientific Management

The development of a complex, interdependent society, in which large-scale business firms operated by professional managers became predominant, has created a need for much greater attention to the problems of management. One of the first persons to develop ways of meeting this challenge was Frederick Winslow Taylor. In his book, The Principle of Scientific Management, he concerned himself with achieving efficiency of human beings and machines through time-and-motion study that has been called the "cornerstone of scientific management."[19] Furthermore, he demonstrated that management can improve the means used to accomplish ends. He was also convinced that the greatest problem in changing to scientific management was the need for a complete revolution in the mental attitudes and habits of all those engaged in management. He emphasized that a prime goal of scientific management is the substitution of science for rule-of-thumb approaches to problem solving. The essence of scientific management is to be found in these four general ideas:

1. Discovering, through use of the scientific method, basic elements of man's work, to replace rule of thumb.
2. Identifying management's function of planning work, instead of allowing workmen to choose their own method.
3. Selecting and training workers and developing co-operation, instead of encouraging individualistic efforts by employees.
4. Dividing work between management and the worker so that each would perform the duties for which he was best fitted, with resultant increase in efficiency.[20]

The advancement of these scientific management ideas--which have focused attention upon managerial problems faced at relatively low levels of administration in the firm and upon the actual work performed by non-managerial employees--continues today in industrial engineering and management departments at many universities.

Operations Research

The term operations research (O.R.) means many things to many people. There are probably as many definitions of operations research as there are writers in the field. Miller and Starr feel that operations research is applied to problems confronting the management in performing their functions:

> Operations Research is applied decision theory. It uses any scientific, mathematical, or logical means to attempt to cope with the problems that confront the executive when he tries to achieve a through going rationality in dealing with his decision problems.[21]

Churchman, Ackoff, and Arnoff emphasize the application of scientific method and techniques and stress the optimum solution of operations research:

> O.R. [operation research] in the most general sense can be characterized as the application of scientific methods, techniques and tools to problem solving the operations of systems so as to provide those in control of the operations with optimum solutions to the problems.[22]

Thierauf and Grosse present this description of operations research and its attributes:

> Operations research utilizes the planned approach (scientific method) and an interdisciplinary team in order to represent complex functional relationships as mathematical models for the purpose of providing a quantitative basis for decision making and uncovering new problems for quantitative analysis.[23]

Thus, it can be acknowledged that there is no precise definition of operations research. No definition of operations research is satisfactory to everyone; each definition emphasizes a different viewpoint. However, operations research can be defined simply as a systematic investigation to problem-solving for decision-maker. The objective of operations research is to implement and enhance the tasks of analysis and decision making inherent in planning and controlling complex systems. Its aim is not to replace the decision-maker but rather to provide quantitative information from which more intelligent decision can be made. Operations research does promise a considerable improvement in the quality of managerial decisions. Operations research may be distinguished most easily from other sciences and disciplines on the basis of the following inherent characteristics:

1. System orientation
2. Team (multidisciplinary) approach
3. Scientific method [systematic investigation][24]

Management Science

The term, management science, is not clearly distinguishable from operations research and scientific management. In this regard, H. A. Simon stated:

> No meaningful line can be drawn any more to demarcate operations research from scientific management or scientific management from management science.[25]

Charles T. Horngren points out the difference between operations research and management science as follows:

> Operations research is sometimes referred to as management science. The distinction between the two is fuzzy. Management science is a broader concept in the sense that it embraces computer technology as a science plus operations research.[26]

Gifford H. Symonds sees the similarity and the difference between operations research and management science as follows:

> Application of the scientific method to specific problem-solving in the area of management is called operations research. . . . Operations research uses scientific principles and methods in solving specific problems. Operations research study does not usually produce general laws or fundamental truths. Although operations research and management science are now closely related, they are quite different but complementary in their purposes. Operations research represents the problem-solving objective; management science the development of general scientific knowledge. Nevertheless, much of our understanding of management sciences came through operations research, as well as industrial engineering and econometrics. Study of specific problem solutions as, for example, in inventory control, led some investigators to approach an understanding of general theory in the area. All general theory requires the pragmatic test. Operations research, applying general theory to specific operations, is a desirable means for making this pragmatic test. . . . Management science, in its present state of development,

> has little in the way of general laws and general truths. But from the great body of general management knowledge and experience and from specific operations research applications, will come the fundamental relationships of predictive theory which will distinguish management science as a true science.[27]

Miller and Starr indicated that operations research is a subset of management science: "Operations research and decision theory framework are part of a current world wide management science."[28]

They further say:

> Management science differs from Taylor's scientific management in many ways. It /management science/ is not primarily concerned with production tasks and the efficiency of men and machines. Rather, it views efficiency as a secondary achievement which should follow adequate planning.[29]

Management science is, therefore, at least a broader concept than operations research and scientific management and can be simply defined as scientific approach to the solution of operational problems. Management science is concerned with providing management with <u>decision aids</u> or <u>decision rules</u> derived from:

1. A total-system orientation.
2. Scientific methods of investigation
3. Models of reality, generally based on quantitative measures and techniques.[30]

In conclusion, because tools of decision making constitute the analytical approach that aids the decision maker, one must understand the relationship of these tools to the management, as well as the basic characteristics of the tools.

All management function falls under these four prime activities: (1) setting organizational goals and objectives, (2) developing plans for the reaching these objectives, (3) combining the human and the physical resources so that the objectives are met, and (4) monitoring the results in an attempt to see that the desired objectives are met. These activities can be effectively performed only with the aid of objective analysis. The quantitative tools of decision making used by management in the conduct of these activities are extensive and varied.

Quantitative tools of decision making include all analyses to aid managerial decisions under the following conditions: (1) the analysis is based on a systematic investigation; (2) the analysis explicitly recognizes some set of organizational goals or subgoals; (3) the analysis explicitly recognizes relationships among some set of relevant variables (i.e., models); (4) the recommended course of action is explicit and independently reproducible (i.e., objectivity concept).[31]

Summary

The evolution of quantitative tools of decision making can be classified into the following three time periods: (1) before nineteenth century in which management was practiced without systematization and on a personalized basis (i.e., rule of thumb), (2) the early nineteenth century in which the Industrial Revolution began

and management was practiced as a quasi-science, and (3) the twentieth century in which the businessman and the decision maker are confronted with a complexity and a diversity of business operations, and, thus, management utilizes the systematic investigation for problem solving to avoid bias and make complete disclosure in the final recommendations of a course of action. However, the following three very significant factors have affected the development of tools of decision making: (1) the adaptation of the scientific method to the solution of management problems, (2) the development of mathematical models for solving management problems, and (3) the increasing availability, understanding, and use of electronic computer. In brief, the framework of tools of decision making is old, but, the mathematical and computational tools necessary for proliferation of its effective use have been developed only recently.

The quantitative tools of decision making in this chapter are defined as "the systematic approach for organizing, summarizing, and analyzing individual elements of a problem that can be measured and by which management intuition is minimized through reliance on analytical techniques whose results are independently reproducible and whose degree of congruence with organizational goals can be explicitly defined." The tools may range from the simple financial ratio analysis to the complex mathematical

analysis and computer models used in operations research and/or management science. The general headings under which these tools may be included are items such as problem solving, scientific method, scientific management, operations research, and management science.

Chapter II Footnotes

[1]Norton M. Bedford, "Emerging Tools for Managerial Accounting," N.A.A. Bulletin, Vol. 43 (October, 1961), pp. 31-37; Norton M. Bedford, Charles H. Griffin and Thomas H. Williams, "Emerging Role of Mathematical Methodology in Accountancy," N.A.A. Bulletin, Vol. 48 (June, 1962), pp. 33-38; Harold F. Smiddy and Linnel Naum, "Evolution of a 'Science of Managing' in America," Management Science, Vol. 1 (October, 1954), p. 29; Melvin L. Hurni, "The Needs and Opportunities for Operations Research and Synthesis," ed. Abe Shuchman, Scientific Decision Making in Business (New York: Holt, Rinehart and Winston, Inc., 1963), pp. 38-42; W. J. Fabrycky and P. E. Torgersen, Operations Economy: Industrial Applications of Operations Research (Englewood Cliffs, N.J.: Prentice Hall, Inc., 1966), pp. 3-15.

[2]C. West Churchman, Russell L. Ackoff and Leonard Arnoff, Introduction to Operations Research (New York: John Wiley & Sons, Inc., 1957), p. 3.

[3]Smiddy and Naum, "Evolution of a 'Science of Managing' in America," op. cit., pp. 4-5.

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[7]Ibid., p. 12.

[8]F. S. Hillier and G. J. Lieberman, Introduction to Operations Research (San Francisco: Holden-Day, Inc., 1967), p. 4.

[9]Robert J. Thierauf and Richard A. Grosse, Decision Making through Operations Research (New York: John Wiley & Sons, Inc., 1970), p. 6.

[10]Richard I. Levin and R. P. Lamone, Linear Programming for Management Decisions (Homewood, Illinois: Richard D. Irwin, Inc., 1969), p. 2.

[11]Irwin D. J. Bross, "Models," Richard I. Levin and Rudolph P. Lamone, ed., Quantitative Disciplines in Management Decisions (Belmont, California: Dickenson Publishing Company, Inc., 1969), p. 51; Thierauf and Grosse, Decision Making through Operations Research, op. cit., p. 22.

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[14]Henry C. Lucas, Jr., Computer Based Information Systems in Organization (Chicago: Science Research Associates, Inc., 1973), p. 6.

[15]Cyril C. Hermann and John F. Magee, "Operations Research for Management," Harvard Business Review, Vol. 31, (July-August, 1953), p. 100.

[16]R. J. Thierauf and R. A. Grosse, Decision Making through Operations Research, op. cit., pp. 31-35.

[17]Ibid., p. 35.

[18]For similar study concerning the systematic investigation see also Robert A. Hammond, "Making Operations Research Effective for Management," Business Horizons (Vol. 5, No. 1 (Spring, 1969), pp. 73-82; E. Leonard Arnoff and M. J. Netzorg, "Operations Research--The Basic," Management Services, Vol. 2 (January-February, 1965), pp. 42-51; Russell L. Ackoff, "The Development of Operations Research as a Science," Operations Research, Vol. 4, No. 3 (June, 1956), pp. 265-287; E. Leonard Arnoff, "Operations Research and Decision-Oriented Management Information Systems," Management Accounting (June, 1970), pp. 11-16; Churchman, Ackoff and Arnoff, Introduction to Operations Research, op. cit., p. 13; and Robert E. Schellenberger, Managerial Analysis (Homewood, Illinois: Richard D. Irwin, Inc., 1969), Chap. 1, pp. 7-24.

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[20]Fedrick W. Taylor, The Principle of Scientific Management (New York: Harper & Row Publishers, Inc., 1947), pp. 36-37.

[21]Ibid., p. 104.

[22]Churchman, Ackoff and Arnoff, Introduction to Operations Research, op. cit., p. 18.

[23]Thierauf and Grosse, Decision Making through Operations Research, op. cit., p. 14.

[24]Gordon L. Murray, "Scientific vs. Practical Management: A Pragmatic Approach," Management Services, Vol. 4 (January-February, 1967), pp. 14-15.

[25]H. A. Simon, The New Science of Management Decision, op. cit., p. 15.

[26]Charles T. Horngren, Cost Accounting: A Managerial Emphasis (Englewood Cliffs, N.J.: Prentice-Hall, Inc., 1972), p. 897.

[27]Gifford H. Symonds, "The Institute of Management Sciences: Progress Report," Management Science, Vol. 3 (January, 1957), pp. 125-219.

[28]David W. Miller and Martin K. Starr, Executive Decisions and Operations Research (Englewood Cliffs, N.J.: Prentice-Hall, Inc., 1960), p. 8.

[29]Ibid., p. 9.

[30]Robert G. Murdick and Joel E. Ross, Information Systems for Modern Management (Englewood Cliffs, N.J.: Prentice-Hall, 1971), p. 377.

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CHAPTER III

RESEARCH DESIGN AND METHODOLOGY

A survey questionnaire was developed to collect data from the controllers of all Fortune 500 major industries in the United States. The purpose of this survey was to ascertain the corporate controller's opinions and attitudes concerning (1) the extent and the level of business usage of quantitative tools of decision making currently taught in managerial accounting courses at the college level, and (2) the desirable job qualifications of the potential controller or management accountant. Collection of the responses required two mailings of the data collection instruments. The data were coded and the statistical tests chosen for (1) analyzing the research questions and (2) testing the null hypotheses stated in this chapter.

This chapter explains the methods and the procedures used in the conduct of this research project. The research methodology employed in this study was: (1) the before-survey procedures--all the procedures completed prior to the data collection, (2) the survey procedures--the actual procedures followed in collecting data from all

500 desired controller participants, and (3) the data analysis procedures--the procedures utilized in (a) analyzing the research questions and (b) testing the null hypotheses of the research project. The subsequent discussion concentrates on the steps enumerated above.

The Before-Survey Procedures

The Choice of Research Design

According to Green and Tull, a research design is "the specification of methods and procedures for acquiring the information needed."[1] The research design is the overall operational pattern or framework for this research project. Research design is the researcher's set of blueprints and specifications.[2] The succeeding discussion, therefore, centers around the kinds of information gathered in this study, the data sources, and the specific procedures used in gathering and collecting these data.

Research designs may be classified according to many criteria. The selection of the most useful of research design is the major purpose of the investigation. Table III-1 incorporates research design classification developed by Green and Tull.[3]

Exploratory studies have as their major purposes the identification of problems, the more precise formulation of problems, including the identification of relevant

TABLE III-1

RESEARCH CLASSIFIED PARADIGM SUGGESTED BY GREEN AND TULL

Purpose of Research Design	General Sources of Information
1. Exploratory	1. Secondary Information (Sources)
2. Descriptive	2. Respondents (or Surveys)
3. Causal	3. Observational Studies
	4. Experiments
	5. Simulation

variables and formulation of new alternative courses of action or formulation of new hypotheses.[4] Descriptive research, in contrast to exploratory research, is marked by the prior formulation of specific research questions that are answered by describing these questions with the data collected.[5] Causal studies search for the reason why. The purpose is to find any relationships of causal factors of whatever the researcher is predicting.[6]

The design of this research project was primarily exploratory in nature, with some aspects of descriptive research design. As a general source of information, the first two chapters reviewed the most applicable secondary information and/or relevant literature. A survey questionnaire was the primary source of information.

Questionnaire Construction and Testing

Construction of a Questionnaire

The customary reservations with regard to the use of mail questionnaire was reviewed.[7] The major limitations in the sample are the problem of nonresponses and the problem of limited sampling concerning both procedure and knowledge possessed.

In addition to the above general inherent limitations of mail surveys, the problems peculiar to mail surveys stemming largely from the lack of personal communication between the individual conducting the study and the respondents were specific limitations of this research effort. The major questions were (a) whether the concepts underlying quantitative tools of decision making and future qualifications necessary to perform the controllership function could be adequately explained in a questionnaire and (b) whether the desired controllers participants had enough knowledge to respond intelligently and thoughtfully to the questions.

Questionnaire Design

To insure a maximum return, a well-designed mail questionnaire was essential. The nature and the format of information sought in the controller's questionnaire were primarily determined through (1) an extensive review of relevant literature concerning (a) the extent and the level of business usage of certain quantitative tools of decision making currently taught in managerial accounting courses in college, and (b) the desirable job qualifications for future controllers or management accountants, (2) consultation with dissertation committee directing the study, (3) the preconceptions of the writer, and (4) the limitations imposed by the questionnaire design.

The information sought by the controller's questionnaire (see Appendix A) basically could be divided into nine categories shown in Table III-2.

TABLE III-2

THE NINE CATEGORIES CONSIDERED IN DESIGNING THE CONTROLLER'S QUESTIONNAIRE

1. Questions concerning the extent and the level of business usage of quantitative tools of decision making.
2. Questions concerning the areas of operations in which firms use quantitative tools of decision making.
3. Questions regarding the frequency of use of quantitative tools of decision making in business operations problems.
4. Questions regarding the overall results of using the quantitative tools of decision making in analyzing the business operations problems.
5. Questions concerning the types of business operations problems analyzed with quantitative tools of decision making.
6. Questions regarding the implementation of quantitative tools in business practice.
7. Questions concerning the controller's acquisition of knowledge of these quantitative tools if they are now being used.
8. Questions regarding job qualifications of future controllers and/or management accountants.
9. Questions regarding controller's business experience and educational background.

Pilot Study

After the controller's questionnaire had undergone a number of revisions, a pilot study was undertaken to test the data collection capabilities of the instrument and to determine whether further revisions were necessary. The pilot study group consisted of six (6) controllers of

industrial corporations residing in the Oklahoma City, Oklahoma. Each of these controllers was contacted personally and asked to help test the controller's questionnaire. On a predetermined date, each of the participating controllers filled out the questionnaire in the presence of the writer and offered his comments and observations regarding (1) the questionnaire design, (2) the terminology, (3) the time required to answer the controller's questionnaire, (4) the degree of understability, and (5) the content of the controller's questionnaire in regard with the extent and the level of business usage of quantitative tools of decision making in his firm in general. After careful observation and evaluation of the comments and suggestions made by pilot study group, the researcher then revised the controller's questionnaire and printed it in final form (see Appendix A).

Test of Questionnaire Reliability

A number of tests are available for checking the reliability of the questionnaire. Four commonly used techniques are (1) test-retest reliability, (2) alternate-form reliability, (3) split-half or odd-even reliability, and (4) Kuder-Richardson reliability.[8] One assumption of all these tests is that the respondents can be retested either with the same instrument (test-retest), or with one that is similar (alternate form), or that the instrument can be internally divided and the internal parts checked against each other or some total (split-half or odd-even and the

Kuder-Richardson). Because the questionnaire to be used did not lend itself to any of the techniques stated above, two questions were rephrased and repeated in different parts of the questionnaire to determine whether any inconsistencies existed in the responses. The two questions were D-4 of section I and A of section II. The purpose of these questions was to determine whether the controllers used any of the quantitative tools of decision making in business practice. The fact that 99.7 percent of the time consistent answers were made to the two questions and that a strong correlation measure existed between the two implied that the controller's questionnaire responses could be considered or accepted as reliable.[9]

The Population Scheme

The population for this study was defined as all 500 controllers of the Fortune 500 largest United States industrial corporations that were dominant in the United States economy and that accounted for "65 percent of the sales of all U.S. industrial corporations, 76 percent of the employees, and 79 percent of the profits,"[10] during 1973. Because of the significance of the study, all 500 controllers of Fortune's 500 major industries were selected to participate in the study. The choice of this broadside approach, as compared with a selected sample, was in part a matter of cost; but this approach was intended more to make it easier for many controllers in the entire population of

Size of Firm Classification

The population was stratified into four sub-populations according to the size of firm (sales). The major source for this classification was the May, 1974, issue of The Fortune Double 500 Directory of the Largest U.S. Industrial Corporations.

The result of this classification is shown in Table III-3.

TABLE III-3

THE POPULATION CLASSIFIED BY SIZE OF FIRM (SALES)

Amount of Sales	Number of Firms in Each Firm Size	Size of Firm Code
Less than $399.50 million	142	M_1
$400 - $699.50 million	132	M_2
$700 - $999.50 million	59	M_3
Over 1 billion	167	M_4
TOTAL	500	

Major Industry Group Classification

Commenting on major industry group classification, W. J. Vatter stated "industry classifications are always difficult; in this day of diversification, acquisition, and technical change, it is not easy to put a given company into the same group with very many others."[12] However, for the purpose of this research project, the population

is classified into three major industry groups according to sources available and certain preconceptions of the writer. The results of this classification are tabulated in Table III-4 on the next page. The following sources were available:

(1) Standard Industrial Classification Manual[13] used to classify the firms into (SIC) code according to their major products;

(2) Statistical Abstract[14] used to classify firms into major industry group;

(3) The Standard Poor's Register of Corporation[15] and Value Line[16] utilized to determine the major sources of revenues of each corporation according to (SIC) code.

Table III-5 shows a cross-classification of population by size of firm (M_i, where i = 1,2,3,4) and major industry groups (N_j, where j = 1,2,3). Table III-5 is a consolidation of Tables 1 and 2.

The stratification of the population according to size of firm and major industry group is shown in Table III-6 which is a reclassification of the details in Table III-5. The information provided in Table III-6 was used as a basis for determining the number of questionnaires to be mailed to the firms in each major industry group and size.

TABLE III-4

THE POPULATION CLASSIFIED BY MAJOR INDUSTRY GROUP

SIC Code	SIC Title	# of Firms in SIC Class	Statistical Abstract Title	# of Firms in Industry	Major Industry Group Code
33	Primary Metals	31			
34	Fabricated Metal Products	20			
35	Machinery except Electrical	62			
37	Transportation Equipment	31			
38	Instruments and Related Products	15	Durable Manufacturing	229	N_1
32	Stone, Clay, Glass, and Concrete Products	16			
31	Electrical and Electrical Machinery, Equipment, and Supplies	36			
24	Lumber, Wood Products	13			
39	Miscellaneous Manufacturing Industries	5			
22	Textile Mill Products	18			
23	Apparel Products	14			
26	Paper and Allied Products	22	Nondurable Manufacturing	209	N_2
27	Printing and Publishing	10			
28	Chemicals and Allied Products	51			
29	Petroleum Products	13			
30	Rubber and Plastic Products	11			
20	Foods and Kindred Products	68			
31	Leather and Leather Products	3			
13	Oil and Gas Extraction	17			
10	Metal Mining	6			
14	Mining and Quarrying of Nonmetalic Minerals	4			
15	Construction	2			
40	Transportation	3	Unclassified[17]	62	N_3
48	Communication	3			
49	Services	2			
50	Trading Companies	17			
67	Holding and Investment Companies	6			
78	Motion Picture	3			
	TOTALS	500		500	

TABLE III-5

THE POPULATION CLASSIFIED BY SIZE OF FIRM AND MAJOR INDUSTRY GROUP

Size of Firm	Major Industry Group N_1	N_2	N_3	Totals
M_1	71	52	19	142
M_2	60	61	11	132
M_3	22	30	7	59
M_4	76	66	25	167
TOTALS	229	209	62	500

TABLE III-6

SUMMARY OF THE POPULATION TO SIZE OF FIRM AND MAJOR INDUSTRY GROUP

Size of Firm and Major Industry Group Code	Number of Firms in Each Size of Firm and Major Industry Group
M_1N_1	71
M_1N_2	52
M_1N_3	19
M_2N_1	60
M_2N_2	61
M_2N_3	11
M_3N_1	22
M_3N_2	30
M_3N_3	7
M_4N_1	76
M_4N_2	66
M_4N_3	25
TOTAL	500

Pattern of Survey Responses

On January 4, 1975, a cover letter, a confidential controller's questionnaire, and a return stamped envelope were mailed to all 500 controllers of Fortune's 500 major industries for their opinions and attitudes concerning (1) the extent and the level of business usage of certain quantitative tools of decision making by controllers or management accountants and (2) the desirable job qualifications for potential controllers and/or management accountants. In an attempt to increase the number of returns, the cover letter was signed by Professor Bart W. Ward, Chairman of the Dissertation Committee. The cover letter explained the purpose of the research project and assured the potential respondents that the research was being conducted for academic reasons only. Copies of all items sent to the controllers are included as Appendix A.

A thirty-day period was allowed for the controllers to reply. Because the first mailing did not provide sufficient data to analyze the research questions and to test the null hypotheses of research project, on February 5, 1975, a follow-up letter, a confidential controller's questionnaire and a return stamped envelope were mailed to nonrespondents. Another thirty-day was allowed for replies to this follow-up request; however, replies received after March 7, 1975, were not considered in final data analysis.

The first and second mailing resulted in 236 replies

(47.2 percent). Of the 236 replies, 208 usable questionnaire (41.6 percent) were received. The remaining replies were from the controllers who had refused for a variety of reasons to participate in the study. One controller, for example, wrote:

> We are unfortunately buried under a growing number of requirements from the Government, including the FTC Line of Business reporting, the New Pension Reform Act of 1974, the expanded SEC reporting, the Product Safety Commission, the Senate Committee on International Companies, The Environmental Protection Agency, OSHA, and at least a half dozen others that I haven't mentioned.

Another controller noted: "In accordance with Company Policy, we are sorry to inform you that we are unable to respond to your inquiry." Under the protection of anonymith, no attempt was made to identify respondents and/or companies.

Table III-7 summarizes the response patterns/rates of participants to the first and second mailing of the controller's questionnaire and presents a detailed breakdown of the responses by firms in each size of firm and major industry.

The Problem of Nonresponse Bias

Technically, the only way to insure absolute assurance that a sample is representative of the population is to obtain a 100 percent response rate. Because a 100 percent response rate is seldom experienced, study of nonresponses are frequently undertaken to provide additional information concerning potential nonresponse biases other than those associated with random sampling error.[19]

TABLE III-7

RESPONSE PATTERNS/RATES OF THE PARTICIPANTS TO THE FIRST AND SECOND MAILINGS OF THE CONTROLLER'S QUESTIONNAIRE

Population Box Codes (M_iN_i) (1)	No. of Firms in Each Population Box (2)	No. of Questionnaires Mailed per Box (3)	Total Responses Received per Box (4)	Usable Responses per Box (5)	Unusable Responses per Box (6)	Usable Response Rate per Box (7)=(5)/(3)
M_1N_1	71	71	32	27	5	38.2%
M_1N_2	52	52	20	19	1	28.5%
M_1N_3	19	19	10	8	2	42.1%
M_2N_1	60	60	29	25	4	40.1%
M_2N_2	61	61	21	20	1	32.8%
M_2N_3	11	11	7	6	1	54.5%
M_3N_1	22	22	11	10	1	45.4%
M_3N_2	30	30	15	13	2	43.3%
M_3N_3	7	7	5	5	-	71.4%
M_4N_1	76	76	40	35	5	46.0%
M_4N_2	66	66	32	28	4	42.4%
M_4N_3	25	25	14	12	2	48.0%
TOTALS	500	500	236	208	28	

Because the problem of nonresponse is a common one, a number of reliable statistical methods have been devised to eliminate or at least to reduce the bias in any type of survey. For example, the Politz-Simmons method classifies respondents according to the chance of locating them and weighting the responses accordingly.[20] Hansen and Hurwitz have developed a double sampling procedure that offers a formula for determining the number of mail questionnaires to be sent out and the number of personal interviews to complete in following up nonresponses to the mail questionnaires, in order to attain the required precision at minimum cost.[21] Dalenius has prepared a special design of the Hansen-Hurwitz scheme aimed at the "hard to contact" segment of the sample.[22] One may use all these methods to conduct a sample survey of nonresponses either by telephone call or by personal interview. Such actions were not taken here for the following reasons:

1. The more homogeneous the sample, the less concern is needed about obtaining a very high percentage of response.[23] In this study the population was defined as all the controllers of first Fortune 500 major industrial corporations in the United States and thus they were considered to be homogeneous in nature.

With regard to homogeneous population Robinson stated:

> The fact that mail survey is of a sample of a homogeneous population may be a sufficient reason for the researcher to make the practical assumption that returns of 30 percent are at least representative enough for the information gathered to be used.[24]

2. According to Green and Tull, even with added mailings, response to mail questionnaires is generally a small percentage of those sent, the modal response rate is of the order of 20 to 40 percent.[25]

The usable response rate of 41.6% in this study leads reasonably therefore to the assumption that there is no difference between the characteristics of those who responded and those who did not answer the controller's questionnaire. In other words the usable responses were considered to be representative of the population.

3. The anonymity policy expressed in letters accompanying the controller's questionnaire served to reduce any non-response bias due to fear of identification.
4. Practical constraints of time and money precluded through study of nonresponses.

Data Analysis Methodology

Prior to statistical manipulation of data, it was necessary (1) to determine the usability of the questionnaire responses, (2) to code the data into more manageable terms, (3) to transfer the usable responses from controller's questionnaire to data analysis sheets, and (4) to choose the statistical methods to be utilized in the interpretation of data.

Two statistical methods were utilized to interpret the data obtained from the controller's questionnaire. Descriptive statistical analysis, such as means, percentages, and standard deviations, were utilized to analyze the eight research questions in this study summarized in Table III-8.

TABLE III-8

THE EIGHT RESEARCH QUESTIONS ANALYZED IN THE STUDY

1.	What is a controller's overall educational background?
2.	To what extent controllers use the quantitative tools of decision making in business operations?
3.	In what areas of business operations do controllers use quantitative tools of decision making?
4.	How often do controllers use the quantitative tools of decision making in business operations?
5.	In controller's opinion, what overall results have been achieved from using these tools?
6.	What types of business operations problems are analyzed with quantitative tools of decision making by controllers?
7.	What problems are being encountered in using the quantitative tools of decision making in business operations problems?
8.	What qualifications and attributes do controllers look for in a prospective management accountant and/or controller?

The following statistical techniques could have been used to test the hypotheses stated in this study: (1) parametric model--analysis of variance and (2) nonparametric

models such as (a) chi-square test, (b) Kruskal-Wallis H test, and (c) Mann-Whitney U test. However, for the purpose of this study, three-way analysis of variance (unequal cell frequencies) was utilized to test the hypotheses. The reasons for using analysis of variance were: (1) the technique of analysis of variance is one of the most powerful of statistical methods,[26] (2) the techniques of analysis of variance are the most appropriate methods for solving and analyzing the hypotheses such as those stated in this study, (3) the techniques of analysis of variance are insensitive to violation of its most assumptions, and (4) the researcher is able to test hypotheses involving either comparisons of two or more groups on a single variable or the interaction of two or more variables. The total sum of squares was utilized to solve three-way analysis of variance. This method is used because the computer provides answers with speed and accuracy far beyond anything that can be achieved by any other method.[27]

The analysis of variance provides the basis for determining whether several sample means differ significantly. The assumptions underlying the analysis of variance are:

1. Each sample is drawn randomly from a normal universe and sample statistics tend to reflect the characteristics of the universe.
2. The universes from which the samples are drawn have identical means and variances.
3. The null hypothesis is tested in that it is assumed that the dispersion of sample observations is the result of random sampling error.[28]

The reasons for not using nonparametric statistical

tests are two-fold: (1) If all the assumptions of the parametric statistical model[28] are in fact met in the data and if the measurement is of the required strength, then nonparametric statistical tests are wasteful of data. The degree of wastefulness is expressed by the power-efficiency of the nonparametric test. (2) There are yet no nonparametric methods for testing interactions in the analysis of variance model, unless special assumptions are made about additivity.[29]

In addition to three-way analysis of variance, the two-way interactions tests (multivariate and univariate tests) were performed to evaluate the two-way interactions among size of firm, major industry group, and controller's education regarding the frequency of use quantitative tools of decision making in business firms.

Notwithstanding the claim that quantitative tools of decision making could be useful, the hypothesis of this writer was that many of these tools and techniques are not being used in business by controllers. To test this hypothesis, the eight subhypotheses stated in null form were tested. The null hypotheses are summarized in Table III-9. The statistical data concerning the analyses of research questions and the testing of null hypotheses are tabulated and evaluated in Chapter IV of this study.

TABLE III-9

THE EIGHT NULL HYPOTHESES TESTED IN THE STUDY

Ho_1	There is no statistically significant difference between the size of firm (sales) and the level of use of quantitative tools of decision making in business firms.
Ho_2	There is no statistically significant difference between the major industry group (type of industry) and the level of use of quantitative tools of decision making in business firms.
Ho_3	There is no statistically significant difference between the controllers' education and the level of their use of quantitative tools of decision making in business firms.
Ho_4	There is no statistically significant interaction effect among the size of firm (sales) and major industry group (type of industry) and controllers' education with regard to the use of quantitative tools of decision making in business firms.
Ho_5	There is no statistically significant difference between the size of firm (sales) and the level of use of EACH quantitative tool of decision making in business firms.
Ho_6	There is no statistically significant difference between the major industry group (type of industry) and the level of use of EACH quantitative tool of decision making in business firms.
Ho_7	There is no statistically significant difference between the controllers' education and the level of their use of EACH quantitative tool of decision making in business firms.
Ho_8	There is no statistically significant interaction effect among the size of firm (sales), major industry group (type of industry), and controllers' education with regard to the use of EACH quantitative tool of decision making in business firms.

Summary

The purpose of this chapter was to explain the research design and methodology utilized in this study. The steps taken in accomplishing this research project are summarized as follows:

1. Selected the general design of study
2. Designed the controller's questionnaire for ascertaining the corporate controllers' opinions and attitudes toward the objectives of the study stated in Chapter I
3. Conducted a pilot study to assure that the contents of controllers' questionnaires were adequate and understandable
4. Chose the population for the study and determined the potential respondents
5. Classified the population into (1) size of firm (sales), major industry group, and (3) controllers' education.
6. Mailed questionnaire, a cover letter, and a return stamped envelope to the controllers
7. Sent a second questionnaire, a follow-up letter, and a return stamped envelope to nonrespondents
8. Determined the usable questionnaire responses
9. Coded and transferred data to analysis sheet
10. Chose statistical methods for analyzing the research questions and testing the null hypotheses
11. Performed statistical analysis, tested the hypothesis, and analyzed the research questions

12. Prepared the tables and figures of results

13. Prepared the final report of empirical investigation

Chapter III Footnotes

[1]Paul E. Green and Donald S. Tull, Research for Marketing Decisions (Englewood Cliffs, N.J.: Prentice-Hall, Inc., 1966), p. 89.

[2]Jerrey E. Drake and Frank I. Miller, Marketing Research: Intelligence and Management (Scranton, Pennsylvania: International Textbook Company, 1969), p. 104.

[3]Green and Tull, Research for Marketing Decision, op. cit., p. 89.

[4]Ibid., p. 92.

[5]Ibid., p. 93.

[6]Ibid., p. 83.

[7]Paul L. Erdos, Professional Mail Surveys (New York: McGraw-Hill, Inc., 1970), pp. 10-13 and 138-150.

[8]David J. Fox, The Research Process in Education (New York: Holt, Rinehart and Winston, Inc., 1969), pp. 353-360.

[9]While reliability is the basic prerequisite for any research procedure, validity is the most important characteristic for the procedure to possess. A questionnaire is valid if it measures what it purports to measure. One of the usual techniques for measuring the validity of an instrument is a comparison of selected results of the survey with prior survey results, census figures, etc., to determine how well the survey results mirror prior results or census results. These types of techniques deal primarily with the type of question that concerns facts or behavior in the past or present. The questionnaire used in this study, however, did not lend itself to these techniques in that the respondents were estimating or predicting the information that was needed for analyses of the future. In such cases, the criterion of validity may be a specified event in the future rather than a fact in the present or past. A test of the validity of a predictive item would depend on the subsequent events of the item being tested. While a method such as this necessarily implies an after-the-fact approach of testing the validity of a questionnaire, no basis in previous research is currently available for testing the predictive validity of the instrument while the results are being analyzed.

For an excellent source on validity that can be used as a guide, see David J. Fox, The Research Process in Education (New York: Holt, Rinehart and Winston, Inc., 1969), pp. 367-377,

and A. N. Oppenheim, Questionnaire Design and Attitude Measurement (New York: Basic Books, Inc., Publishers, 1966), pp. 69-78.

[10]The Fortune Double 500 Directory of the Largest U.S. Industrial Corporations (New York: The Fortune, May, 1974), p. 3.

[11]The Research Project Corporation is a service company which compiles daily information on the officers, as well as the addresses, of the Fortune Double 500 of the largest U.S. industrial corporations and 50 largest commercial banking, financial, retailing, transportation, and utility companies. The company is located at 50 Clinton Street, Hempstead, N.Y. 11550.

[12]William J. Vatter, "The Use of Operations Research in American Companies," The Accounting Review, Vol. 42 (October, 1967), p. 722.

[13]Executive Office of the President--Office of Management and Budget, Standard Industrial Classification Manual (Washington, D.C.: The Statistical Policy Division, 1972).

[14]U.S., Department of Commerce, Bureau of the Census, Statistical Abstract of the United States, 95 edition (Washington, D.C.: Government Printing Office, 1974), p. 714.

[15]Standard Poor's Register of Corporation, Directors and Executives (New York: Standard & Poor's Corporation, 1974).

[16]Value Line (New York: Arnold Bernhard & Co., Inc., 1974).

[17]The unclassified group consisted of companies such as mining, transportation, trading, services and so forth.

[18]Charles T. Clark and Lawrence L. Schkade, Statistical Methods for Business Decisions (Cincinnati, Ohio: South-Western Publishing Company, 1969), p. 470.

[19]W. Edwards Deming, "On a Probability Mechanism to Attain an Economic Balance between the Resultant Error of Response and the Bias of Nonresponse," Journal of the American Statistical Association, Vol. 48 (December, 1953), pp. 743-772, and Carl F. Refuss, "Differences between Persons Responding to a Mailed Questionnaire," American Sociological Review, Vol. 8, 1943, pp. 433-438.

[20]Alfred Politz and Willard R. Simmons, "An Attempt to Get the Not-at-Homes into the Sample without Call-backs," Journal of the American Statistical Association, Vol. 44 (March, 1949), pp. 9-31.

[21]Morris H. Hansen and William N. Hurwitz, "The Problem of Nonresponse in Sample Surveys," Journal of the American Statistical Association, Vol. 41 (December, 1946), pp. 517-529.

[22]Tore Dalenius, "The Treatment of the Nonresponse Problem," Journal of Advertising Research, Vol. 1 (September, 1961), pp. 1-7.

[23]Raymond Franzen and Paul F. Lazarfeld, "Mail Questionnaire as a Research Problem," Journal of Psychology, Vol. 5 (October, 1945), pp. 293-320.

[24]David M. Robinson, Writing Reports for Management Decisions (Columbus, Ohio: Charles E. Merrill Publishing Co., 1969), pp. 138-139.

[25]Paul E. Green and Donald S. Tull, Research for Marketing Decisions (Englewood Cliffs, N.J.: Prentice-Hall, Inc., 1966), p. 158.

[26]Ibid., p. 515.

[27]Ibid., p. 472.

[28]Because the parametric statistical test was used in this study, the variables involved (i.e., the 10 quantitative tools of decision making listed in Table IV-21 on page 114) have been measured with interval scale. According to Siegel the assumptions underlying ordinal and interval measurement are:

1. That the scores we observe are drawn from an underlying continuous distribution. An underlying continuous variate is one that is not restricted to having only isolated values. It may have any value in a certain interval.

2. That the variable being scaled is normally distributed in the individuals being tested.

See Sidney Siegel, Nonparametric Statistics for the Behavioral Sciences (New York: McGraw-Hill Book Company, 1956), pp. 25-27.

With regard to interval measurement and parametric statistical test, Stanford Labovitz argued:

> There are situations where it is advantageous to select the more powerful classical techniques [parametric statistical tests--analysis of variance], even though certain assumptions are not met, or the measurement scale is not exactly interval or ratio. The arguments to support this position are (1) the insensitivity of ordinal and other nonparametric techniques, e.g., the waste of information by not considering the distance between ranks, (2) the small error that results from assigning numbers to ordinal data and then treating the categories as if they conform to an interval scale, (3) tests of statistical robustness, which have shown that certain tests are interpretable, although selected assumptions are not met, and (4) the power-efficiency of tests.

See Sanford Labovitz, "Some Observations on Measurement and Statistics," Social Forces, Vol. 46, No. 2 (December, 1967), pp. 159-160.

CHAPTER IV

ANALYSES OF FINDINGS OF EMPIRICAL INVESTIGATION

The extent to which certain quantitative tools of decision making have become an active part of business can be best determined by direct contact with the users and the potential users of quantitative analytical techniques. To establish such contact, a mail survey was conducted of all the controllers of Fortune 500 industrial corporations in the United States. The practices of this group of corporations, because of its prominent role in American industry, should reflect the latest management techniques such as those stated in this study.

This research project was designed to investigate empirically the eight research questions and the eight hypotheses stated in Chapter III. The main objective of the study was to ascertain the corporate controllers' opinions and attitudes regarding (a) either the appropriateness or the inappropriateness of quantitative tools of decision making for accountants, (b) the extent and the level of business usage of quantitative tools currently taught in college courses in managerial accounting, and (3) the desirable job qualifications of the potential controller and/or management accountants. Descriptive statistical measures such as means,

standard deviations, rankings, and percentages were used to analyze and answer the research questions; and a three-way analysis of variance (multivariate and univariate) was utilized to test the null hypotheses. The subsequent discussion focuses on the analysis of research questions and the null hypotheses of this study.

Analysis of Research Questions

The research questions were used to gather information about the extent and the level of use of quantitative tools of decision making by controllers in business today. The research questions were designed to ascertain the controller's educational background and business experience; the level of usage, the degree of success (i.e., the results achieved), and the difficulties encountered in the application of these tools; and the future outlook for the controllership function.

Eight research questions were included in the controller's questionnaire. Section I of the questionnaire sought such biographical data as the official title of the controller, previous positions held, and the educational background. Section II contained questions about specific quantitative tools of decision making applicable to business firms. In Section III, the respondent was asked for views regarding the attributes and the qualifications of controllers in the future. The subsequent discussion presents the analysis of these research questions.

Section I of Controller's Questionnaire--Biographical Data

The study found that respondents had held various positions before becoming controllers in their respective corporations. In fact, 87.60 percent of respondents have worked in industrial accounting with an average of 11 years' experience; the remaining 12.4 percent worked in public accounting as CPAs (i.e., partners and managers) prior to becoming controllers with an average of 12 years' public accounting experience.

The Results of Research Question Number One--Educational Background

The first research question concerning the controller's educational background was the following: What is a controller's overall educational background?

This study provided the following data about each responding controller:

1. Information concerning the controller's formal education, such as college attendance; number of years completed; majors; and highest degrees earned.
2. Attendance at training sessions and/or seminars concerning such quantitative tools of decision making as flexible budgeting, present-value concepts, linear programming, and so forth?
3. Method of acquiring knowledge of any quantitative tools of decision making now being used.

All 208 responding controllers have attended college

for an average of 5 years. Tables IV-1 and IV-2 provide information concerning the controllers' highest college degrees earned, as well as their college majors.

TABLE IV-1

CONTROLLERS' HIGHEST COLLEGE DEGREES

Degree	Number	Percent
Bachelor of Arts (B.A.)	68	32.69
Bachelor of Science (B.S.)	46	22.12
Bachelor of Business Administration (B.B.A.)	22	10.58
Master of Business Administration (M.B.A.)	71	34.13
Ph.D.	1	.48
Totals	208	100

TABLE IV-2

CONTROLLERS' COLLEGE MAJORS

Area of Concentration	Number	Percent
Accounting	138	66.35
Finance	24	11.54
Business Administration	18	8.65
Management	13	6.25
Economics	8	3.85
Commerce	3	1.44
Management Science	2	.96
Mathematics	1	.48
Operations Research	1	.48
Totals	208	100

A total of 159 or 76.44 percent of the responding controllers have attended training and seminars sessions on the use of one or more of such quantitative tools of decision making as flexible (variable) budgeting, present-value concepts, linear programming, sensitivity analysis (risk analysis), forecasting techniques (regression analysis, exponential smoothing, etc.), statistical techniques (sampling and Bayesian statistics), simulation models, and inventory models. This high rate of participation may imply that the controllers realize that these tools are appropriate to the controllership function.

Table IV-3 shows the sources of controllers' knowledge of specific quantitative tools of decision making. The data in Table IV-3 indicate that a relatively small number of responding controllers acquired their knowledge of respective tools during their formal education. There are three reasons for the small numbers: (1) the majority of controllers have attended college during 1940's and 1950's,[1] (2) these tools have been developed during the recent years,[2] and (3) there is a relatively little emphasis on these tools at the college and university level.[3] Undoubtedly, the information in Table IV-3 also indicates that controllers and/or management accountants are cognizant of the need to keep abreast of current developments and have taken steps to acquire such knowledge, primarily by participating in executive training programs and professional development programs

TABLE IV-3

A SUMMARY OF SOURCES OF CONTROLLERS' KNOWLEDGE OF SPECIFIC QUANTITATIVE TOOLS OF DECISION MAKING
(Amounts Expressed as Numbers and Percentages)

Tools	Source of Knowledge											
	Formal Training		Executive Training Programs		Professional Development Programs		Self Study Via Prof. Journals &/or Textbooks		Working With Consultants		Job Training and Business Experience	
1. Flexible (Variable) Budgeting	108	61.36	25	14.20	20	11.36	77	43.75	16	9.09	18	10.23
2. Present Value Concepts	93	52.84	26	14.77	24	13.64	76	43.18	17	9.66	14	7.95
3. Linear Programming	52	29.55	31	17.61	30	17.05	37	21.02	17	9.66	10	5.68
4. Sensitivity Analysis (Risk Analysis)	42	23.86	28	15.91	36	20.45	56	31.82	14	7.95	13	7.39
5. Forecasting Techniques (Regression Analysis, Exponential Smoothing, Moving Average)	70	39.77	35	19.89	37	21.02	55	31.25	17	9.66	20	11.36
6. Statistical Techniques (Sampling and Bayesian Statistics)	83	47.16	20	11.36	36	20.45	43	24.43	13	7.39	13	7.39
7. Network Analysis (PERT and CPM)	43	24.43	35	19.89	33	18.75	42	23.86	19	10.80	16	9.09
8. Simulation Models (Includes Computer Simulation)	30	17.05	32	18.18	42	23.86	48	27.27	29	16.48	12	6.82
9. Inventory Models (e.g., EOQ)	70	39.77	25	14.20	35	19.89	41	23.30	11	6.25	13	7.39

Note: (1) The respondents allowed to check more than one item.

(2) The total respondents who use quantitative tools of decision making are 176.

through self-study via professional journals and/or textbooks, by working with consultants and on-the-job training. Self-study via professional journals and/or textbooks was the second most frequent source of knowledge of these tools. This finding may help explain the reason for recent changes in professional journals and textbooks from descriptive to more quantitative materials and is supported in current accounting literature that cites varied uses of most of these concepts and tools.

In summary, the conclusion can be drawn from the research question number one that controllers are familiar with and have knowledge of one or more quantitative tools of decision making.

Section II of Controller's Questionnaire--Information Concerning the Quantitative Tools of Decision Making

The purpose of this section was to provide information concerning the quantitative tools of decision making being used in business by controllers. Moreover, the intent was to determine the extent and the level of business usage of specific quantitative techniques currently being taught in managerial accounting courses in colleges. The subsequent discussion centers on the answers to questions 2 through 7.

Results of Research Question Number Two--Extent of Usage of Quantitative Tools

The second research question concerning the levels of usage of quantitative tools of decision making to business problems was: To what extent do controllers use quantitative tools of decision making in business operations?

As shown in Table IV-4, 176 or 84.62 percent of the controllers use one or more quantitative tools of decision making in performing their controllership function. The high percentage level of usage is a good indication that these tools are being used by the controllers.

Table IV-4 classifies the respondents according to (1) the size of firm (sales), (2) the type of industry (major industry), and (3) the controller's education. The controllers in firms with sales over $1 billion used the quantitative tools of decision making 92 percent; in firms with sales ($700-$999.50 million), 85.71 percent; and in firms with sales between $400-$699.50 million and less than $399.50 million, 80 and 78.18 percent, respectively. This may indicate that there is a relationship between the size of firm (sales) and the level of use of quantitative tools of decision making in business firms.[4]

Table IV-4 also provides information concerning the extent and the level of use by types of industry. The controllers in unclassified firms (oil and gas extraction, metal mining, etc.) used the quantitative tools of decision making 90.32 percent; in nondurable manufacturing firms (petroleum, chemicals, rubber and plastics, etc.), 85.71 percent; and in durable manufacturing firms (primary metals, machinery, lumber, wood products, etc.), 84.69 percent. These findings imply that there is no apparent relationship between the type of industry and the level of

TABLE IV-4

A SUMMARY OF THE OVERALL LEVELS OF USE OF QUANTITATIVE TOOLS OF DECISION MAKING BY CONTROLLERS
(Amounts Expressed as Numbers and Percentages)

Responses	Size of Firm (Sales)				Type of Industry			Controllers' Education		Total Respondents
	M_1	M_2	M_3	M_4	N_1	N_2	N_3	E_1	E_2	
Yes:										
Number	43	40	24	69	83	65	28	111	65	176
Percent	78.18	80.00	85.71	92.00	84.69	85.71	90.32	79.86	94.20	84.62
No:										
Number	12	10	4	6	15	14	3	28	4	32
Percent	21.82	20.00	14.29	8.00	15.31	14.29	9.68	20.14	5.80	15.38
Total Respondents	55	50	28	75	98	79	31	139	69	208
Percent	100	100	100	100	100	100	100	100	100	100

Where: M_1 = Less than $399.50 million
M_2 = $400 - 699.50 million
M_3 = $700 - 999.50 million
M_4 = Over 1 billion

N_1 = Durable manufacturing
N_2 = Nondurable manufacturing
N_3 = Unclassified firms

E_1 = Bachelor's degree or equivalent
E_2 = Master's degree or above

use of tools of decision making in business firms.[5]

Table IV-4 also shows that controllers with higher education used quantitative tools 94.2 percent while controllers with bachelor's degree or equivalent used these tools 79.86 percent in performing their controllership function. This implies that there is a relationship between the controller's education and the level of use of quantitative tools of decision making in business firms.[6]

Results of Research Question Number Three--Areas of Use of Quantitative Tools

The third research question concerning the areas of business operations in which controllers use quantitative tools of decision making was: In what areas of business operations do controllers use quantitative tools of decision making?

This research question attempted to determine the areas of business operations in which these tools are being used. The areas of business operations were classified according to: (1) production, (2) marketing and distribution, and (3) accounting (general, managerial, financial).

The use of quantitative tools of decision making in the areas of business operations such as production, marketing/distribution, and accounting is shown in Tables IV-5, IV-6, and IV-7. In these tables, the respondents are classified by (a) size of firm (sales), (b) major industry group (type of industry), and (c) controller's education. Table IV-8 summarizes the use of quantitative tools of decision making in the areas of business operations by controllers. As shown by Table IV-8, 79.81 percent of the respondents indicated that certain quantative tools were

TALBE IV-5

A SUMMARY OF USE OF QUANTITATIVE TOOLS OF DECISION MAKING IN PRODUCTION BY CONTROLLERS
(Amounts Expressed as Numbers and Percentages)

Responses	Size of Firm (Sales)				Type of Industry			Controllers' Education		Total Respondents
	M_1	M_2	M_3	M_4	N_1	N_2	N_3	E_1	E_2	
Yes:										
Number	33	35	22	62	74	56	22	95	57	152
Percent	60	70	78.57	82.67	75.51	70.89	70.97	68.35	82.61	73.08
No:										
Number	22	15	6	13	24	23	9	44	12	56
Percent	40	30	21.43	17.33	24.49	29.11	29.03	31.65	17.39	26.82
Total Respondents	55	50	28	75	98	79	31	139	69	208
Percent	100	100	100	100	100	100	100	100	100	100

Where: M_1 = Less than \$399.5 million
M_2 = \$400 - 699.50 million
M_3 = \$700 - 999.50 million
M_4 = Over \$1 billion

N_1 = Durable manufacturing
N_2 = Nondurable manufacturing
N_3 = Unclassified firms

E_1 = Bachelor's degree or equivalent
E_2 = Master's degree and above

TABLE IV-6

A SUMMARY OF USE OF QUANTITATIVE TOOLS OF DECISION MAKING IN MARKETING AND DISTRIBUTION BY CONTROLLERS
(Amounts Expressed as Numbers and Percentages)

Responses	Size of Firm (Sales)				Type of Industry			Controllers' Education		Total Respondents
	M_1	M_2	M_3	M_4	N_1	N_2	N_3	E_1	E_2	
Yes:										
Number	24	31	18	58	59	56	16	79	52	131
Percent	43.64	62	64.29	77.33	60.20	70.89	51.61	56.83	75.36	62.98
No:										
Number	26	19	10	17	39	23	15	60	17	77
Percent	56.36	38	35.71	22.67	39.80	29.11	48.39	43.17	24.74	37.02
Total Respondents	55	50	28	75	98	79	31	139	69	208
Percent	100	100	100	100	100	100	100	100	100	100

Where: M_1 = Less than \$399.50 million
M_2 = \$400 - \$699.50 million
M_3 = \$700 - \$999.50 million
M_4 = Over \$1 billion

N_1 = Durable manufacturing
N_2 = Nondurable manufacturing
N_3 = Unclassified firms

E_1 = Bachelor's degree or equivalent
E_2 = Master's degree and above.

TABLE IV-7

A SUMMARY OF USE OF QUANTITATIVE TOOLS OF DECISION MAKING IN ACCOUNTING (GENERAL, MANAGERIAL, FINANCIAL)
(Amounts Expressed as Numbers and Percentages)

Responses	Size of Firm (Sales)				Type of Industry			Controllers' Education		Total Respondents
	M_1	M_2	M_3	M_4	N_1	N_2	N_3	E_1	E_2	
Yes:										
Number	39	37	23	67	80	60	26	105	61	166
Percent	70.91	74.00	82.14	89.33	81.63	75.95	83.87	75.54	88.41	79.81
No:										
Number	16	13	5	8	18	19	5	24	8	42
Percent	29.09	26	17.86	11.67	18.37	24.05	16.13	24.46	11.59	20.19
Total Respondents	55	50	28	75	98	79	31	139	69	208
Percent	100	100	100	100	100	100	100	100	100	100

Where: M_1 = Less than \$399.50 million
M_2 = \$400 - \$699.50 million
M_3 = \$700 - \$999.50 million
M_4 = Over \$1 billion

N_1 = Durable manufacturing
N_2 = Nondurable manufacturing
N_3 = Unclassified firms

E_1 = Bachelor's degree or equivalent
E_2 = Master's degree and above

TABLE IV-8

OVERALL SUMMARY OF USE OF QUANTITATIVE TOOLS OF DECISION MAKING IN THE AREAS OF BUSINESS OPERATIONS BY CONTROLLERS
(Amounts Expressed as Numbers and Percentages)

Responses	Production	Marketing and Distribution	Accounting (General, Managerial, Financial)
Yes:			
Number	152	131	166
Percent	73.08	62.98	79.81
No:			
Number	56	77	42
Percent	26.92	37.01	20.19
Total Respondents	208	208	208
Percent	100	100	100

being applied with their firms to managerial or financial accounting activities, 73.08 percent indicated application of such tools to production problems, and 62.98 percent indicated use of such tools to analysis marketing activities.

The Results of Research Question Number Four--Frequency of Use of Quantitative Tools

The fourth research question concerning the frequency of use of the quantitative tools of decision making by controllers was: How often do controllers use the quantitative tools of decision making in business operations?

The purpose of this research question was to determine how often the controllers use these tools in performing their controllership function. Table IV-9 shows the frequency of use by total number of controllers who use these tools, percentage of frequency of use, total frequency score, and rank for each tool. This table is a summary of Tables C_1 through C_9 tabulated in Appendix C. The frequency of use was scored on a scale from zero to four (0 = never, 1 pt. = rarely, 2 pts. = occasionally, 3 pts. = periodically, and 4 pts. = routinely). A total frequency score was computed for each tool to measure the frequency of use of each tool. The tools then were ranked according to their total frequency of use score. In Table IV-10, the importance of quantitative tools of decision making is weighted by frequency of use by controllers. This table also classifies the respondents as to (a) size of firm (sales), (b) major industry group (type

TABLE IV-9

A SUMMARY OF FREQUENCY USE OF QUANTITATIVE TOOLS OF DECISION MAKING BY CONTROLLERS
(Amounts Expressed as Numbers and Percentages)

Quantitative Tools of Decision Making	Routinely (4 pts)	Periodically (3 pts)	Occasionally (2 pts)	Rarely (1 pt)	Total # Controllers Using Tools	Total Frequency Score	Rank
1. Flexible (Variable) Budgeting	120 68.2%*	22 12.5%	11 6%	13 7%	166 94.3%	581	(2)
2. Present Value Concepts	99 56.3	56 31.8	14 8	4 2	173 98.3	596	(1)
3. Linear Programming	27 15.3	44 25	57 32.4	22 12.5	150 85.2	376	(8)
4. Sensitivity Analysis (Risk Analysis)	38 21.6	39 22.2	40 22.7	35 19.9	152 86.4	384	(6)
5. Forecasting Techniques (Regression Analysis, Exponential Smoothing, etc.)	62 35.2	42 23.9	41 23.3	13 71	158 89.8	469	(3)
6. Simulation Models	33 18.8	49 27.8	53 30.1	23 13.1	158 89.8	408	(5)
7. Statistical Techniques (Sampling and Bayesian Statistics)	34 19.3	38 21.60	50 28.4	30 17	152 86.4	380	(7)
8. Network Analysis (PERT and CPM)	32 18.2	33 18.8	48 27.3	31 17.6	144 81.8	354	(9)
9. Inventory Models (e.g.EOQ)	56 31.8	34 19.3	35 19.9	33 18.8	158 89.8	439	(4)

(1) Total respondents who use quantitative tools of decision making are 176.
(2) Total frequency score computed by multiplying number of users of each tool times number of points given to each interval scale, e.g.,
total frequency score of flexible budgeting = (120x4)+(22x3)+(11x2)+(13x1) = 581
(3) This table is a summary of Tables C_1 through C_9 in Appendix C.
(4) The ranking of quantitative tools are made according to total frequency score.
* 120/176 = 68.2%

of industry) and controller's education. As indicated in both Table IV-9 and Table IV-10, the tools ranked in the same order as follows according to both (a) the total frequency[7] of use score and (b) averages of frequency of use:

1. Present Value Concepts
2. Flexible (Variable) Budgeting
3. Forecasting Techniques (Regression Analysis, Exponential Smoothing, etc.)
4. Inventory Models
5. Simulation Models
6. Sensitivity Analysis (Risk Analysis)
7. Statistical Techniques (Sampling and Bayesian Statistics)
8. Linear Programming
9. Network Analysis (PERT, CPM)

The Results of Research Question Number Five--The Degree of Success of Quantitative Tools

The fifth research question concerning the controllers' opinions regarding the results achieved from using quantitative tools of decision making was the following: In the controller's opinion, what overall results have been achieved from using these tools?

The purpose of this research question was to measure the degree of success achieved in each application. Table IV-11 presents the number of controllers using tools, the percentages of the degree of success, as well as the total degree of success score and the rank for each tool. This table is a summary of Tables C_{10} through C_{18} tabulated in

TABLE IV-10

A SUMMARY OF IMPORTANCE OF QUANTITATIVE TOOLS OF DECISION MAKING
WEIGHTED BY FREQUENCY OF USE BY CONTROLLERS
(Amount., Expressed as Averages)*

Quantitative Tools	Size of Firm (Sales)								Type of Industry						Controllers' Education				Total Respondents	
	M_1		M_2		M_3		M_4		N_1		N_2		N_3		E_1		E_2			
	Ave.	Rank	Ave.	Rank	Ave.	Rank	Ave.	Rank	Ave.	Rank	Ave.	Rank	Ave.	Rank	Ave.	Rank	Ave.	Rank	Ave.	Rank
1. Flexible (Variable) Budgeting	3.12	(1)	3.32	(1)	3.54	(1)	3.32	(2)	3.48	(1)	2.95	(1)	3.57	(1)	3.41	(1)	3.12	(2)	3.30	(2)
2. Present Value Concepts	3.05	(2)	3.45	(1)	3.17	(2)	3.64	(1)	3.36	(2)	3.43	(2)	3.36	(2)	3.33	(2)	3.48	(1)	3.39	(1)
3. Linear Programming	1.74	(7)	1.95	(9)	2.46	(5)	2.38	(5)	1.93	(9)	2.26	(4)	2.46	(3)	2.08	(7)	2.23	(7)	2.14	(8)
4. Sensitivity Analysis (Risk Analysis)	1.51	(8)	2.55	(4)	2.25	(8)	2.36	(7)	2.16	(6)	2.09	(7)	2.46	(4)	2.05	(8)	2.42	(4)	2.18	(6)
5. Forecasting Techniques (Regression Analysis, Exponential Smoothing, etc.)	2.40	(3)	2.77	(3)	2.83	(3)	2.71	(3)	2.83	(3)	2.55	(3)	2.43	(5)	2.62	(3)	2.73	(3)	2.66	(3)
6. Simulation Models	2.02	(5)	2.55	(5)	2.33	(6)	2.38	(6)	2.45	(5)	2.17	(6)	2.29	(7)	2.28	(5)	2.38	(5)	2.32	(5)
7. Statistical Techniques (Sampling and Bayesian Statistics)	1.86	(6)	2.05	(8)	2.29	(7)	2.36	(8)	2.11	(7)	2.23	(5)	2.14	(9)	2.23	(6)	2.05	(9)	2.16	(7)
8. Network Analysis (PERT and CPM)	1.51	(9)	2.07	(7)	2.00	(9)	2.29	(9)	2.02	(8)	1.88	(9)	2.29	(8)	1.93	(9)	2.15	(8)	2.01	(9)
9. Inventory Models (e.g., EOQ)	2.16	(4)	2.40	(6)	2.50	(4)	2.46	(4)	2.63	(4)	2.05	(8)	2.43	(6)	2.38	(4)	2.38	(6)	2.38	(4)

Where: M_1 = Less than $399.50 million
M_2 = $400 - $699.50 million
M_3 = $700 - $999.50 million
M_4 = Over $ 1 billion

N_1 = Durable manufacturing
N_2 = Nondurable manufacturing
N_3 = Unclassified firms

E_1 = Bachelor's degree or equivalent
E_2 = Master's degree and above

* Averages are computed by dividing total frequency score (see Table IV-9) into total number of respondents who use quantitative tools of decision making (i.e., 176). Example:

$$\text{Overall average for flexible budgeting} = \frac{\text{Total Frequency Score}}{\text{Total No. of Users}} = \frac{581}{176} = 3.30$$

TABLE IV-11

A SUMMARY OF NUMBER OF CONTROLLERS' OPINIONS CONCERNING THE OVERALL RESULTS ACHIEVED FROM USING QUANTITATIVE TOOLS OF DECISION MAKING
(Amounts Expressed as Numbers and Percentages)

Quantitative Tools of Decision Making	Degree of Success: Very Good (4 pts)	Good (3 pts)	Fair (2 pts)	Poor (1 pt)	Total # of Controllers Using Tools	Total Degree of Success Score	Rank
1.Flexible (Variable) Budgeting	67 38.1%*	68 38.6%	27 15.3%	1 0	161 91.4%	527	2
2.Present Value Concepts	68 38.6	85 48.3	18 10.2	0 0	171 97.2	563	1
3.Linear Programming	23 13.1	54 30.7	59 33.5	8 .5%	142 80.7	380	7
4.Sensitivity Analysis (Risk Analysis	22 12.5	45 25.6	62 35.2	16 .9	145 82.4	363	9
5.Forecasting Techniques (Regression Analysis, Exponential Smoothing, Moving Average)	31 17.6	71 40.0	44 25.0	11 .6	157 89.2	436	3
6.Simulation Models (Includes Computer Simulation)	21 11.9	64 36.4	54 30.7	15 .8	154 87.5	399	4
7.Statistical Techniques (Sampling and Bayesian Statistics)	26 14.8	58 32.9	52 29.5	12 .7	148 84.1	394	5
8.Network Analysis (PERT and CPM)	18 10.2	62 35.2	53 30.1	10 .6	143 81.3	374	8
9.Inventory Models (e.g.,EOQ)	30 17.0	53 30.1	49 27.8	10 .6	142 80.7	387	6

(1) Total respondents who use quantitative tools of decision making are 176.
(2) Total degree of success score computed by multiplying number of respondents who use each tool times number of points assigned to each interval scale, e.g., total frequency score for flexible budgeting=(67x4)+(68x3)+(27x2)+(1x1) = 527
(3) This table is a summary of Tables C_{10} through C_{18} in Appendix C
(4) The ranking of quantitative tools are made according to the total degree of success score.

* 67/176 = 38.1%

Appendix C. The degree of success was ranged from zero to four for the purpose of data analysis (i.e., never = 0, poor = 1 pt., fair = 2 pts., good = 3 pts., and very good = 4 pts.). A total degree of success score was computed for each tool and the tools were then ranked according to their success score. As indicated in Table IV-11, the tools are ranked in the following order: (1) present value concepts, (2) flexible budgeting, (3) forecasting techniques, (4) simulation models, (5) statistical techniques, (6) inventory models, (7) linear programming, (8) network analysis, and (9) sensitivity analysis (risk analysis). Table IV-12 shows the importance of quantitative tools of decision making weighted by the degree of success achieved by controllers. The respondents are classified according to (a) size of firm (sales), (b) major industry (type of industry), and (c) controller's education. The tools in each classification are ranked according to the averages of degree of success. The overall results of the rankings in Table IV-12 are the same as those in Table IV-11.

The Results of Research Question Number Six--Types of Business Problems

The sixth research question concerning the types of business problems analyzed by controllers with quantitative tools of decision making was: What types of business operations problems are analyzed with quantitative tools of decision making by controllers?

The purpose of this research question was to determine

TABLE IV-12

A SUMMARY OF IMPORTANCE OF QUANTITATIVE TOOLS OF DECISION MAKING
WEIGHTED BY OVERALL RESULTS ACHIEVED BY CONTROLLERS
(Amounts Expressed as Averages)

Quantitative Tools	Size of Firm (Sales)								Type of Industry						Controllers' Education				Total Respondents	
	M_1		M_2		M_3		M_4		N_1		N_2		N_3		E_1		E_2			
	Ave.	Rank	Ave.	Rank	Ave.	Rank	Ave.	Rank	Ave.	Rank	Ave.	Rank	Ave.	Rank	Ave.	Rank	Ave.	Rank	Ave.	Rank
1. Flexible (Variable) Budgeting	2.88	(2)	2.88	(2)	3.25	(1)	3.04	(2)	3.23	(1)	2.63	(2)	3.14	(2)	3.07	(2)	2.86	(2)	2.99	(2)
2. Present Value Concepts	3.16	(1)	3.13	(1)	2.92	(2)	3.36	(1)	3.19	(2)	3.20	(1)	3.21	(1)	3.13	(1)	3.32	(1)	3.20	(1)
3. Linear Programming	1.77	(8)	2.27	(7)	2.21	(5)	2.32	(5)	2.01	(9)	2.29	(5)	2.29	(6)	2.07	(7)	2.31	(6)	2.16	(7)
4. Sensitivity Analysis (Risk Analysis)	1.53	(9)	2.47	(5)	2.00	(8)	2.17	(9)	2.07	(8)	1.97	(8)	2.25	(8)	1.98	(9)	2.20	(8)	2.06	(9)
5. Forecasting Techniques (Regression Analysis, Exponential Smoothing, etc.)	2.33	(3)	2.67	(3)	2.25	(4)	2.54	(3)	2.55	(3)	2.37	(3)	2.50	(3)	2.40	(3)	2.62	(3)	2.48	(3)
6. Simulation Models	2.07	(4)	2.57	(4)	2.04	(7)	2.29	(8)	2.43	(4)	2.14	(7)	2.07	(9)	2.27	(5)	2.26	(7)	2.27	(4)
7. Statistical Techniques (Sampling and Bayesian Statistics)	1.98	(5)	2.22	(9)	2.17	(6)	2.43	(4)	2.14	(7)	2.31	(4)	2.36	(4)	2.30	(4)	2.14	(9)	2.24	(5)
8. Network Analysis (PERT and CPM)	1.84	(7)	2.27	(8)	1.83	(9)	2.32	(6)	2.22	(6)	1.94	(9)	2.29	(7)	2.00	(8)	2.34	(4)	2.13	(8)
9. Inventory Models (e.g., EOQ)	1.95	(6)	2.38	(6)	2.50	(8)	2.30	(7)	2.30	(5)	2.17	(6)	2.36	(5)	2.22	(6)	2.34	(5)	2.20	(6)

Where: M_1 = Less than $399.50 million
M_2 = $400 - $699.50 million
M_3 = $700 - $999.50 million
M_4 = Over $1 billion

N_1 = Durable manufacturing
N_2 = Nondurable manufacturing
N_3 = Unclassified firms

E_1 = Bachelor's degree or equivalent
E_2 = Master's degree and above

what specific tools are used for analyzing each purpose or problem in business operations. Table IV-13 summarizes the number of controllers applying these quantitative tools of decision making to business problems. This table is a summary of Tables C_{19} through C_{27} in Appendix C. The tables in Appendix C classify the respondents according to (a) size of firm (sales), (b) major industry group (type of industry), and (c) controller's education who applied these tools to business problems. Table IV-13 also provides information concerning the ranking of quantitative tools of decision making, as well as the business operations problems. The tools are ranked as follows according to total number of controllers who used the tools:

1. Flexible Budgeting
2. Linear Programming
3. Present Value Concepts
4. Forecasting Techniques
5. Simulation Models
6. Statistical Techniques
7. Network Analysis (PERT and CPM)

Furthermore, the business operations problems ranked as follows on the total number of controllers who use these tools.

1. Production Planning and Control
2. Financial Forecasting and Budgeting
3. Analyzing Capital Investment Projects
4. Facilities Planning
5. Forecasting Demand, Supply, and Price

TABLE IV-13

A SUMMARY OF NUMBER OF CONTROLLERS APPLYING QUANTITATIVE TOOLS OF DECISION MAKING TO BUSINESS OPERATION PROBLEMS
(Amounts Expressed as Numbers and Percentages)

Business Problems	Linear Programming		Flexible Budgeting		PERT and CPM		Present Value Concepts		Forecasting Techniques		Simulation		Statistical Techniques		Total	Rank
1. Production Planning and Control	87	49.43*	58	32.95	30	17.05	34	19.32	60	34.09	58	32.95	30	17.05	356	1
2. Make-or-Buy Decisions	27	15.34	30	17.05	6	3.41	105	59.66	24	13.64	17	9.66	15	8.52	224	6
3. Production Mix	61	34.66	31	17.61	8	4.55	12	6.82	44	25.00	29	16.48	12	6.82	197	7
4. Blending Mix (e.g., gasoline)	52	29.55	12	6.82	2	1.14	4	2.27	9	5.11	16	9.09	4	2.27	99	25
5. Distribution (Transportation Problem)	65	36.93	20	11.36	11	6.25	11	6.25	17	9.66	37	21.02	11	6.25	172	10
6. Plant and Warehouse Allocation	41	23.30	23	13.07	15	8.52	21	11.93	17	9.66	27	15.34	14	7.95	158	13
7. Joint Product Costs	32	18.18	45	25.57	1	0.57	17	9.66	8	4.55	13	7.39	15	8.52	131	19
8. Opportunity Costs	6	3.41	22	12.50	12	6.82	73	41.48	13	7.39	9	5.11	13	7.39	148	16
9. Analyzing Capital Investment Projects	13	7.39	19	10.80	33	18.75	127	72.16	27	15.34	23	13.07	17	9.66	259	3
10. Transfer Pricing	29	16.48	30	17.05	4	2.27	10	5.68	10	5.68	13	7.39	9	5.11	105	24
11. Planning and Developing Internal and External Audit	2	1.14	17	9.66	46	26.14	6	3.41	13	7.39	9	5.11	44	25.00	137	18
12. Forecasting Demand, Supply and Price	14	7.95	26	14.77	7	3.98	19	10.80	86	48.86	35	19.89	44	25.00	231	5
13. Financial Forecasting & Budgeting	9	5.11	69	39.20	8	4.55	35	19.89	77	43.75	46	26.14	46	26.14	290	2
14. Replacement and Maintenance of Machinery/Equipt.	5	2.84	17	9.66	16	9.09	45	25.57	14	7.95	35	19.89	18	10.23	150	14
15. Planning and Implementing Revisions of Accounting Systems (e.g., Standard Costs)	6	3.41	47	26.70	48	27.27	3	1.70	11	6.25	12	6.82	19	10.80	146	15
16. Material Allocation	45	25.57	21	11.93	4	2.27	2	1.14	19	10.80	14	7.95	15	8.52	120	22
17. Inventory Analysis and Control	21	11.93	22	12.50	12	6.82	11	6.25	39	22.16	30	17.05	51	28.98	186	9
18. Project Planning and Control	16	9.09	26	14.77	63	35.80	34	19.32	22	12.50	22	12.50	27	15.34	210	8
19. Quality Control	14	7.95	5	2.84	7	3.98	3	1.70	9	5.11	12	6.82	73	41.48	123	21
20. Capacity	40	22.73	23	13.07	15	8.52	18	10.23	23	13.07	27	15.34	16	9.09	162	12
21. Planning and Controlling the Budgetary Process	8	4.55	71	40.34	36	20.45	13	7.39	26	14.77	13	7.39	13	7.39	168	11
22. Contribution Margin	28	15.91	60	34.09	5	2.84	11	6.25	11	6.25	14	7.94	11	6.25	140	17
23. Differential Cost Studies	21	11.93	45	25.57	11	6.25	21	11.93	12	6.82	9	5.11	9	5.11	128	20
24. Departmental Cost	10	5.68	79	44.89	5	2.84	3	1.70	13	7.39	3	1.70	3	1.70	116	23
25. Facilities Planning	51	28.98	28	15.91	27	15.34	54	30.68	29	16.48	39	22.16	20	11.36	240	4
Total	703		846		432		692		633		562		549			
Rank	2		1		7		3		4		5		6			

Note: (1) This table is a summary of Tables C_{20}-C_{27} in Appendix C.

(2) Total respondents who use quantitative tools of decision making are 176.

*87/176 = 49.43%

6. Make-or-Buy Decision
7. Production Mix
8. Project Planning and Control
9. Inventory Analysis and Control
10. Distribution--Transportation Problems and so forth

The Results of Research Question Number Seven--Major Barriers in Implementation of Quantitative Tools

The seventh research question concerning difficulties in either the implementation or the use of quantitative tools of decision making by controllers was: What difficulties are being encountered in using the quantitative tools of decision making in business operations problems?

The purpose of this research question was to determine the major barriers in implementation of these tools. Table IV-14 shows the number of controllers encountering various difficulties in using quantitative tools of decision making. This table classifies the respondents according to (a) size of firm, (b) major industry group, and (c) controller's education, and total respondents who did use or applied the tools. These difficulties are ranked for each classification according to percentage of controllers who use quantitative tools. The difficulties are ranked as follows:

1. Top management does not understand.
2. Returns from expenditures on these tools are inadequate.
3. Accounting data are incompatible with modeling requirements.

TABLE IV-14

A SUMMARY OF NUMBER OF CONTROLLERS' ENCOUNTERING VARIOUS DIFFICULTIES IN IMPLEMENTATION OR USE OF QUANTITATIVE TOOLS OF DECISION MAKING
(Amounts Expressed as Percentages)

Difficulties Encountered	Size of Firm (Sales)								Type of Industry						Controllers' Education				Total Respondents	
	M_1		M_2		M_3		M_4		N_1		N_2		N_3		E_1		E_2			
	%	Rank	%	Rank	%	Rank	%	Rank	%	Rank	%	Rank	%	Rank	%	Rank	%	Rank		
1. Top management does not understand	30.23	(1)	42.50	(1)	33.33	(1)	43.48	(1)	33.73	(1)	41.54	(1)	46.43	(1)	38.74	(1)	38.46	(1)	38.64	(1)
2. Lack of sufficiently competent personnel	18.60	(5)	25.00	(4)	20.83	(3)	26.09	(5)	20.48	(5)	29.23	(3)	17.86	(4)	21.62	(5)	26.15	(4)	23.30	(4)
3. The computer is inadequate	13.95	(6)	10.00	(8)	12.50	(6)	8.70	(7)	9.64	(7)	12.31	(7)	10.71	(7)	12.61	(7)	7.69	(8)	10.80	(7)
4. Returns from expenditures on these tools are inadequate	23.26	(3)	27.50	(2)	29.17	(2)	30.43	(3)	21.69	(4)	30.77	(2)	39.29	(2)	25.23	(2)	32.31	(2)	27.84	(2)
5. It takes too long to get answers	23.26	(4)	15.00	(6)	20.83	(4)	18.84	(6)	18.07	(6)	23.08	(5)	14.29	(6)	18.92	(6)	20.00	(6)	19.32	(6)
6. These models make too many unrealistic assumptions	13.95	(7)	27.50	(3)	12.50	(7)	30.43	(4)	31.33	(2)	15.38	(6)	17.86	(5)	23.42	(4)	23.08	(5)	23.30	(5)
7. Accounting data incompatible with modeling requirements	25.58	(7)	20.00	(5)	20.83	(5)	33.33	(2)	24.10	(3)	26.15	(4)	35.71	(3)	24.32	(3)	30.77	(3)	26.70	(3)
8. Not applicable to this business at all	4.65	(8)	12.50	(7)	4.17	(8)	4.35	(8)	6.02	(8)	7.69	(8)	3.57	(8)	4.50	(8)	9.23	(7)	6.25	(8)
Total number of respondents who use quantitative tools	43		40		24		69		83		65		28		111		65		176	

Where: M_1 = Less than $399.50 million
M_2 = $400 - 699.50 million
M_3 = $700 - 999.50 million
M_4 = Over $1 billion

N_1 = Durable manufacturing
N_2 = Nondurable manufacturing
N_3 = Unclassified firms

E_1 = Bachelor's degree or equivalent
E_2 = Master's degree and above

4. Sufficiently competent personnel are lacking.
5. The models make too many unrealistic assumptions.
6. It takes too long to get answers.
7. The computer is inadequate.
8. These tools are not applicable to this business.

Section III of Controller's Questionnaire--The Future Qualifications Necessary to Perform the Controllership Function

The purpose of this section was to ascertain the controllers' attitudes concerning the future controllership function regarding (a) a common body of knowledge beyond the requirement courses in accounting, (b) professional certifications, (c) formal training, and (d) business experience. The following items are included in this section: quantitative methods, behavioral sciences, information sciences, communication, professional certifications, formal training, and business experience. The subsequent discussion presents research question number eight, which is related to the above items. The eighth research question stated as follows: What qualifications and attributes do controllers look for in a prospective management accountant and/or controller?

A. Controllers' Attitudes Concerning the Quantitative Methods Necessary for Future Controllership Function

The controllers' attitudes concerning the importance of selected areas of the quantitative methods for future controllership is shown in Table IV-15. This table classifies the respondents as to (a) size of firm (sales), (b) major industry group (type of industry), and (c) controller's

TABLE IV-15

A SUMMARY OF CONTROLLERS' ATTITUDE CONCERNING THE IMPORTANCE (RANK) OF SELECTED AREAS OF THE QUANTITATIVE METHODS FOR CONTROLLERSHIP FUNCTION
(Amounts Expressed as Percentages)

Quantitative Methods	Size of Firm (Sales)								Type of Industry						Controllers' Education				Total Respondents	
	M_1		M_2		M_3		M_4		N_1		N_2		N_3		E_1		E_2			
	%	Rank	%	Rank	%	Rank	%	Rank	%	Rank	%	Rank	%	Rank	%	Rank	%	Rank		
1. High school algebra	81.82	(1)	70.00	(1)	71.43	(2)	78.67	(1)	74.49	(1)	77.22	(1)	80.65	(1)	76.98	(1)	75.36	(1)	76.44	(1)
2. Geometry	29.09	(2)	32.00	(5)	3.57	(8)	38.67	(2)	33.67	(7)	26.58	(6)	25.81	(8)	30.22	(6)	28.99	(7)	29.81	(7)
3. Trigonometry	29.09	(3)	30.00	(7)	25.00	(5)	38.67	(3)	56.12	(3)	25.32	(7)	32.26	(7)	35.97	(5)	24.64	(8)	32.21	(6)
4. Differential calculus	32.73	(4)	32.00	(6)	25.00	(6)	42.67	(5)	35.71	(6)	34.18	(5)	35.48	(6)	26.62	(7)	52.17	(5)	35.10	(5)
5. Bayesian statistics	27.27	(5)	30.00	(8)	17.86	(7)	28.00	(8)	26.53	(8)	20.25	(8)	45.16	(5)	25.18	(8)	30.43	(6)	26.92	(8)
6. Classical statistics	52.73	(3)	46.00	(4)	50.00	(4)	62.67	(3)	56.12	(3)	51.90	(4)	54.84	(4)	51.08	(4)	60.87	(3)	54.33	(4)
7. Decision theory	49.09	(4)	60.00	(3)	67.86	(3)	54.67	(4)	48.98	(4)	60.76	(3)	67.74	(3)	55.40	(3)	57.97	(4)	56.25	(3)
8. Operations research	67.27	(2)	62.00	(2)	75.00	(1)	66.67	(2)	62.24	(2)	69.62	(2)	80.65	(1)	69.06	(2)	62.32	(2)	66.83	(2)
Total Respondents	55		50		28		75		98		79		31		139		69		208	

Where: M_1 = Less than $399.50 million
M_2 = $400 - 699.50 million
M_3 = $700 - 999.50 million
M_4 = Over $1 billion

N_1 = Durable manufacturing
N_2 = Nondurable manufacturing
N_3 = Unclassified firms

E_1 = Bachelor's degree or equivalent
E_2 = Master's degree and above

education in selection of the quantitative methods for future controllership function. In Table IV-15, the respondents' attitudes are expressed as percentages used to rank the importance of the quantitative methods. The overall controllers' attitudes concerning the quantitative methods are ranked in the following order:

1. High School Algebra
2. Operations Research
3. Decision Theory
4. Classical Statistics
5. Differential Calculus
6. Trigonometry
7. Geometry
8. Bayesian Statistics[8]

B. Controllers' Attitudes concerning the Behavioral Sciences for Future Controllership Function

Four subjects were included in behavioral sciences. Table IV-16 shows the controllers' attitudes concerning the importance of selected areas of the behavioral sciences. The information in this table is expressed as percentages of total respondents (i.e., 208). The table classifies the respondents as to (a) size of firm, (b) major industry group, and (c) controller's education regarding the behavioral sciences subjects. The subjects are ranked according to the percent of the respondents. The overall analysis concerning the controllers' attitudes in regard to the behavioral sciences

TABLE IV-16

A SUMMARY OF CONTROLLERS' ATTITUDE CONCERNING THE IMPORTANCE (RANK) OF SELECTED AREAS OF THE BEHAVIORAL SCIENCES AND COMMUNICATION
(Amounts Expressed as Percentages)

Subjects	Size of Firm (Sales)								Type of Industry						Controllers' Education				Total Respondents	
	M_1		M_2		M_3		M_4		N_1		N_2		N_3		E_1		E_2			
	%	Rank	%	Rank	%	Rank	%	Rank	%	Rank	%	Rank	%	Rank	%	Rank	%	Rank		
Behavioral Sciences																				
1. Management Organization Theory	89.09	(1)	82.00	(1)	82.14	(1)	85.33	(1)	81.63	(1)	89.87	(1)	83.87	(1)	84.89	(1)	85.51	(1)	85.10	(1)
2. Sociology	27.27	(4)	24.00	(4)	21.43	(4)	32.00	(4)	30.61	(4)	22.78	(4)	29.03	(4)	25.90	(4)	30.43	(4)	27.40	(4)
3. Psychology	43.64	(3)	44.00	(3)	25.00	(3)	56.00	(3)	41.84	(3)	50.63	(3)	45.16	(3)	45.32	(3)	46.38	(3)	45.67	(3)
4. Motivation Theory	74.55	(2)	66.00	(2)	60.71	(2)	58.67	(2)	61.22	(2)	68.35	(2)	67.74	(2)	65.47	(2)	63.77	(2)	64.90	(2)
Communication																				
1. Written	92.73	(1)	86.00	(1)	92.86	(1)	93.33	(1)	87.76	(1)	94.94	(1)	93.55	(1)	89.93	(1)	94.20	(1)	91.35	(1)
2. Oral	78.18	(2)	70.00	(2)	67.86	(2)	89.33	(2)	78.57	(2)	78.48	(2)	80.65	(2)	79.14	(2)	78.26	(2)	78.85	(2)
Total Respondents	55		50		28		75		98		79		31		139		69		208	

Where: M_1 = Less than $399.50 million
M_2 = $400 - 699.50 million
M_3 = $700 - 999.50 million
M_4 = Over $1 billion

N_1 = Durable manufacturing
N_2 = Nondurable manufacturing
N_3 = Unclassified firms

E_1 = Bachelor's degree or equivalent
E_2 = Master's degree and above

are ranked as follows:

1. Management Organization Theory
2. Motivation Theory
3. Psychology
4. Sociology

C. Controllers' Attitudes concerning the Communication for Future Controllership Function

Table IV-16 also provides information concerning the controllers' attitudes toward communication (i.e., written and oral). A total of 208 or 91.35 percent of the responding controllers indicated that written communication is necessary for controllers to perform the future controllership function, while 78.85 percent felt that oral communication is important for controllership function.

D. Controllers' Attitudes concerning the Information Sciences for Future Controllership Function

Information sciences consist of six areas of interest. Table IV-17 shows a summary of controllers' attitudes regarding the importance of selected areas of information sciences. This table classifies the respondents as to (a) size of firm, (b) major industry group, and (c) controller's education in selected areas of information science. The selected areas are ranked as follows according to the percent of responding controllers:

1. Management Information System
2. System Analysis
3. Computer Languages

TABLE IV-17

A SUMMARY OF CONTROLLERS' ATTITUDE CONCERNING THE IMPORTANCE (RANK) OF SELECTED AREAS OF INFORMATION SCIENCES
(Amounts Expressed as Percentages)

Information Sciences	Size of Firm (Sales)								Type of Industry						Controllers' Education				Total Respondents	
	M_1		M_2		M_3		M_4		N_1		N_2		N_3		E_1		E_2			
	%	Rank	%	Rank	%	Rank	%	Rank	%	Rank	%	Rank	%	Rank	%	Rank	%	Rank		
1. Computer languages (FORTRAN, COBOL, etc.)	47.27	(3)	24.00	(5)	32.14	(4)	38.67	(3)	34.69	(4)	35.44	(3)	45.16	(3)	34.53	(3)	40.58	(3)	36.54	(3)
2. Systems analysis	54.55	(2)	60.00	(2)	60.71	(2)	50.67	(2)	50.00	(2)	53.16	(2)	77.42	(1)	52.52	(2)	60.87	(2)	55.29	(2)
3. On-line information retrieval	34.55	(5)	24.00	(6)	25.00	(6)	32.00	(5)	30.61	(6)	30.38	(4)	25.81	(6)	31.65	(6)	26.09	(6)	29.81	(6)
4. Knowledge of hardware	32.73	(6)	28.00	(4)	32.14	(5)	37.33	(4)	37.76	(3)	29.11	(6)	29.03	(5)	33.81	(4)	31.88	(5)	33.17	(5)
5. Management info. system	69.09	(1)	70.00	(1)	67.86	(1)	73.33	(1)	66.33	(1)	75.95	(1)	70.97	(2)	69.78	(1)	72.46	(1)	70.67	(1)
6. Data base management	38.18	(4)	32.00	(3)	39.29	(3)	30.67	(6)	33.67	(5)	30.38	(5)	45.16	(4)	33.81	(5)	34.78	(4)	34.13	(4)
Total Respondents	55		50		28		75		98		79		31		139		69		208	

Where: M_1 = Less than $399.50 million
M_2 = $400 - 699.50 million
M_3 = $700 - 999.50 million
M_4 = Over $1 billion

N_1 = Durable manufacturing
N_2 = Nondurable manufacturing
N_3 = Unclassified firms

E_1 = Bachelor's degree or equivalent
E_2 = Master's degree and above

4. Data Base Management

5. Knowledge of Hardware

6. On-Line Information Retrieval

The controllers' attitudes concerning the importance of common body of knowledge for future controllership function are shown in Table IV-18. This table is an overall summary of Tables IV-15, IV-16 and IV-17, and provides information regarding the selected areas of each discipline field listed according to their importance (rank) (i.e., percent of responding controllers).

E. Controllers' Attitudes concerning the Importance of Professional Certifications for Future Controllership Function

In recent years, the National Association of Accountants has established the Institute of Management Accounting to administer the program, conduct the examinations and grant the Certificate in Management Accounting (CMA). The writer was interested in ascertaining the controllers' attitudes toward this new professional certificate, as well as the old, well-established Certificate in Public Accounting (CPA) and the Certificate in Internal Accounting (CIA). Table IV-19 shows the controllers' attitudes concerning the importance of professional certifications for future controllership function. This table classifies the respondents as to (a) size of firm, (b) type of industry, and (c) controllers' education. The data displayed in Table IV-19 are presented as percentages of total respondents in each category. On the overall 45.19 percent of the total (208)

TABLE IV-18

A SUMMARY OF CONTROLLERS' ATTITUDES CONCERNING THE IMPORTANCE OF COMMON BODY OF KNOWLEDGE FOR CONTROLLERSHIP FUNCTION

Common Body of Knowledge	Number	Percent
Quantitative Methods:		
1. High School Algebra	159	76.44
2. Operation Research	139	66.83
3. Decision Theory	117	56.25
4. Classical Statistics	113	54.33
5. Differential Calculus	73	35.10
6. Trigonometry	67	32.21
7. Geometry	62	29.81
8. Bayesian Statistics	56	26.92
Behavioral Sciences:		
1. Management Organization Theory	177	85.10
2. Motivation Theory	135	64.90
3. Psychology	95	45.67
4. Sociology	57	27.40
Information Sciences:		
1. Management Information System	147	70.67
2. System Analysis	115	55.29
3. Computer Languages	76	36.54
4. Data Base Management	71	34.13
5. Knowledge of Hardware	69	33.17
6. On-Line Information Retrieval	62	29.81
Communication:		
1. Written	190	91.35
2. Oral	164	78.85
Total Respondents	208	

TABLE IV-19

A SUMMARY OF NUMBER OF CONTROLLERS' ATTITUDE CONCERNING THE IMPORTANCE OF PROFESSIONAL CERTIFICATIONS FOR CONTROLLERSHIP FUNCTION
(Amounts Expressed as Percentages)

Professional Certifications	Size of Firm (Sales)				Type of Industry			Controllers' Education		Total Respondents
	M_1	M_2	M_3	M_4	N_1	N_2	N_3	E_1	E_2	
1. Certificate in Management Accounting (CMA)	49.09	44.00	39.29	52.00	40.82	49.37	51.61	46.04	44.93	45.19
2. Certificate in Public Accounting (CPA)	40.00	42.00	32.14	44.00	39.80	43.04	51.61	42.45	43.48	43.27
3. Certificate in Internal Auditing (CIA)	3.64	4.00	0.00	10.67	6.12	5.06	6.45	4.32	8.70	5.77
Total Respondents	55	50	28	75	98	79	31	139	69	208

Where: M_1 = Less than \$399.50 million
M_2 = \$400 - 699.50 million
M_3 = \$700 - 999.50 million
M_4 = Over \$1 billion

N_1 = Durable manufacturing
N_2 = Nondurable manufacturing
N_3 = Unclassified firms

E_1 = Bachelor's degree or equivalent
E_2 = Master's degree and above

respondents felt that the CMA is important, while 43.27 and 5.77 percent of responding controllers thought that either a CPA or a CIA is necessary. In all categories, the respondents have indicated that the CMA is more important for controller or management accountant than either the CPA or the CIA.[9]

F. Controllers' Attitudes concerning the Importance of Minimum Education Level for an Effective Controller

The controllers' attitudes regarding the importance of minimum education level for future controllership is summarized in Table IV-20. In this table the respondent's are classified according to (a) size of firm, (b) type of industry, and (c) controllers' education. In summary, 67.79 percent of the total respondents felt that a bachelor's degree should be sufficient, whereas 31.73 percent of the controllers thought that a master's degree should be required for future controllership function.

The controllers' attitudes concerning the minimum business experience were varied. Although some commented that the minimum business experience should vary with the level of business sophistication, on average of 10 years' business experience was expected.

Additional Comments

Question F in Section III of the questionnaire solicited additional comments about the future attributes and qualifications necessary to perform the controllership function. Only 17 or 8 percent of the total 208 respondents chose to make additional comments.

TABLE IV-20

A SUMMARY OF NUMBER OF CONTROLLERS' ATTITUDE CONCERNING THE IMPORTANCE OF MINIMUM EDUCATIONAL LEVEL FOR AN EFFECTIVE CONTROLLER
(Amounts Expressed as Percentages)

Education Level	Size of Firm (Sales)				Type of Industry			Controllers' Education		Total Respondents
	M_1	M_2	M_3	M_4	N_1	N_2	N_3	E_1	E_2	
Bachelor's degree	67.27	70.00	71.43	65.34	70.41	64.55	67.74	84.17	34.78	67.79
Master's degree	32.73	30.00	28.57	33.33	29.59	34.18	32.26	15.83	63.77	31.73
Ph.D. degree	0.00	0.00	0.00	1.33	0.00	1.27	0.00	0.00	1.45	.48
Total Respondents	55	50	28	75	98	79	31	139	69	208
Percent	100	100	100	100	100	100	100	100	100	100

Where: M_1 = Less than \$399.50 million
M_2 = \$400 - 699.50 million
M_3 = \$700 - 999.50 million
M_4 = Over \$1 billion

N_1 = Durable manufacturing
N_2 = Nondurable manufacturing
N_3 = Unclassified firms

E_1 = Bachelor's degree or equivalent
E_2 = Master's degree and above

Some of the comments frequently made by responding controllers included:

1. Controllers should be managers who are knowledgeable in relation to their company and its industry--not technical giants.
2. Controllers function is changing and now requires a "man for all seasons," a well-trained, sensible leader who is technically qualified.
3. Behavioral sciences are intuitive, generally. Spend more time on communication which is the most important one. Information sciences are nice to have, to avoid snow jobs, but not in great detail.
4. Good basic education is required--so far, in my opinion, practical experience is more valuable than advanced (post-graduate) education.
5. I believe a controller of a large company will have to be a "generalist."
6. Knowledge about all of the tools is desirable, but it is difficult to remain ignorant about them if any effort is made to review or read professional publications on a regular basis.
7. Prudent man approaches to most opportunities.
8. A good controller is not only an accountant and financial manager, but also a good business generalist, who understands the problems of other business disciplines and functions as a part of the management team.
9. For an "effective controller," a M.B.A. and professional

association are required.

10. The larger the company, the more the controller needs to be slanted toward the management and away from the technical. A good controller of a manufacturing company must be operationally oriented and able to relate to the operating people while providing a good system to collect both the accounting and operating data.

The Null Hypotheses

Testing the Hypotheses

In testing the hypotheses the following actions were taken: (1) first, the main effects and the interactions were evaluated using all ten dependent variables (frequency of use of the nine tools and the total frequency of all nine tools), as shown in Table IV-21, in a multivariate analysis of variance. Each variable was scored ranging from zero to four for the purpose of data analysis (i.e., 4 = routinely used, 3 = periodically used, 2 = occasionally used, 1 = rarely used, and 0 = never used). The main purpose of the multivariate analysis of variance test was to determine whether there were statistically significant differences among the main effects and interactions on the basis of (a) size of firm (sales), (b) major industry group (type of industry), and (c) controller's education with regard to 10 dependent variables listed above; (2) then, if the results of the multivariate analysis of variance tests were significant (i.e., the null hypothesis

TABLE IV-21

DEFINITION OF TEN VARIABLES

Variable No.	Variable That Defines the Item
1	Flexible (variable) budgeting
2	Present value concepts
3	Linear programming
4	Sensitivity analysis (risk analysis)
5	Forecasting techniques (regression, exponential smoothing, moving averages)
6	Simulation models (includes computer simulation)
7	Statistical techniques (sampling and Bayesian statistics)
8	Network analysis (PERT and CPM)
9	Inventory models (e.g., EOQ)
10	Total frequency of use

was rejected), ten univariate analyses of variance were performed on each dependent variable to determine whether there were statistically significant differences among the main effects and interactions of (a) size of firm, (b) major industry group, and (c) controller's education and the frequency of use of <u>each</u> quantitative tool of decision making in business firms; and (3) whenever a significant univariate analysis of variance was found, a Newman-Keuls[10] probing procedure was utilized to compare all possible pairs of means of each dependent variable at the .05 level of significance. The means and the standard deviations of the three groups (i.e., size of firms, major industry group, and controller's education) on these 10 dependent variables are presented in Table IV-22.

TABLE IV-22

MEANS (M) AND STANDARD DEVIATIONS (SD) BY GROUP AND VARIABLES

Variables		Size of Firm (Sales)				Major Industry Group (Type of Industry)			Controllers' Education	
		M_1	M_2	M_3	M_4	N_1	N_2	N_3	E_1	E_2
1	M	3.12	3.32	3.54	3.32	3.48	2.95	3.57	3.41	3.12
	SD	1.45	1.25	.66	1.18	.93	1.55	.88	1.11	1.36
2	M	3.05	3.45	3.17	3.64	3.36	3.43	3.36	3.33	3.48
	SD	.97	.85	1.05	.62	.97	.83	.56	.90	.79
3	M	1.74	1.95	2.46	2.38	1.93	2.26	2.46	2.08	2.23
	SD	1.40	1.18	1.22	1.15	1.19	1.14	1.17	1.34	1.09
4	M	1.51	2.55	2.25	.36	.16	.09	2.46	2.05	2.42
	SD	1.22	1.34	1.29	1.32	1.29	1.44	1.26	1.38	1.25
5	M	2.40	2.77	2.83	2.71	2.83	2.55	2.43	2.62	2.74
	SD	1.45	1.35	1.17	1.23	1.30	1.35	1.20	1.38	1.18
6	M	2.02	2.52	2.33	2.38	2.45	2.17	2.29	2.28	2.38
	SD	1.37	1.18	1.09	1.16	1.24	1.23	1.08	1.21	1.22
7	M	1.86	2.05	2.29	2.36	2.11	2.23	2.14	2.23	2.05
	SD	1.30	1.41	1.30	1.21	1.36	1.28	1.18	1.30	1.30
8	M	1.51	2.07	2.00	2.29	2.02	1.88	2.29	1.93	2.15
	SD	1.28	1.47	1.44	1.23	1.34	1.33	1.44	1.43	1.20
9	M	2.16	2.40	2.50	2.46	2.63	2.05	2.43	2.38	2.38
	SD	1.54	1.39	1.10	1.54	1.50	1.42	1.26	1.56	1.26
10	M	19.79	23.20	23.08	24.39	23.33	21.77	23.75	20.82	23.31
	SD	6.71	6.10	5.80	5.46	6.09	6.24	5.36	6.96	5.10

Note:
M_1 = less than 399.5 million
M_2 = 400 - 699.5 million
M_3 = 700 - 999.5 million
M_4 = over 1 billion
N_1 = durable manufacturing
N_2 = nondurable manufacturing
N_3 = unclassified industry
E_1 = Bachelor's degree or equivalent
E_2 = Master's degree and above

Results of Testing Null Hypotheses Number One and Five-- Size of Firm and Frequency of Use

The first and fifth null hypotheses concerning the size of firm (sales) and the frequency of use (overall and each) quantitative tools of decision making in business firms were:

Ho_1 There is no statistically significant difference between the size of firm (sales) and the level of use of quantitative tools of decision making in business firms. (Multivariate test)

Ho_5 There is no statistically significant difference between the size of firm (sales) and the level of use of EACH quantitative tool of decision making in business firms. (Univariate test)

The multivariate analysis of variance test for size of firm produced a significant Wilks' Lambda[11] (Λ = 1.505, p less than .04), indicating that the frequency of use of the ten tools (variables) was influenced by the size of firm (sales). In other words, the first null hypothesis, evaluated with a multivariate test, was rejected. Thus, the conclusion drawn is that the size of firm does not significantly effect the level of use of all quantitative tools of decision making in business firms.

Because the multivariate test for the first null hypothesis was significant, ten univariate analyses of variance were performed to test the fifth null hypothesis. The results showed that the four firm sizes differed significantly in the use of four of the individual tools and total frequency of all tools. The results of the ten univariate analyses of variance are summarized in Table IV-23.

TABLE IV-23

THE RESULTS OF UNIVARIATE F TESTS FOR TEN VARIABLES ON FREQUENCY OF USE OF EACH QUANTITATIVE TOOL OF DECISION MAKING BY SIZE OF FIRM

Variable	F(3, 152)	Mean SQ	P Less Than
1	0.754	0.967	0.522
2	5.090	3.548	0.002*
3	3.451	4.827	0.018*
4	5.470	9.032	0.001*
5	0.862	1.477	0.462
6	1.233	1.898	0.300
7	1.447	2.527	0.231
8	2.989	5.418	0.033*
9	0.454	0.958	0.715
10	4.910	191.064	0.003*

*$p < .05$

There was a significant difference ($p < .05$) among the four sizes of firm regarding the frequency of use of variables 2, 3, 4, 8, and 10, whereas variables 1, 5, 6, 7, and 9 did not show any significance among the four sizes of firms.

The Newman-Keuls[12] tests for the five significant analyses of variance indicated no pairwise differences among the means of each tool or variable in the four firm sizes. This finding indicates that there is some significant contrast of the means with no significance pairwise differences. Because the differences among the means are relatively small compared to the mean square error (MS_{error}) for each individual variable or tool. For example, for Variable 2 (present-value concepts)

the means 3.05, 3.45, 3.17 and 3.64 (for M_1, M_2, M_3 and M_4, respectively) were judged to be significantly different in an analysis of variance; however, the pairwise analysis of these means using the Newman-Keuls procedure revealed no pairwise significance.

Results of Testing Null Hypotheses Number Two and Six--Type of Industry and Frequency of Use

The second and sixth null hypotheses concerning the major industry group (type of industry) and the frequency of use (overall and each) quantitative tools of decision making in business firms were as follows:

Ho_2 There is no statistically significant difference between the major industry group (type of industry) and the level of use of quantitative tools of decision making in business firms. (Multivariate test)

Ho_6 There is no statistically significant difference between the major industry group (type of industry) and the level of use of EACH quantitative tool of decision making in business firms. (Univariate test)

The multivariate analysis of variance test of major industry group (type of industry) showed a significant Wilks' Lambda (Λ = 1.699, p less than .033). This significance indicates that the frequency of use of quantitative tools of decision making of the ten tools of variables was related to the type of industry. In other words, the null hypothesis (Ho_2) for multivariate test was rejected. The rejection of the second null hypothesis (Ho_2) indicates that there was a significant difference among the major industry group and the level of use of quantitative decision making in business firms. Because the overall multivariate analysis of variance

revealed a significant difference, ten univariate analyses of variance were performed to test the sixth null hypothesis. The results indicated that the frequency of use of two of the individual tools differed significantly only on the basis of type of industry. The results of the ten univariate analyses of variance are summarized in Table IV-24. There was no significant differences among the three types of industry with respect to the frequency of use of variables or tools 2, 3, 4, 5, 6, 7, 8, and 10, while variables 1 and 9 did show a significant difference among the three types of industry regarding the level of use of each tool.

TABLE IV-24

THE RESULTS OF UNIVARIATE F TESTS OF TEN VARIABLES ON FREQUENCY OF USE OF QUANTITATIVE TOOLS OF DECISION MAKING BY TYPE OF INDUSTRY

Variable	F(2, 152)	Mean SQ**	P Less Than
1	5.084	6.525	0.007*
2	0.075	0.053	0.927
3	2.371	3.317	0.097
4	1.047	1.729	0.353
5	1.483	2.542	0.230
6	1.044	1.608	0.354
7	0.120	0.209	0.887
8	1.041	1.888	0.355
9	3.084	6.502	0.049*
10	1.842	71.670	0.162

*$p < .05$

**SQ stands for Squared.

Once again, the Newman-Keuls tests for the two significant analyses of variance was performed to ascertain any differences among the means of each variable or tool in three types of industry. The test showed that there were no pairwise differences among the means of each variable. This finding shows that there is some contrast of the means that is significant, with no significant pairwise differences. Again, the reason for this is that the differences between the means are relatively small compared to the MS_{error} of each variable.

Results of Testing Null Hypotheses Number Three and Seven--Controller's Education and Frequency of Use

The third and seventh null hypotheses concerning the controller's education and the frequency of use (overall and each) tools of decision making in business firms were as follows:

Ho_3 There is no statistically significant difference between the controller's education and the level of their use of quantitative tools of decision making in business firms. (Multivariate test)

Ho_7 There is no statistically significant difference between the controller's education and the level of their use of EACH quantitative tools of decision making in business firms. (Univariate test)

Multivariate analysis of variance was performed to test the third hypothesis. The result of the test indicated that Wilks' Lambda ($\Lambda = 1.054$, p less than .402) was not significant and indicated that the frequency of use of quantitative tools of decision making of the ten tools or variables was not related to the controller's education. The third null hypothesis for multivariate test was, therefore, accepted.

This acceptance indicates that there is no significant difference among the two types controller's education and the overall use of quantitative tools of decision making in business firms.

Because the multivariate analysis of variance test was not significant, ten univariate analyses of variance were not performed, and the seventh null hypothesis was accepted. Hence, there was no significant difference among the controller's education and the level of use of each quantitative tool in business firms.

Results of Testing Null Hypotheses of Number Four and Eight--Interaction Effects of Size of Firm, Type of Industry, and Controller's Education

The fourth and eighth hypotheses concerning the interaction effects of the size of firm (sales), the major industry group (type of industry), and the controller's education were as follows:

Ho_4 There is no statistically significant interaction effect among the size of firm (sales) and major industry group (type of industry) and controller's education with regard to the 10 dependent variables (Multivariate test)

Ho_8 There is no statistically significant interaction effect among the size of firm (sales), major industry group (type of industry), and controller's education with regard to the use of EACH quantitative tools of decision making in business firms. (Univariate test)

When the multivariate analysis of variance was performed to test the fourth null hypothesis, the Wilks' Lambda (Λ = 1.171, p less than .183) was not significant. The null hypothesis for multivariate test was, therefore, accepted,

because there was no significant difference among the interaction effects of size of firm, type of industry and controller's education, and the overall frequency of use of quantitative tools of decision making in business firms. Inasmuch as the overall multivariate analysis of variance test was accepted, the ten univariate analyses of variance were not performed and the seventh null hypothesis was accepted. The conclusion can, therefore, be drawn that there was no significant interaction among the size of firm, major industry group, the controller's education, and the level of use of each quantitative tools of decision making in business firms.

Results of Testing Null Hypotheses[13] for Six Possible Two-Way Interactions

In addition to the foregoing analyses (i.e., three-way interactions tests), the two-way interactions tests (multivariate and univariate tests) were also performed to evaluate the two-way interactions among size of firm, major industry group, and controller's education regarding all 10 dependent variables listed in Table IV-21. The multivariate and univariate tests revealed no statistically significant differences among the six possible two-way interactions of (a) size of firm (sales), (b) major industry group (type of industry), and (c) controller's education regarding the frequency of use of tools of decision making in business firms. In other words, all six null hypotheses were accepted to indicate that there are no significant two-way interactions among the size of firm, type of industry, and

controller's education regarding the level of use of (overall and each) quantitative tools of decision making in business firms.

Summary

This chapter presented the findings of empirical investigation of controllers' attitudes and opinions regarding (1) the extent and the level of use of quantitative tools of decision making in business firms and (2) the future job qualifications and attributes for performing the controllership function. Descriptive statistics such as percentages, means, standard deviations, and rankings were used to analyze answers to the eight research questions. The first area of investigation was concerned with controllers' educational background (i.e., research question #1). The following results were obtained:

1. All 208 responding controllers have attended college.
2. Of the 208 responding controllers, all have a bachelor's degree, 64.39 percent have only a bachelor's degree, and 34.61 percent had at least a master's degree.
3. Over three-fourths of the responding controllers attended training and seminars sessions on the use of one or more quantitative tools of decision making, such as flexible budgeting, present-value concepts, and so forth.
4. The controllers acquired their knowledge from one or more of the following sources: formal training, executive training programs, professional development programs,

professional journals, working with consultants, and on-the-job training.

The second area of investigation, dealing with research questions 2 through 7, provided the following information regarding the extent and the level of use of quantitative tools of decision making in business firms by controllers:

1. 84.62 percent of the responding controllers reported that they were applying one or more quantitative tools of decision making to business problems in performing their controllership function.
2. 79.81 percent of responding controllers used one or more quantitative tools of decision making in the area of accounting, 73.08 percent in production, and 62.98 percent in marketing and distribution.
3. The quantitative tools of decision making ranked as follows according to the total frequency of use and weighted averages of frequency:
    1. Present-value concepts
    2. Flexible (variable) budgeting
    3. Forecasting techniques (regression analysis, exponential smoothing, etc.)
    4. Inventory models
    5. Simulation models
    6. Sensitivity analysis (risk analysis)
    7. Statistical techniques (sampling and Bayesian statistics)

8. Linear programming
9. Network analysis (PERT and CPM).

4. The controllers' views concerning the degree of success (i.e., the overall results achieved from using these tools in business firms) ranked as follows according to averages of degree of success:
   1. Present-value concepts
   2. Flexible budgeting
   3. Forecasting techniques
   4. Simulation models
   5. Statistical techniques
   6. Inventory models
   7. Linear programming
   8. Network analysis
   9. Sensitivity analysis (risk analysis)
5. The types of business operations problems analyzed with quantitative tools of decision making ranked as follows by the controllers:
   1. Production planning and control
   2. Financial forecasting and budgeting
   3. Analyzing capital investment projects
   4. Facilities planning
   5. Forecasting demand, supply and price
   6. Make-or-buy decision, and so forth.
6. The various difficulties in using quantitative tools of decision making by controllers who use these tools ranked

as follows:

1. Top management does not understand
2. Returns from expenditures on these tools are inadequate
3. Accounting data are incompatible with modeling requirements
4. There is a lack of sufficiently competent personnel
5. The models make too many unrealistic assumptions
6. Too much time is required to get answers
7. The computer is inadequate

The third area of investigation was concerned with the future attributes and qualifications necessary to perform the controllership function. The controllers' attitudes suggest, prima facie, a common body of knowledge ranked according to the percentages of responding controllers as follows:

1. A. Quantitative methods
    1. High school algebra
    2. Operations research
    3. Decision theory
    4. Classical statistics
    5. Differential calculus
    6. Trigonometry
    7. Geometry
    8. Bayesian statistics

B. Behavioral sciences
    1. Management organization theory

2. Motivation theory

3. Psychology

4. Sociology

C. Information sciences

1. Management information systems

2. System analysis

3. Computer languages

4. Data base management

5. Knowledge of hardware

6. On-line information retrieval

D. Communication

1. Written

2. Oral

2. Controllers' preferences concerning professional certifications for future controllership ranked as follows:

1. CMA: 45.19 percent

2. CPA: 43.27 percent

3. CIA: 5.7 percent

3. Controllers' attitudes concerning the importance of minimum education level for an effective future controller were:

a. Bachelor's degree sufficient: 67.79 percent

b. An M.B.A. or equivalent: 31.73 percent

4. An average 10-year business experience was recommended by the controllers for future controllership function.

The fourth area of investigation dealt with testing

the eight null hypotheses of the research project with a three-way analysis of variance test. The multivariate tests were performed to determine whether there were statistically significant differences among the main effects and interactions of (a) size of firm (sales), (b) the major industry group (type of industry), and (c) controller's education regarding the frequency of use of all 10 quantitative tools of decision making in business firms. The rejection of the first and second null hypotheses may indicate that there is significant differences among (a) size of firm (sales) and (b) major industry group (type of industry) regarding the frequency of use of quantitative tools of decision making. The acceptance of the third null hypothesis indicated that there was no statistically significant difference among the controller s education regarding the frequency of use of quantitative tools of decision making in business. Likewise, the acceptance of the fourth hypothesis indicated that there were no statistically significant interaction effects among the size of firm (sales), major industry group (type of industry), and the controller's education regarding the 10 dependent variables.

Whenever the multivariate analysis of variance tests were significant, ten univariate analyses of variance were performed on each dependent variable to determine any statistically significant differences among the main effects and interactions of (a) size of firm (sales), (b) major

industry group (type of industry), and (c) controller's education regarding the frequency of use of each quantitative tool of decision making in business firms. Furthermore, whenever a significant univariate analysis of variance test was found, a Newman-Keuls procedure was used to compare all possible pairs of means of each dependent variable at the .05 level of significance. The univariate tests produced the following results:

1. In testing the fifth null hypothesis, a significant difference ($p < .05$) was found among the four sizes of firm regarding the frequency of use of variables 2 (present-value concepts), 3 (linear programming), 4 (sensitivity analysis (risk analysis)), 8 (network analysis), and 10 (total frequency of use). Variables 1, 5, 6, 7, and 9, on the other hand, did not show any significant difference on the basis of size of firm.
2. In testing the sixth null hypothesis, no significant difference ($p < .05$) was found among the three types of industry with respect to the frequency of use of variables or tools 2, 3, 4, 5, 6, 7, 8, and 10. However, variables 1 (flexible budgeting) and 9 (inventory model) did show a significant difference among the three types of industry regarding the level of use of each of these tools.
3. The test of the seventh null hypothesis revealed no significant difference ($p < .05$) among the two levels of controller's education with respect to the frequency

of use of each of 10 dependent variables.

4. In testing the eighth null hypothesis, no significant interaction effect was found among the size of firm (sales), major industry group (type of industry), and controller's education regarding the frequency of each quantitative tool of decision making in business firms.

Chapter IV Footnotes

[1]The information obtained from the responding controllers supported this statement.

[2]This trend is supported in current accounting literature and other related disciplines that cites examples of the varied use of most of these concepts and tools.

[3]For example, at the University of Oklahoma where this study was completed, there is a relatively little emphasis on these tools. This situation may be true about the other institutions.

[4]For the significance test, see hypothesis number one on page 116.

[5]For the significance test, see hypothesis number two on page 118.

[6]For the significance test, see hypothesis number three on page 120.

[7]"Frequency" means the relative number of applications of the quantitative tools within a firm by controller.

[8]Theoretically, the decision theory and the Bayesian Statistics concepts are closely related. Therefore, these two tools should have been ranked sequentially. The findings contradict this premise. Perhaps the respondents thought that the decision theory was similar to economic organization theory, indicating that the decision theory is a broader concept than the Bayesian Statistics. From a social research instrumentation perspective, results must therefore be considered an undesirable artifact. From an accounting perspective however this is a quite significant finding. Result may indicate that controller have, to date, had little or no exposure to Bayesian or decision theoretic analysis. Evaluation of the utility of such tools is probably premature. Perhaps accounting scholars should explore and communicate to financial management potential application which might enrich corporate planning and control.

[9]The present study did not test the significance between the controllers' attitudes concerning the importance of CMA, CPA, and CIA certificate for the future controllership function. Such test could be a desirable topic for future research.

[10]For an excellent source that can be used as a guide, see B. J. Winer, Statistical Principles in Experimental Design (New York: McGraw-Hill Book Company, Inc., 1962), pp. 85-103.

[11] Wilks' criterion

A criterion of general use in multivariate analysis for testing hypotheses concerning multivariate normal populations, especially hypotheses of homogeneity in means or dispersions. The criterion occurs in various forms and depends essentially on the ratio of the determinants of two matrices of sums of squares and products, with the numerator corresponding to a sum-within-classes and the denominator to a total-sum.

The criterion, devised by Wilks in 1932, has been subsequently extended by him and others. He also devised a test of significance sometimes called the Wilks' test.

The sampling distribution of Λ (Lambda) has been found under the assumption that the k sets of variables are independent in the population and exact expressions for the probability integrals have been given for several of the simple cases. This makes it possible to use Λ as a criterion for making significance tests of independence. In short, the assumption underlying the Wilks' Lambda ( ) is that the vector of observation for any individual in any cell has a multivariate normal distribution.

For an excellent source, on Wilks' Lambda Criterion, that can be used as a guide see S. S. Wilks, "Certain Generalizations in the Analysis of Variance," Biometrika, Vol. 23, 1932, pp. 471-494, _____, "On the Independence of k Sets of Normally Distributed Statistical Variables," Econometrica, Vol. 3, 1935, pp. 309-326, C. Radhakrishna Rao, Advanced Statistical Methods in Biometric Research (Darien, Conn.: Hafner Publishing Company, Inc., 1970), pp. 258-261, and M. G. Kendall and W. R. Buckland, A Dictionary of Statistical Terms (London, England: Oliver and Boyd, 1960), 2nd edition, p. 316.

[12]This is an application of the Newman-Keuls test in testing on differences between all pairs of means for variable #2 (present value concepts).

Tests on Differences between All Pairs of Means for Variable # 2 (Present Value Concepts)

	Size of Firm		M_1	M_3	M_2	M_4
		Ordered Means	3.05	3.17	3.45	3.64
	M_1	3.05	--	.12	.40	.59
	M_3	3.17	--	--	.28	.49
(i)	M_2	3.45	--	--	--	.19
	M_4	3.64	--	--	--	--
				r=2	r=3	r=4
(ii)		$q_{.95}(r,152)$		2.77	3.31	3.63
(iii)	$\sqrt{MS_{error}/\bar{n}_h} \times q_{.95}(r,152)$			1.059	1.266	1.388 (critical value)

where: M_1 = less than $399.5 million

M_2 = $400- 699.5 million

M_3 = $700- 999.5 million

M_4 = over $1 billion

q = the statistic to be used in making tests on these differences (studentized range statistic)

r = the number of steps the two means are apart on an ordered scale

df = degrees of freedom from MS_{error} = 152

MS_{error} = mean square = $(.835)^2$

$\bar{n}_h$ = harmonic mean = 4.7659

α = .05 (level of significance)

1. The first test was made on the difference of .59 in the upper, right of part (i). Because this figure is the difference between two means that are four steps apart, the critical value is 1.388. Hence the data do not contradict the hypothesis that $T_1 = T_4$.

2. The next test was on entry .40, the difference between two means which are three steps apart. The critical value for this test is 1.266. Hence the data do not contradict the hypothesis that $T_2 = T_1$.

3. The entry .12, which is the difference between two means are two steps apart, was tested next. The critical value is 1.059. Hence, the data do not contradict the hypothesis that $T_3 = T_1$.

4. The entry .49 was tested against the critical value of 1.266, because this entry is the difference between two means that are three steps apart. Hence the data do not contradict the hypothesis that $T_3 = T_4$.

5. The entry .28 was tested against the critical value 1.059. The data do not contradict the hypothesis that $T_2 = T_3$.

6. The entry .19 was tested against the critical value 1.059. The data do not contradict the hypothesis that $T_2 = T_4$.

A similar test performed for the remaining 9 tools indicated no pairwise differences among the means of each variable in the four sizes of firms. The assumption underlying the Newman-Keuls Test is that errors are normally and independently distributed with means zero and common variance.

Because the Newman-Keuls probing procedure for the five analyses of variance indicated no pairwise differences among the means some question about reliability within the cells may arise. Further research in order to determine within cell variability might therefore prove fruitful. Alternative exploration methods for discovery of significance differences might also be order. Such method include tests devised by (1) Duncan (Winer, p. 86), (2) Tukey (Winer, p. 87), and Scheffe (Winer, p. 88).

[13]The null hypotheses are as follows:

Ho'_1 There is no statistically significant interaction effect between size of firm (sales) and major industry group (type of industry) with regard to the 10 dependent variables (multivariate test).

Ho'_2 There is no statistically significant interaction effect between size of firm and major industry group with regard to the frequency of use of each quantitative tool of decision making in business firms. (Univariate test)

Ho'_3 There is no statistically significant interaction effect between size of firm and controller's education with regard to the 10 dependent variables.

Ho'_4 There is no statistically significant interaction effect between size of firm and controller's education with regard to the frequency of use of each quantitative tool of decision making in business firms.

Ho'_5 There is no statistically significant interaction effect between major industry group and controller's education with regard to the 10 dependent variables.

Ho'_6 There is no statistically significant interaction effect between major industry group and controller's education with regard to the frequency of use of each quantitative tool of decision making in business firms.

CHAPTER V

SUMMARY, CONCLUSIONS, AND RECOMMENDATIONS

Summary

Until recently, accounting alone has been the most important quantitative reporting aid to managers. However, the quantitative information now being developed and made available to managers through such decision-analysis techniques as quantitative tools of decision making is threatening the importance of accounting. Accounting and accounting information are being criticized for the following reasons: (1) the presence of open-ended information, (2) a lack of a broad concept of information development, (3) a lack of an analytical approach, and (4) a lack of a sophisticated problem-solving approach. Because of these animadversions, particularly the vast amount of new thinking in other disciplines in the general area of business administration, several specific changes in accounting during the last decade were manifested in faculty, research, and course content. As a result, quantitative techniques and tools became a predominant part of the subject material in managerial accounting courses at college and universities.

A review of accounting literature revealed no pertinent

empirical research in this area to indicate (1) the extent to which quantitative tools of decision making application in controllership are being used, (2) the psychological and/or educational preparation of controllers to deal with these tools, (3) the reasons for success or failure of such methods when used by the controllership function and (4) the criteria for assessing the importance of such techniques in managerial accounting curriculum. In view of these problems, the objective of the study was to investigate empirically the extent and the level of business usage of certain quantitative tools of decision making currently taught in managerial accounting courses at college and university levels. To accomplish this objective, eight research questions and eight hypotheses were designed to be tested empirically. A mail survey was conducted to ascertain the opinions and the attitudes of corporate controllers regarding (1) the extent to which quantitative tools of decision making are being used in business by controllers, (b) the appropriateness or the inappropriateness of quantitative techniques for accountants, and (c) the future job qualifications and attributes necessary to perform the controllership function.

The scope of the study was limited to (1) data obtained from a questionnaire sent to the controllers of all first Fortune 500 major industrial corporations in the United States, (2) managerial accounting, on the assumption that a major role of the management accountant and/or controller

is to design and improve information systems for management decision making and implementation, and (3) specific quantitative tools of decision making currently a predominant part of the subject material in managerial accounting courses. These tools are flexible (variable) budgeting, present-value concepts, linear programming, sensitivity analysis (risk analysis), forecasting techniques, statistical techniques, network analysis (PERT and CPM), inventory models and simulation models.

For this study, the population was defined to be the controllers of the first 500 industrial firms in the United States listed in the May, 1974, Fortune Directory. The population was then classified according to (1) size of firm (sales), (2) major indystry group (type of industry), and (3) the controller's education.

The questionnaire was developed, tested, and mailed to the controllers of the first 500 firms listed in the May, 1974, Fortune Directory of corporations in the United States. The usable response rate was 41.6 (208/500)[1] percent. The controller's questionnaire was divided into the following sections: (a) biographical data, (b) information about the quantitative tools of decision making used by the controllers in the company, (c) views concerning future attributes and qualifications for performing the controllership function. Descriptive statistics were used to analyze all eight research questions. The purpose of research questions was to gather

information about the extent and the level of usage of quantitative tools by controllers in business today. The research questions were concerned with (1) the controllers' educational background, (2) the extent and the level of use of quantitative tools in business by controllers, (3) the areas of business operations in which controllers use quantitative tools of decision making, (4) the frequency of use, (5) the overall results achieved, (6) the types of specific business operations problems analyzed with the aid of quantitative tools, (7) the various difficulties encountered in the application of these tools, and (8) the future outlook for the controllership function.

The three-way analysis of variance (multivariate and univariate) was utilized to test the eight hypotheses. The first set of hypotheses was concerned with (1) size of firm (sales), (2) major industry group (type of industry), (3) controller's education, and (4) the interaction effect among size of firm, type of industry, and controller's education with regard to the frequency of use of quantitative tools of decision making in the business firm. The second set of hypotheses dealt with (5) size of firm, (6) major industry group, (7) controller's education, and (8) the interaction effect among these three groups with regard to the frequency of use of each quantitative tools of decision making in the business firm.

Conclusions

Conclusions were drawn from the analyses of findings of empirical investigation of controllers' attitudes and opinions regarding (1) the extent and the level of usage of quantitative tools of decision making in business firm and (2) the future job qualifications and attributes necessary to perform the controllership function.

A. The following conclusions were drawn from analyses of research questions:

1. A total of 76.44 percent of the 208 controllers attended the training and/or seminars sessions regarding the use of one or more quantitative tools of decision making, such as flexible budgeting, present-value concepts, linear programming, sensitivity analysis (risk analysis), forecasting techniques, network analysis, inventory models, and simulations. The controllers' sources of knowledge for these tools included at least one of the following: formal training, executive training programs, professional development programs, professional journals, work with consultants, and on-the-job training. This finding indicates (1) that the controllers are constantly updating themselves with current developments and have steps to obtain such knowledge and (2) that the controllers realize that these tools are appropriate for their controllership function.

2. A total of 84.62 percent of the responding controllers indicated that they use one or more quantitative tools of decision making in solving business problems in their controllership function. This figure indicates that the quantitative tools of decision making are appropriate for accountants and that a relationship exists between the procedures used in business and those emphasized in the classroom.
3. One or more quantitative tools of decision making are used by controllers 79.81 percent in accounting (general, managerial, financial); 73.08 percent, in production (inventory control, production scheduling, etc.); and 62.98 percent, in marketing and distribution.
4. The quantitative tools of decision making ranked as follows according to the total frequency of use: (1) present-value concepts, (2) flexible (variable) budgeting, (3) forecasting techniques (regression analysis and exponential smoothing), (4) inventory models, (5) simulation models, (6) sensitivity analysis (risk analysis), (7) statistical techniques (sampling and Bayesian statistics), (8) linear programming, and (9) network analysis (PERT and CPM).
5. The controllers' opinions concerning the degree of

success or the results achieved from using these tools in business firms ranked as follows: (1) present value concepts, (2) flexible budgeting, (3) forecasting techniques, (4) simulation models, (5) statistical techniques, (6) inventory models, (7) linear programming, (8) network analysis, (9) sensitivity analysis (risk analysis).

6. The types of specific business problems analyzed with quantitative tools of decision making by controllers who use these tools ranked as follows: (1) production planning and control, (2) financial forecasting and budgeting, (3) analyzing capital investment projects, (4) facilities planning, (5) forecasting demand, supply, and price, (6) make-or-buy decision and so forth. The responding controllers who use these tools ranked the quantitative tools of decision making applied to specific business problems in the following order: (1) flexible budgeting, (2) linear programming, (3) present-value concepts, (4) forecasting techniques, (5) simulation models, (6) statistical techniques, (7) network analysis (PERT and CPM).

7. The controllers who use the quantitative tools of decision making ranked the various difficulties in implementation or the use of these tools as follows: (1) top management does not understand, (2) returns from

expenditures on these tools are inadequate, (3) accounting data are incompatible with modeling requirements, (4) there is a lack of competent personnel, (5) the models make too many unrealistic assumptions, (6) too much time is required for getting answers, and (7) the computer is inadequate.

8. The controllers' attitudes concerning the suggested common body of knowledge necessary for future controllership function were ranked as follows:

   a. Quantitative Methods

      1. High school algebra
      2. Operations research
      3. Decision theory[2]
      4. Classical statistics
      5. Differential calculus
      6. Trigonometry
      7. Geometry
      8. Bayesian statistics[2]

   b. Behavioral Sciences

      1. Management Organization Theory
      2. Motivation Theory
      3. Psychology
      4. Sociology

   c. Information Sciences

      1. Management information systems
      2. Systems analysis

3. Computer languages
4. Data base management
5. Knowledge of hardware
6. On-line information retrieval

d. Communication

1. Written
2. Oral

9. Although over 50 percent of the responding controllers did not indicate their opinions concerning the importance of the professional certifications for future controllership function, the remaining controllers' attitudes were ranked as follows: (1) the Certificate in Management Accounting, (2) the Certificate in Public Accounting, and 3) the Certificate in Internal Auditing.
10. In commenting on the minimum education level for an effective future controller, 67.79 percent of the responding controllers recommended a bachelor's degree; 31.73 percent, an M.B.A. or equivalent degree.
11. The controllers felt that the future controller should be required to have a minimum of 10 years' business experience.

B. The following conclusions were drawn after testing the hypotheses:

1. The first and second null hypotheses were rejected, because there were statistically significant differences among (a) size of firm and (b) major industry regarding the frequency of business use of quantitative

tools of decision making.

2. The third hypothesis was accepted, inasmuch as there was no statistically significant difference between the controller's education level and the frequency of use of quantitative tools of decision making in business.
3. The fourth hypothesis was accepted. This indicates that there are no statistically significant differences between the interaction effects on the basis of size of firm, major industry group, and controller's education level and the frequency of use of quantitative tools.
4. In testing the fifth null hypothesis, there was a significant difference at .05 level between the four sizes of firms and the frequency of use of present-value concepts, linear programming, sensitivity analysis, network analysis. However, quantitative tools, such as flexible budgeting, forecasting techniques, simulation models, statistical techniques, and inventory models, did not show any significant difference on the basis of size of firm.
5. In testing the sixth null hypothesis, there was no significant difference ($p < .05$) among the three types of industry with respect to the frequency of use of present-value concepts, linear programming, sensitivity analysis, forecasting techniques,

and network analysis; flexible budgeting and inventory models did show a significant difference among the three types of industry in regard to the level of use of each of these tools.

6. In testing the seventh null hypothesis, there was no significant difference ($p < .05$) among the two levels of controller's education and the frequency of use of each of the nine specific quantitative tools of decision making.
7. In testing the eighth null hypothesis, there was no significant interaction effect between the size of firm, major industry group, and controller's education and the frequency of use of each of the nine specific quantitative tools of decision making in business firms.

Recommendations

As a result of the study, the following recommendations are made:

1. In designing a managerial accounting curriculum for colleges and universities, the following common body of knowledge should be given high priority:
   A. Quantitative Methods:
      1. Present-value concepts
      2. Flexible budgeting
      3. Operations research
      4. Decision theory

5. Classical statistics

B. Behavioral Sciences:

1. Management organization theory

2. Motivation theory

3. Psychology

C. Information Sciences:

1. Management information systems

2. Systems analysis

3. Computer languages

4. Data base management

D. Communication

2. To carry out such an extensive program, the following two alternatives seem logical:

a. Adopt a five-year program similar to the AICPA recommendations with concentration on the suggested common body of knowledge deemed necessary for future controllership function.

b. Follow the present four-year program with field specialization; e.g., degree in managerial accounting.

3. A similar study to be undertaken to ascertain the CPAs' opinions regarding the extent and the level of quantitative tools of decision making in relation to their clients.

4. A similar study to be undertaken to ascertain the accounting educators' views concerning the inclusion

of quantitative tools of decision making in accounting curriculum.

5. A similar study to be undertaken in the future for a trend analysis.

Chapter V Footnotes

[1]The assumption was made that there is no difference between the characteristics of those who responded to the questionnaire and those who did not. In other words, the usable responses assumed to be representative of the entire population.

[2]See footnote 8 on page 131.

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APPENDIX A

CONTROLLER'S QUESTIONNAIRE AND ACCOMPANYING LETTERS

CONFIDENTIAL

CONTROLLER'S QUESTIONNAIRE

SECTION I: BIOGRAPHICAL DATA

A. Official Title _____

B. Seniority:

1. Years with Company _____

2. Years as Controller _____

C. List previous positions and durations:

	Position	Firm	Years
1.	_____	_____	_____
2.	_____	_____	_____

D. **Educational Background:**

1. Have you attended college? Yes_____ No_____ (If "No," please skip to Question 3 of Section I)

2. Highest Degree Earned	Major	Number of Years Attended	Date Last Attended
_____	_____	_____	_____

3. Have you attended training sessions or seminars on the uses of computers or tools of decision making such as present value concepts, linear programming, sensitivity analysis (risk analysis) forecasting Techniques (regression Analysis, Exponential Smoothing, Moving Average), statistical techniques (sampling, Bayesian statistics), network analysis (PERT, CPM) simulation models, inventory models, etc.? Yes_____ No_____

4. How did you acquire the knowledge of tools of decision making if they are now being used? (Please check the applicable boxes — more than one box may be checked for each item).

	Formal Training	Executive Training Programs	Professional Development Programs	Self-Study via: Professional Journals and/or Textbooks	Working with Consultants	Other (Please specify)
1. Flexible (Variable) Budgeting	☐	☐	☐	☐	☐	☐
2. Present Value Concepts	☐	☐	☐	☐	☐	☐
3. Linear Programming	☐	☐	☐	☐	☐	☐
4. Sensitivity Analysis (Risk Analysis)	☐	☐	☐	☐	☐	☐
5. Forecasting Techniques (Regression Analysis, Exponential Smoothing, Moving Average)	☐	☐	☐	☐	☐	☐
6. Statistical Techniques (Sampling and Bayesian statistics)	☐	☐	☐	☐	☐	☐
7. Network Analysis (PERT and CPM)	☐	☐	☐	☐	☐	☐
8. Simulation Models (includes Computer Simulation)	☐	☐	☐	☐	☐	☐
9. Inventory Models (e.g. EOQ)	☐	☐	☐	☐	☐	☐
Other (Please specify)						
10. _____	☐	☐	☐	☐	☐	☐
11. _____	☐	☐	☐	☐	☐	☐
12. _____	☐	☐	☐	☐	☐	☐

SECTION II: INFORMATION ABOUT TOOLS OF DECISION MAKING IN YOUR COMPANY

In Section II: We are attempting to determine the level of use of some of the tools of decision making currently taught at the college and university level.

A. Do you use ANY of the following tools of decision making in your business operations?

1. Flexible (Variable) budgeting
2. Present Value concepts
3. Linear Programming
4. Sensitivity Analysis (Risk Analysis)
5. Forecasting Techniques (Regression Analysis, Exponential Smoothing, Moving Average)
6. Statistical Analysis (sampling and Bayesian statistics)
7. Simulation Models (includes computer simulation)
8. Network Analysis (PERT and CPM)
9. Inventory Models

Yes_____ No_____ (If "No," please skip to Question F in Section II)

B. Do you use the quantitative decision making tools in:

	Yes	No
1. Production	☐	☐
2. Marketing/Distribution	☐	☐
3. Accounting (General, Management, Financial)	☐	☐

Continued on next page

C. How often do you use the following tools of decision making in your business operations? In your opinion, what overall results have been achieved while using these tools? Please check the appropriate boxes.

	Frequency of Use					Overall Results				
	Routinely	Periodically	Occasionally	Rarely	Never	Very Good	Good	Fair	Poor	Not Applicable
1. Flexible (Variable) Budgeting	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
2. Present Value Concepts	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
3. Linear Programming	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
4. Sensitivity Analysis (Risk Analysis)	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
5. Forecasting Techniques (Regression Analysis, Exponential Smoothing, Moving Average)	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
6. Simulation Models (includes Computer Simulation)	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
7. Statistical Techniques (Sampling and Bayesian Statistics)	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
8. Network Analysis (PERT and CPM)	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
9. Inventory Models (e.g. EOQ)	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Other (Please specify)										
10. _____	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
11. _____	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
12. _____	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐

D. Which tools of decision making are used to study the following types of business operations problems in your firm? (Please check applicable boxes — more than one box may be checked for each item).

	Linear Programming	Flexible Budgeting	PERT and CPM	Present Value Concepts	Forecasting Techniques (Regression Analysis, Exponential Smoothing, Moving Average)	Simulation Models	Statistical Techniques	OTHER				
1. Production Planning and Control	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
2. Make-or-Buy Decisions	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
3. Production Mix	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
4. Blending Mix (e.g., gasoline)	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
5. Distribution (Transportation Problem)	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
6. Plant and Warehouse Allocation	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
7. Joint Product Costs	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
8. Opportunity Costs	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
9. Analyzing Capital Investment Projects	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
10. Transfer Pricing	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
11. Planning and Developing Internal and External Audit	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
12. Forecasting Demand, Supply and Price	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
13. Financial Forecasting & Budgeting	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
14. Replacement and Maintenance of Machinery/Equipt.	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
15. Planning and Implementing Revisions of Accounting 16. Systems (e.g., Standard Costs)	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
17. Material Allocation	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
18. Inventory Analysis and Control	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
19. Project Planning and Control	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
20. Quality Control	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
21. Capacity	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
22. Planning and Controlling the Budgetary Process	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
23. Contribution Margin	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
24. Differential Cost Studies	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
25. Departmental Cost	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
26. Facilities Planning	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐

Continued on next page

E. What problems has your company encountered in using the following tools of decision making: Flexible Budgeting, Present Value Concepts, Linear Programming, PERT and CPM, Computer Simulation, Forecasting Techniques (Regression Analysis, Exponential Smoothing), Statistical Techniques (Sampling and Bayesian Statistics), etc.? (Please check the appropriate box.)

1. Top management does not understand ☐
2. Lack of sufficiently competent personnel ☐
3. The computer is inadequate ☐
4. Returns from expenditures on these tools are inadequate ☐
5. It takes too long to get answers ☐
6. These models make too many unrealistic assumptions ☐
7. Accounting data incompatible with modeling requirements ☐
8. Not applicable to this business at all ☐
9. Other (Please specify) ☐
   _____ ☐

F. Please comment on any other use of tools of decision making at your business firm, or any problems associated with their use which have not been covered in this questionnaire.

_____

_____

SECTION III: FUTURE ATTRIBUTES NECESSARY TO PERFORM THE CONTROLLERSHIP FUNCTION

Working in the controllership area, we are sure that you have some ideas about the requirements for the future controller. Based upon your expectations about future functions, changes, etc., what qualifications or attributes would you look for in a potential controller (or management accountant)? (Please check the appropriate boxes.)

A. **Quantitative Methods**
1. High school algebra ☐
2. Geometry ☐
3. Trigonometry ☐
4. Differential calculus ☐
5. Baysian statistics ☐
6. Classical statistics ☐
7. Decision Theory ☐
8. Operations research ☐
   Please Specify others
9. _____ ☐

B. **Behavioral Sciences**
1. Management Organization Theory ☐
2. Sociology ☐
3. Psychology ☐
4. Motivation Theory ☐
   Please Specify others
5. _____ ☐

C. **Information Sciences**
1. Computer languages (FORTRAN, COBAL, etc.) ☐
2. Systems analysis ☐
3. On-Line Information Retrival ☐
4. Knowledge of hardware ☐
5. Management Info. System ☐
6. Data Base Management ☐
   Please Specify others
7. _____ ☐

D. **Communication**
1. Written ☐
2. Oral ☐

E. **Professional Certifications**
1. Certificate in Management Accounting (CMA) ☐
2. Certificate in Public Accounting (CPA) ☐
3. Certificate in Internal Auditing (CIA) ☐

F. **Formal Training**
What do you feel will be the minimum educational level desired for an "effective" controller? _____

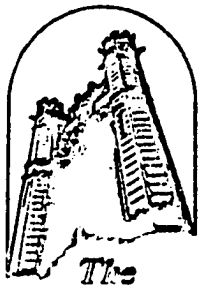
G. **Business Experience**
What do you feel will be the minimum years business experience (Public Accounting background, worked with competitor, Experience within firm, etc.) desired for an "effective" controller?

H. **Other Comments**

_____

_____

Concluded



The University of Oklahoma 307 West Brooks, Room 200 Norman, Oklahoma 73069

Division of Accounting
College of Business Administration

January 4, 1975

Dear Controller:

As part of an effort at our university to become more involved in the discipline of Management Accounting, Mr. Kiani-Aslani is doing dissertation research under the direction of our faculty. His study involves assessment of the importance of quantitative techniques to the controllership function.

As an active participant in business management, and one concerned with balance between accounting theory and practice, your opinions about the usefulness of quantitative decision tools are important to this study. Your responses will help in determining (a) the appropriateness of quantitative techniques for controllership; (b) the extent to which these tools are being used in controllership today; and, (c) desirable qualifications for future controllers.

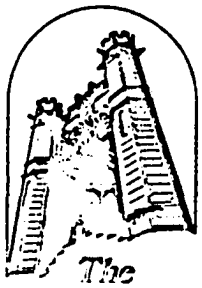
The information you provide by completing the enclosed questionnaire will be held in confidence. No signatures are necessary. Only statistical summaries will be published. Individual responses will not be identified.

The questionnaire has been designed so that you can respond quickly and easily. Your prompt attention to this request for information will facilitate completion of this important project. Will you please return the questionnaire in the enclosed stamped envelope? Thank you.

Sincerely,

Bart H. Ward
Assistant Professor and
Chairman of Dissertation Committee

Enclosure



The University of Oklahoma 307 West Brooks, Room 200 Norman, Oklahoma 73069

Division of Accounting
College of Business Administration

February 5, 1975

Dear Controller:

Recently I requested your participation in an important study concerned with my doctoral dissertation. Your response is urgently needed. In addition, your completing the questionnaire will help me in fulfilling the requirements for a doctoral degree at the University of Oklahoma.

If you have already returned the questionnaire, please consider this note a "thank you" for your valuable help.

If you have not had a chance to do so as yet, would you return the completed form now in the enclosed stamped envelope? I am trying to get as near a "perfect survey" as possible. This goal means getting a reply from everyone who received a questionnaire. Your opinions about the various items in the questionnaire will lead to a better understanding of the needs of the quantitative areas of management accounting.

Your participation is <u>vital</u> to the success of my study. I shall be most grateful for your participation and assistance.

Sincerely yours,

R. Kiani-Aslani
Special Instructor in Accounting
and Research Director

Enclosure

APPENDIX B

MANAGERIAL CONSIDERATIONS OF QUANTITATIVE TOOLS OF DECISION MAKING

APPENDIX B

MANAGERIAL CONSIDERATIONS OF QUANTITATIVE TOOLS OF DECISION MAKING

Introduction

In recent years, the accelerating trend toward the application of techniques and scientific methodology of the tools of decision making to management problems has brought about drastic changes in the structure and the texture of managerial decision making. In fact, these changes have been so rapid and so profound that no organization and no executive can be either aloof or immune to the implications or the challenge of these changes that have spiderwebbed the entire framework of management theory and practice.

There is no escaping the fact that the size and the complexity of modern organizations have added new problems, new uncertainties, new variables. Today's executive, if only in self-defense, must have some basic understanding of the capabilities and the limitations of the quantitative tools of decision making to aid him in seeking out not only solutions to new problems, but also new and refined solutions to old problems. In this respect, Brinckole quoted the Editors of Harvard Business Review:

> In the competitive executive market in which he operates today, the highly motivated manager realizes that his progress through the executive hierarchy will depend importantly on his ability to supplement personal skills with the best of the new managerial tools.[1]

Obviously, these changes have created difficult problems for accounting and accountants. Becker has noticed these difficult problems and stated:

> Since World War II, the demands made upon accountants have grown in intensity and urgency. This has occurred at both macro- and micro-economic levels, as more precise quantitative tools are sought for measuring performance, predicting future events, and making rational decisions. These demands for more meaningful measurements are a challenge to traditional accounting concepts and procedures. However, they also provide a stimulus for improving the level of public service performed by the profession. In the final analysis, accounting is only an instrument for measuring and communicating financial information. Its contribution to society can best be evaluated in terms of its ability to satisfy user needs.
>
> Many of the problems confronting the accounting profession are exceedingly complex, reflecting the dynamic conditions of contemporary society. Moreover, the alternative solutions available are often delicately balanced. Only a thorough understanding of the nature and ramifications of the problems and their potential solutions will bring success in overcoming these difficulties.[2] /Underscoring is that of the researcher./

In many respects, changes have occurred so fast that they made students of all who work with or process accounting information. Those who manage business enterprises and rely upon reports of status and effectiveness must keep pace with changes. Thus, the

decision maker no longer can decide and plans merely on either judgment, hunches, or intuition. Likewise, practicing accountants must be continually alert if they are to take advantage of the new developments. Certainly, accountants can effectively use certain quantitative tools of decision-making models in designing, developing, and implementing a decision-oriented management information system. In doing so, the accountants can then be in a position to provide the informational needs of management.

In essence, the aim of this appendix is to provide the reader with an understanding of quantitative tools of decision making that have become essential tools of modern business and business management. In addition, this chapter is designed for today's versatile accountant, whose expanding horizons require him to understand the management uses of quantitative tools of decision making.

The major purpose of this report is to place quantitative tools of decision making in perspective as they relate to the science and the art of managing (i.e., managerial decision making). In surveying these tools, no attempt will be made to cover the techniques exhaustively; each technique warrants book-length treatment to ensure some expertise or even understanding. Rather, the writer will describe the tools and the techniques from the manager's point of view and emphasize those aspects that are

important in assessing applicability.

In this appendix, the following quantitative tools of decision making will be discussed briefly: flexible budgeting, present-value concept, statistical techniques, statistical forecasting techniques, network analysis (PERT/CPM), linear programming, sensitivity analysis (risk analysis), inventory models, and simulation studies.

Budgeting

Budgeting is a management tool for effective financial control. The subsequent discussion concentrates on the definition of budgeting, as well as the current status, nature, limitations, and principles of effective budgeting.

Definition of Budgeting

Although familiar to almost everyone, the word "budget" means different things to different people. Within a business organization, some members of management view budget as a planning and control tool to aid the firm in meeting various objectives. Further down the organizational hierarchy, others consider budgets as a pressuring device applied by management to exploit the work force. Still others in the organization look upon budgets as a game to be played once each year.[3]

A conceptually stronger meaning and certainly less

biased is one advanced in a recent National Industrial Conference Board research study that suggested the following:

> Budgeting--involves the preparation and adoption of a detailed operating plan, expressed in financial terms, for an organization for a definite future period. It also includes comparison of the results of actual operations with those set forth in the plan and analyses of the reasons for deviations from planned performance.[4]

In accordance with the above definition, budgets can be classified into two divisions: operating budgets and financial budgets. A budgeted item relating to the income statement (i.e., sales, expenses, production, etc.) is designated as an operating budget. Likewise, a budgeted item pertaining to the balance sheet (i.e., cash, working capital, etc.) is designated as a financial budget.[5]

Current Status of Business Budgeting

The business budget is largely a twentieth century phenomenon. The early business budget was borrowed from the government and was usually of an appropriation type (concerned with expenditure control) imposed by top

management. Its appearance in the business firm was, at first, limited to production departments.[6]

In 1931, the first empirical study of the use of budgeting in business was conducted.[7] Since then, and especially with the rapid acceptance of budgeting after World War II, budgeting has become a major part of the scientific management process.

The present level of maturity in business budgeting is analogous to the status of accounting in the United States from 1906 to 1922. The literature in budgeting, similar to the literature in accounting before 1922, is engrossed with mechanics.[8] McKinsey's[9] work is about as advanced in its presentation as writings by Knight and Weinwurm,[10] Welsch,[11] and Vatter.[12]

The limitations in budgeting literature may be summarized as follows:

1. There is an overemphasis on techniques and use of illustrative tables.
2. Very little attention is given to service and not-for-profit organizations.
3. The difference between planning and control is not clearly acknowledged in much of literature. Planning should be viewed as the process of deciding organizational objectives and deciding the resources to be employed in attaining the objectives. Control, on the other hand, is the process by which management assures that resources are obtained and used efficiently in accomplishment of organizational objectives.
4. The relationship between optimization of resource usage in a department and overall optimization of the firm is not adequately explored. Textbook budgeting techniques approach the problem of resource utilization within the firm but do not derive optimal solutions.

As for the future, presently evolving budgeting techniques, such as planning-programming-budgeting systems, simulation budgeting, and behavioral budgeting process, have the potential for revolutionizing business planning. In fact, organizational structures will probably be altered because of these developments. Large-scale, complex corporations, with difficult resource allocation problems

and strategic planning problems especially stand to benefit by the application of planning-programming-budgeting systems and simulation budgeting.

Nature of Budgeting: Fixed and Flexible Budgets

According to Andrew Stedry, one budget cannot serve both as a planning and control tool even if original budgeted expectations and actual volume are the same. Controls must be variable according to the characteristics and aspirations of the person being controlled.[13] Consequently, it is becoming more popular in practice for a firm to use one budget for planning and another for control. The planning function is served by a fixed or static budget, while the control function employs a variable or flexible budget.

Flexible budgeting involves preparing a series of budgets at various levels of business operations for a given department. The flexible budgeting techniques offer opportunities for managing dynamic business environments that are virtually unattainable with traditional, "static" budgeting methods. Flexible budgeting is one of the most powerful tools for coping with today's inflationary and fluctuating business environments. More often, however, the flexible budget is expressed as a simple formula

composed of these two elements: (1) fixed costs that remain constant for a given period and (2) variable costs that fluctuate in accordance with some measure of activity.

While flexible budgets are used to control day-to-day and month-to-month operations, the fixed budget should form the basis for the annual profit plan and should not change after that plan is adopted.[14] Fixed budgets are best used to control yearly operations and to permit an organization to move toward achievement of one year goals in its long-range profit plan.

Principles of Effective Budgeting

Budgeting techniques must meet the needs of the business organization for which they are designed. Since no two firms are alike, no two budgeting approaches will be exactly the same. However, no matter how specialized a particular business may be, certain fundamentals must be applied to achieve an effective budgeting program. These fundamentals or conditions necessary for effective budgeting are defined herein as <u>principles of budgeting</u>. From a review of the literature, twelve such principles come to light. These are:[15]

1. Budgets should be carefully tailored to the organizational characteristics, needs, and philosophy of the individual firm. A budget system that works effectively in one firm will not necessarily do so in another.
2. Budgets should be based on and be in accordance with broad corporate objectives (long-range plans), and as many as possible of these broad objectives (e.g., desired earnings per share, desired return on investment) should be quantified. Unless corporate goals are decided first, the budget suffers.
3. Budgets should be based on a sound organizational structure that has clear-cut lines of authority and responsibility.
4. Budgets should be based on an adequate accounting system that generates sufficient and timely data in a form that is compatible with the budget system.
5. Budgets should have adequate support from top management. In fact, genuine support of all levels of management is essential.
6. Budgets should seek maximum participation. That is, those responsible for carrying out the budget plan should participate in its preparation.
7. Budgets should contain realistically attainable goals and objectives. Budgets should express management's best estimate as to what is most

likely to occur during the forthcoming period.

8. Budgets should not run the business. There must be enough flexibility to allow an organization to take advantage of unforeseen opportunities. Preferably, budgets used for control should be revised as activity levels change while the annual profit plan (fixed budgets) should remain unchanged throughout the budget period.
9. Budgets should be supported by a reporting system that incorporates a comparison of actual with expected performance. Variances should be isolated and, if material, explained.
10. Budgets (comprehensive, in nature) should be approved by management at a high level.
11. Budgets, their objectives, and their construction should be specified in a budget manual. The responsibilities and authority of all management and employees concerned with budgetary procedure should be defined and budgetary reporting procedures should be documented in the budget manual.
12. Budgets should be supported by either a qualitative or a quantitative description of the activities required for their realization.

In summary, because the budget is a tool that permits management both to investigate the effects of alternatives and the plan against which performance is

compared, it is part of the control process. The budget serves to communicate, coordinate, and anticipate the activities of the business organization.

Present Value Concept

Capital budgeting, which involves commitments for large outlays whose benefits (or drawbacks) extend well into the future, is of the greatest significance to a firm. Because decisions in these areas will have a major impact on the future well-being of the firm, the capital budgeting decisions should be made in a manner that will contribute to the health and the growth of a firm.

Capital budgeting may be defined as the series of decisions by individual economic units as to how much and where resources will be obtained and expended for future use, particularly in the production of future goods and services.[16]

There are many different methods[17] of making capital budgeting decisions, and the information requirements are somewhat dependent on the method chosen. The succeeding discussion will concentrate only on the present value concept for evaluating investment decisions.

The present-value analysis incorporates the objectives of maximizing the present monetary value of investments. The present value is the sum of all anticipated future earnings (net revenues) associated with the investments, discounted to the present by an appropriate interest rate. Thus, the present-value analysis incorporates the magnitude, the time value of money, and the duration of earnings that an investment typically generates at periodic intervals.[18]

The valuation of capital assets consists of the present value of all future earnings and benefits computed at a discount rate (or interest rate) commensurate with the risk and uncertainty of the future earnings and benefits. Therefore, the valuation of assets involves estimating future earnings and benefits, as well as determining an appropriate discount rate. Although accurate estimates of earnings in the distant future are difficult to make, this limitation is not serious. Accurate estimates of earnings in the distant future are not necessary because these distant earnings are discounted so heavily and, therefore, contribute little to the present value.

Whenever the present value of investment earnings exceeds the cost of investment, that is, whenever the net present value (NPV) is greater than zero, the investment

is profitable. NPV = Present Value of Earnings - Cost. The greater the net present value of an investment, the more financially attractive it becomes. In a sense, the net present value represents the present value of the "income" of the investment after all expenses--including the interest cost (at an appropriate interest rate) on the money invested--have been charged.

The net present-value method measures the "profit" of an asset, irrespective of (1) its economic life (or earning period), (2) its earnings pattern, and (3) the initial cost of the asset.

According to Matz and Curry, the major advantages of present value method are:

1. Considers the time value of money.
2. Considers income over the entire life of the project.[19]

Several difficult technical problems have to be faced in the application of the present-value concept. For one, it is difficult to determine just what value should be taken to represent the cost of capital (i.e., cut-off rate). Furthermore, the present-value model is based on the assumption that the decision maker possesses relatively accurate information about the size of the future earnings--i.e., assume conditions of certainty. In this respect, Johnson indicated that the present-value

method and the internal rate of return are not widely utilized in industry today. Rather, quite frequently:

> Rougher techniques are used, sometimes because they are reasonably suitable to the needs of the firm, sometimes because more sophisticated techniques are not understood by management, and sometimes because management is still in process of training and educating its personnel in the use of rate of return or present value.[20]

To sum up, the capital budgeting probably spells the difference between success and failure for many business concerns. Regardless of the size of the business firm or the level at which the decisions are made, the principles should be the same. The decision makers are committing a sum of money today in return for anticipated net earnings in the future. Evaluation of desirability of a particular investment decision requires that decision makers give greater weight to income that is to be received in the near future. Decision makers must consider the time value of money. Thus, the present-value concept is an approach for evaluating investment decisions that takes into account the time value of money.

Statistical Techniques (Statistical Sampling and Baysian Statistics): Tools for Coping with Lack of Information

Management operates under a cloud of uncertainty. Without a crystal ball to foretell the future, the decision maker must draw on his own experience and that of others to

predict events. His decisions must be formulated from the limited information that can be collected at a reasonable cost. Very often, inferences concerning the whole or population must be drawn from observations of a part or sample. Although accounting provides a reasonably accurate record of data concerning what has happened, the data are usually little more than historical facts from which calculations and projections can be made. Statistical techniques, such as statistical sampling and Bayesian statistics, provide a means by which these data can be manipulated so that more meaningful inferences can be drawn from them.

Statistical techniques, such as statistical sampling and Bayesian statistics, provide a useful tool for the decision-making process, planning, and control, primarily, in the realms of estimation and hypothesis testing. This connotation is presented in the following:

> It is the purpose of statistical analysis to provide methods of treating data so that the maximum information can be obtained with a predetermined risk of drawing false conclusions. No method of analysis can extract more information from a set of data than is contained therein, and no method, statistical or otherwise, can draw conclusions from experimental data with zero risk of error. The use of statistical methods is based on a reasonable assumption that accepted principles of logic and probability should produce correct answers more often than guessing.[21]

The use of statistical sampling is widespread. In some cases, it is the only approach to obtaining data

for decision making; in other cases, it is the only feasible approach in terms of time and/or money. The purpose of statistical sampling is to obtain information concerning the whole or population by examining a cross-section or the sample. In other words, the primary purpose of statistical sampling is to provide an objective estimate of the characteristics of the population with some measure of the reliability of that estimate.

Use of statistical sampling techniques has a long history of successful application in the field of quality control where it has been proved that acceptable conclusions about the conditions of the units being manufactured can be based on inspections of relatively small portions. In accounting, widespread application is found in auditing in verifying accounts receivable, testing inventories, cost control, vouchering invoices, and so forth. This is supported in current accounting literature[22] that cites examples of the varied use of this concept.

The statistical sampling used in auditing can be classified as either: (1) estimation sampling, (2) acceptance sampling, or (3) discovery sampling. Furthermore, the sampling methods can be of such categories as simple random sampling, stratified random sampling, systematic sampling, and cluster sampling.

The major advantages of statistical sampling techniques can be summarized as follows:

1. Produces objective, defensible results.
2. Provides an advanced, objective estimation of sample size.
3. Provides an estimate of sampling error.
4. May save time and money.
5. Provides a basis for possible objective evaluation of test results.[23]

Bayesian Statistics

Bayesian statistics is relatively new to decision theory. The concepts of Bayesian decision theory provide a means for (1) utilizing subsequent information to modify personal (subjective) probabilities and (2) estimating the value of further economic investigation.[24] In other words, the Bayesian statistics to decision making under conditions of uncertainty tend to treat uncertainty problems as if they were risk problems by relying on subjective probability rather than objective probabilities.[25] In effect, Bayesian statistics base probabilities on confidence that the decision maker has in the truth of a specific proposition.[26] This confidence is expressed in numbers that must follow certain rules of consistency.[27] However, by testing the subjective probabilities empirically, the decision maker can arrive at increasingly objective elements for choice purposes.

In summary, both statistical sampling and Bayesian statistics involve decision rules to minimize risk. The classical sampling techniques are used more widely than Bayesian techniques, but Bayesian techniques are widely

acknowledged as being more powerful. They are compared briefly below.

Classical statistics techniques classify error as either Type I (rejecting a hypothesis incorrectly) or Type II (accepting a hypothesis when it is not correct). Typically, the statistical sampling technique minimizes the Type II error, subject to a restriction the probability of committing a Type I error. The decision theory techniques, however, are concerned not only with the probabilities of committing errors which hypothesized, but also with the opportunity losses due to error.[28]

Statistical Forecasting Techniques

Planning--whether strategic (long-range) or tactical (short-range)--cannot be effective without a realistic appraisal of future economic conditions and other environmental factors such as sales forecasting. Future sales are usually the most important factor in determining the budget and the most critical element in projecting financial statements. According to Buckley and Lightner, "Forecasting is the process of estimating future events. Recording the accounting significance of the outcomes of such events is budget planning."[29]

As a foundation for the sales budget, the sales

forecast, in turn, provides a basis for production planning, inventory control, cash-flow management and capital-budget planning. As a result, the sales forecast represents a most critical step in the construction of a comprehensive budget and forms the bedrock for any budget planning program.

Forecasting techniques range from simple approaches to complex mathematical models of analysis and prediction. The inputs to these models, both simple and mathematical, ". . . are facts, rumors, conjectures, statistical techniques, and above all else, common sense."[30] Two essential ingredients of any forecast are fact and judgment. ". . . all modern-day techniques are designed either to limit the area in which judgment must be exercised, or to improve the quality of judgment reinforcing it with facts."[31]

Various techniques are used in attempting to develop useful forecasts as a prerequisite for rational planning activities. These techniques can be classified into the following groups: (1) judgmental techniques (such as jury of executive opinion, sales force composite, and so forth), and (2) statistical forecasting techniques. The succeeding discussion is concerned only with such statistical forecasting techniques as moving average, exponential smoothing, and regression or correlation analysis.

Moving Average

This technique attempts to compromise the opposing characteristics inherent in short averaging periods and long averaging periods. The objective is to establish the duration of the averaging period so that it is long enough to permit random fluctuations to be attenuated or cancelled out while, at the same time, being short enough to discard the influence of information that is <u>older</u> and perhaps <u>no longer relevant</u> to current conditions.

Exponential Smoothing

The exponentially smoothed average is a weighted average with the unique characteristic that the greatest weight is assigned to the <u>most recent</u> information, while the least weight is assigned to the <u>most distant</u> (oldest) information. In between these two extremes, there is a gradation of weights--as the information becomes progressively older, the weights become commensurately smaller.

The exponential smoothing model can be expressed as follows:

Current Average = C (Current Demand) + (1-C) (Previous Demand)

where C is the smoothing constant and can assume values between 1 (for no smoothing) and approaching zero (for completely smoothed).

The greatest disadvantage inherent in moving averages is the relatively large amount of historical data

required to compute them. The exponential smoothing, on the other hand, eliminates the need for retaining large amounts of historical data, and greatly facilitates the computation of the averages, whether manually or by computer. In addition, the exponential smoothing response to changes in environmental factors, as well as control of forecast accuracy, is readily achieved by modifying the value of the smoothing constant. It is particularly appropriate for computer applications, because minimal information storage is required.

Correlation or Regression Analysis

Correlation analysis can be used as a tool for forecasting, budgeting, and measuring business operating activities. This technique is concerned with discovering and measuring the degree of association between variables (dependent and independent variables). If knowledge of one variable provides no information about a second variable, little or no association exists. If, however, knowledge of one variable provides information about a second variable, some degree of association exists. Some examples are: domestic freight ton miles and gross national product are closely associated, as are total sales volume of the ethical drug industry and consumers' personal disposable income.[32]

The relationship between the dependent variable (i.e., firm's sales) and the independent variables (i.e., the environmental factors) is often expressed as a mathematical equation such as the following:

$$y = a + bx + cz \quad .$$

where: y = dependent variable (i.e., sales)

x & z = independent variables (given or forecasted)

a, b & c = regression coefficients.

A firm using correlation or regression analysis has to determine whether to use a regression equation with one independent variable (simple linear correlation) or with more than one independent variables (multiple linear and multiple curvilinear correlation). In this respect, as Knapp indicated, "it is difficult to conceptually present more than two independent variable correlations, but some of the one and two independent variable relationships that we have found applicable are presented in [Figure 3.1] with their respective equations in general form."[33] Figure 3.1 on the next page illustrates various applications of correlation curves which have been found in business practice.

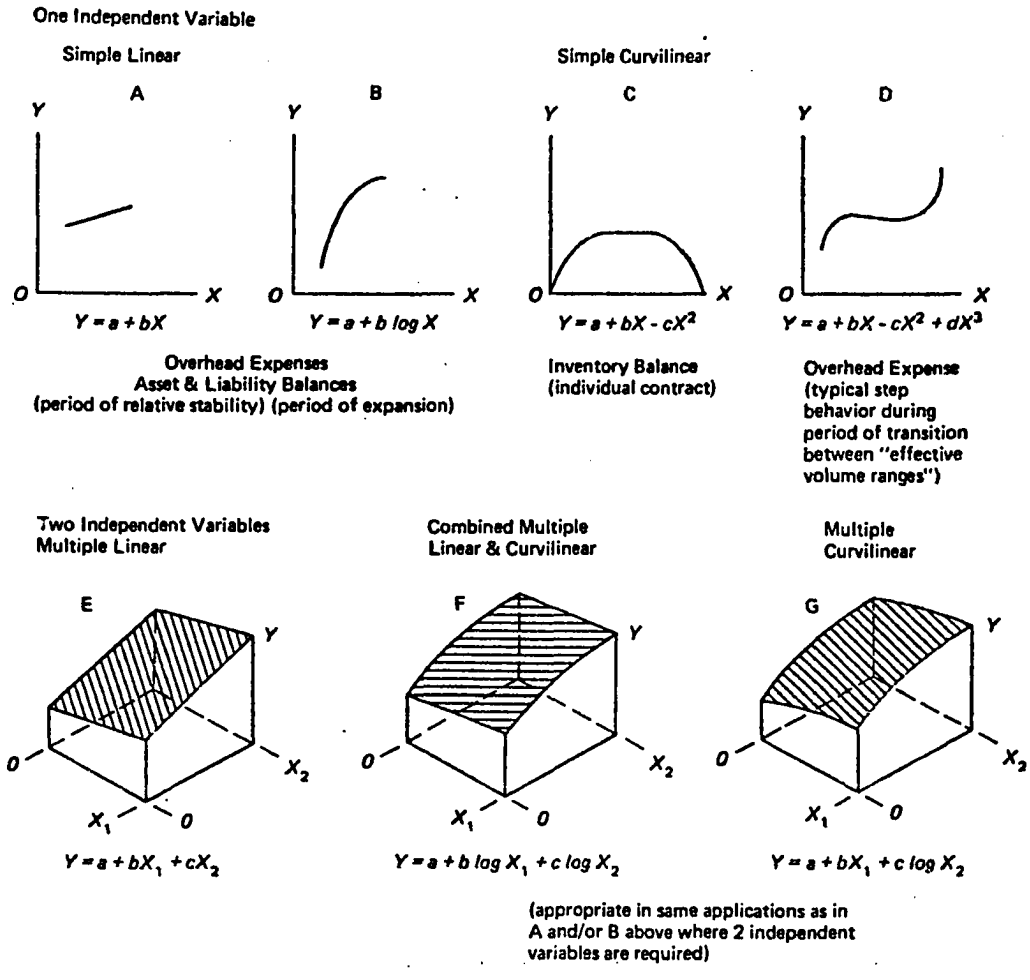


Figure 3. Sample correlation curves. Source: Knapp, "Forecasting and Measuring with Correlation Analysis," p. 17.

Network Analysis (PERT and CPM)

Planning long-range objectives is a function that perpetually confronts most managers of business organizations. Much of this planning is, of necessity, limited to subjective analysis and appraisal. Information is not always either reliable or readily available, market surveys are subject to error, economic conditions can be only reasonably well predicted, and technological developments are difficult to anticipate. Consequently, many of the long-range planning decisions are limited to subjective evaluation and require considerable judgment, intuition, and experience in the relevant environment.

Fortunately, not all long-range planning is limited to qualitative analysis. Quantitative disciplines are available and can appropriately be applied to the solution of various types of long-range planning activities. Network analysis is one of the tools of decision making available for planning and controlling nonroutine, periodic activities that recur relatively infrequently. Such analysis is an extremely effective tool for analyzing, planning, monitoring, and controlling complex projects.

The succeeding discussion centers around the following aspects of network techniques: the definition of PERT (program evaluation and review technique) and CPM (critical path method), the distinctions between PERT and

CPM, advantages and limitations of network analysis, as well as the application of network analysis.

What is PERT

The Program Evaluation and Review Technique (PERT) is a method of managing, a tool used by the manager in planning, controlling, and manipulating resources to successfully attain a stated goal. Thomas Sobczak stated:

> PERT is a statistical technique--diagnostic and prognostic--for quantifying knowledge under uncertainties faced in completing intellectual and physical activities essential for timely achievement of program deadlines. It is a technique for focusing management attention on danger signals that require remedial decisions, and on areas of effort for which trade-offs in time, resources, or technical performance might improve capacity to meet a major deadline.[34]

PERT is not intended to usurp the manager's function, but to aid the manager in performing his function more decisively. It does not manage but depends entirely upon the manager's ability to use the technique for uncovering and recognizing problems.

PERT does not solve problems but rather puts them into perspective so that all factors relating to the problem can be judged. The full implication of a management decision is seldom known at the time of decision; uncertainty pervades the consideration of any problem. PERT offers an effective method of reducing uncertainty so that

decisions made and actions taken are pertinent to the actual problem and have a predictable possibility of success. PERT adopts a probabilistic approach to network planning and utilizes statistical techniques such as standard deviations and variances to facilitate determination of the probability of meeting time schedules for each project.[35] In this respect, Dopuch, Birnberg, and Demski stated:

> One important characteristic of PERT is that it is designed to control the completion time of specific activities of a project. The expected times for completion represent standards for each activity and can be described in terms of probability distributions. Hence, the significance of any deviation from expected completion times for an activity can be assessed initially by determining how the deviation affects the expected completion date of the project. The economic significance of any such deviation can be measured by the penalty cost imposed if the project is not completed in a specified time period. A deviation in completion times is economically significant if it requires an increase in the expected payout cost (penalty cost weighted by the probability of not finishing on time) that is greater than the cost of reducing the completion time of subsequent activities.[36]

PERT is not a panacea, it has limitations (fallible human judgment and the cost of implementation). Nevertheless, the benefits derived from its proper use are unmatched in any other existing system. In this regard, Ivars Avots stated that "Generally, PERT is a superior system for (a) identification of potential trouble spots, and (b) reallocation of resources."[37]

One of the recent extensions of PERT/Time is PERT/Cost. PERT/Cost is a dynamic control tool that provides a means of obtaining the optimum mix of time and cost on a project. Alternative time--cost plans for accomplishing objectives also may be developed to provide better project planning and control.

A variation of the flexible-budgeting concept, PERT/Cost requires that accounting systems generate at least the direct costs of projects or activities. Indirect costs may also be included in the budget. The use of PERT/Cost demands effective coordination at all managerial levels of activities of persons involved in the project.

Implementation of PERT/Cost systems is likely to require "investment" in planning and system modification, but the payoff may justify it.[38]

Basic Concept of CPM

The Critical Path Method, like PERT, is a decision-making tool that is widely accepted at all levels of management. In this regard, Levy, Thompson and Wiest stated:

> Recently added to the growing assortment of quantitative tools for business decision making is the Critical Path Method--a powerful but basically simple technique for analyzing, planning, and scheduling large, complex projects. In essence, the tool provides a means of determining (1) which jobs or activities, of the many that comprise a project, are "critical" in their effect on total project time, and (2) how best to schedule all jobs in the project in order to meet a target date at minimum cost.[39]

Although PERT and CPM methods of network analysis are conceptually similar, there are several distinguishing characteristics. One of the most salient features of CPM is the attempt to optimize the total project cost (when project duration must be reduced) by shortening appropriate project activities. CPM focuses on optimizing the total costs (that is, overhead plus activity costs) for various possible project completion dates; however, no systematic procedure was initially proposed to effectively achieve this goal of cost optimization.[40] The major difference between PERT and CPM is that, while CPM adopts a deterministic approach to network planning, PERT adopts a probabilistic approach.[41]

Salient Characteristics of Network Analysis

Network analysis is a technique for planning, and controlling complex projects efficiently. Some of its salient characteristics are:

1. It focuses management's attention on the overall project requirements.
2. It focuses emphasis and control where it is most needed--on the critical activities and other important activities.
3. It identifies interrelationships and interdependencies among activities.
4. It aids in establishing resource requirements (men, capital, and equipment).
5. It identifies the types and quantities of resources that should be allocated to each activity in order to meet the schedule.
6. It indicates which activities to shorten, as well as how much.
7. It permits the development of comprehensive, efficient project plans and schedules.[42]

Application of Network Analysis

The application of network analysis has occurred in almost every facet of business. From a review of literature, the following applications of network analysis come to light.[43]

Accounting

The PERT technique has been used in planning and developing internal and external audit in accounting, in integrating and coordinating month- and year-end closing of the ledgers, in planning and implementing revisions of accounting systems, such as standard costs, in preparing the annual report for stockholders, bankers, and governmental agencies, in planning and controlling the budgetary process, and in preparing consolidated financial statements.

Finance

In finance, network analysis has been used for organizing and determining a priority for the acquisition of capital equipment and the timing of the purchase, in preparing and paying dividends, and in timing and placing new stock and bond issues.

General Management

General management applications of this technique have been in the installation and the conversion to computer

systems, for scheduling unusual operations, for setting down or moving an operation or plant, for installing and integrating a new organizational structure, for long-range planning of management succession, for timing and coordinating a merger, for revising or installing a management reporting system, and for starting up standby facilities.

Marketing

In the marketing field, PERT has been used in planning advertising media and measuring its effectiveness, in implementing sales promotion campaigns, in measuring the effectiveness of market channels, in entering new marketing areas, in introducing a new product, in realigning sales territory, and in planning special promotions, conventions, and sales meetings.

Production

Applications of network analysis in production have been in scheduling product tests, planning production and materials flow, planning and implementing maintenance programs, installing major capital equipment, and studying the production process.

Purchasing

Purchasing applications of network analysis have been limited in preparing bills and proposals for materials and parts, as well as for timing acquisitions or material.

Transportation

In the transportation field, PERT has been used for coordinating and timing shipment of goods with demand dates and for measuring the effectiveness of methods for transportation.

In brief, network analysis provides data for immediate and continuing control and re-evaluation, while the graphical techniques provide additional means of communicating and interpreting results, as well as pinpointing critical areas of concern.

Linear Programming (L.P.)

Increasingly, new tools and techniques of decision making are being used by decision makers as they seek to make intelligent planning decisions and control operations. At the heart of management's responsibility and planning decisions is the best or optimum use of scarce resources.

One of the methods of quantitative tools of decision making that have found extensive application in optimizing planning decisions is linear programming. Linear programming permits determination of the best use of available resources and is a valuable aid to management by providing a systematic and efficient guide in the decision making process. The following discussion will concentrate on the definition of LP, the characteristics or requirements of LP, the cautions of linear

programming, the other models related to linear programming, and finally the applications of linear programming.

Definition of Linear Programming

Ferguson and Sargent defined linear programming as:

> . . . a technique for specifying how to use limited resources or capacities of a business to obtain a particular objective, such as least cost, highest margin, or least time, when those resources have alternate uses. It is a technique that systematizes for certain conditions the process of selecting the most desirable course of action from a number of available courses of action, thereby giving management information for making a more effective decision about the resources under its control.[44]

Thus, linear programming deals with the problem of allocating limited resources among competing activities in an optimal manner. The allocation problem can arise whenever the decision maker must select the level of certain activities that must compete for scarce, necessary resources.

Linear programming uses a mathematical model to describe the problem of concern. The adjective "linear" means that all the mathematical functions in the model must be linear functions. The word "programming" means planning. Thus, linear programming involves the planning of activities to obtain an "optimal" result, i.e., a result that reaches the specified goal best among all feasible alternatives.

Characteristics of Linear Programming

Regardless of the way in which one defines linear programming, certain basic requirements or characteristics are necessary for utilizing the technique in the solution of a business problem. These characteristics are as follows:

1. Objective Function. A well-defined objective serves either to maximize contribution by utilizing the available resources, to minimize costs by using limited resources, or determine the best distribution of the productive factors within a certain period of time. This objective function must be capable of being defined mathematically.
2. Alternative Course of Action. Selection must be made among various combinations of manpower, machinery, manufacturing capacity, and so forth.
3. Linearity. The objective function and its constraints must be expressed as either linear equations or inequalities.
4. Variables. The variables in the problem must be interrelated. Relationships among variables must be established into mathematical formulations capable of describing the problem and all relationships among variables.
5. Limited Resources. Without this condition, there would be no need for allocation. This condition,

furthermore, normally determines the constraints on the objective function.[45]

Cautions of Linear Programming

Linear programming is a power tool but not a cure-all. Some of the cautions or difficulties associated in applying linear programming are as follows:

1. Obsolete Information. After inputs have been collected, the information may become obsolete due to either internal or external factors. The manager may recognize this situation but, because of limited time and money, will proceed with the information at hand. Also, the manager may be unaware of changing information and proceed in ignorance. In either case, solutions will be distorted and often erroneous.

2. Consideration of All Constraints and Variables. Managers who use this technique must be sure that they have a practical application of the selected model for linear programming. For example, the computer program available may not be capable of handling all of the constraints and/or variables. If such a program were used, certain constraints and/or variables would have to be dropped, and the answers would become basically unusable.

3. Nonlinear Relationships. If the objective function and the constraints are nonlinear, extreme caution must be used in applying linear programming. The misapplication of linearity, whether assumed or misunderstood, usually results in an incorrect solution.
4. Costs. There is a maintenance cost for the necessary factors in a problem of this type. Management may question whether the cost of programming with new data is worth the change. The manager must decide the importance of the degree of accuracy in his solution.[46]

Other Related Models of Linear Programming

Because of their complexity, other optimization models are outside the intended scope of this study. Some of the more common related models are briefly mentioned below.

1. Dual linear programming that is an extension of linear programming.
2. Goal programming that is a method of minimizing deviations from goals.
3. Integer programming that is a method of finding the optimal integer solution. Merely rounding the optimal non-integer solution will not necessarily yield the best policy.

4. The transportation (or distribution) and assignment models which may be used when a problem has certain characteristics.
5. Convex (nonlinear) programming that utilizes the idea of linear programming to solve certain nonlinear problems.
6. Dynamic programming that refers to a technique for solving a set of problems in which sequential decisions must be made--each decision has an impact on the scope and the potential of subsequent decisions.

Applications of Linear Programming

Linear programming is a mathematical technique for obtaining the optimal solution to problems that can be put in a particular structural form. Linear programming has many useful applications in almost every facet of business.

For some time, it has been recognized that there are tantalizing similarities between the economic interpretations of linear programming models of the firm and the accounting procedures used for reporting and evaluating company performance. Samuels[47] has shown the dual variables (or shadow prices or simplex multipliers) of a linear programming model can be used as the basis for an opportunity

costing for production planning and control. Wright[48] and Carsberg[49] have shown how the linear programming model can be used for evaluating fixed factors in production; in their models the shadow prices are used as a basis for depreciation accounting. Baumol and Fabian[50] have shown how the decomposition algorithm can be used to model the decentralization of decision making in a firm and how the resulting shadow prices can serve as transfer prices for interdivisional purchases and sales. Smith[51] has shown how the linear programming model can be used in accounting for allocating "joint" costs to proper product. Linear programming may also be applied to certain problems of break-even analysis,[52] as well as to the multiple break-even points in which they can be effectively located by the method of goal programming,[53] which is a variation of linear programming. Demski[54] developed a system of variance analysis which is applicable to situations in which a firm utilizes a well-specified linear programming decision model as a planning tool. Demski argued that in situations of this type, variances can be more meaningfully defined than they are in traditional variance analysis.

Linear programming may also be used to solve problems of financial budgeting and planning. This involves the decision as to how much fixed and working capital the firm will need and how these needs should best be financed.

A firm that expands its assets without regard to the cost and availability of funds runs the risk of financial loss and even bankruptcy. Conversely, a firm cannot formulate its financing plans without knowing its anticipated needs. So the crux of financial budgeting and planning is the problem of maximizing profit within the constraints of liquidity and solvency. If the profit function and the financial constraints can be approximated by linear functions, these problems can be solved with the optimizing technique of linear programming.

Other specific applications of linear programming to business operations are summarized as follows:[55]

1. Determination of the maximum profit combination of products that may be obtained with existing equipment.
2. Determining which parts are to be manufactured and which to be purchased to get the maximum profit margin.
3. Programming the processing of products on machines at the minimum cost consistent with delivery terms.
4. Determining the best allocation of warehouses in a marketing area to minimize total transportation cost.
5. Meeting fluctuations in demand at the minimum inventory cost on the assumption of a fixed production level and stabilization of manpower.
6. Subdividing production among various factories so

as to maximize profits by taking into account manufacturing and distribution costs.

7. Programming the processing cycle for a refinery plant.
8. Determining the optimum allocation of investments.
9. Determining the capacity allocation and so forth.

In all these examples, the considerable attraction of the linear programming model for the accountant lies in the fact that the model both allocates and evaluates simultaneously. As a result, it provides opportunity values that are based on the objectives of the firm. In this respect, Crowningshield and Gorman stated, "Because of its /linear programming/ wide applicability in decision making, and because it depends heavily upon accounting data, linear programming should find a place in the accountant's tool kit."[56] Furthermore, Summers added "linear programming offers an extremely powerful analytical and decision model for describing resource allocation problems in terms of accounting, and technological information."[57] Therefore, "so many accountants and managers use linear programming operating directly from accounting data and expressing the results in the form of accounting statements."[58]

In summary, linear programming model represents a significant contribution to management by providing an efficient formalized approach for handling resource

allocation problems involving a considerable degree of complexity. The linear programming problem, whether maximization of profit or minimization of costs, can be solved by using one of the following methods: (1) the graphical method, (2) the algebraic method, or (3) the simplex method. However, all of the linear programming problems can be handled quite easily by the means of use of electronic computers, regardless of their extensive computational work. In this respect, Buckley and Lightner stated:

> The Mathematical Programming System/360 (MPS/360) developed for the IBM System 360 computers can solve problems with 300 constraints in a matter of hours. Use of MPS/360 involves building the mathematical model, finding an optimal solution, determining the ranges of the objective function elements and right-hand side elements for which the solution is optimal, computing a sequence of related optimal solutions as progressively varied, and preparing a management report. A simplified version of this system, called Linear Programming System (LPS) is available for the IBM 1130 computers.[59]

Sensitivity Analysis[60]

Perhaps the most widely known approach to information evaluation is sensitivity analysis. Sensitivity analysis is an examination of the impact of changes in the magnitude of parameters (or environmental variables) or changes in the form of the objective function or the constraints on

the objective function and the optimal magnitude of the decision variables. This analysis is usually applied after an initial prediction has been made and an initial solution to the problem has been obtained. Horngren offers the following view of sensitivity analysis:

> Sensitivity analysis is a widely used approach to the problem of uncertainty. Sensitivity analysis is a technique that measures how the basic forecast results in decision model will be affected by changes in the critical data input that influence those results. In the context of capital budgeting, sensitivity analysis answers the question "How will my rate of return or net present value be changed if the useful life or the cash flows that I used for its computation are inaccurate?"[61]

Simon emphasizes the "risk analysis" and "information economics" applications of sensitivity analysis:

> Because management scientists became keenly aware of the imperfections of the data with which they worked, they early developed an interest in "sensitivity analysis." Sensitivity analysis is aimed at estimating the costs of making decisions with bad data and, correlatively, at estimating the value of procedures to improve the data.[62]

Rappaport explains how sensitivity analysis can be an important aid in improving the basis for management decision making:

1. In its applied organizational setting, sensitivity analysis may be broadly defined as a study to determine the responsiveness of the conclusions

of an analysis to changes or errors in parameter values used in the analysis.

2. Sensitivity analysis tests the responsiveness of model results to possible changes in parameter values, and thereby offers valuable information for appraising the relative risk among alternative courses of action.
3. Sensitivity analysis can provide systematic guidelines for allocating scarce organizational resources to data collection and data refinement activities.
4. Under the sensitivity analysis approach, if the value of a decision is insensitive to estimated parameter variations, the decision to purchase no additional information can be made without introducing a statistical decision model.
5. If the value of a decision is sensitive to estimated parameter variations and the information decision is not obvious, a statistical decision model may be developed to guide the information decision.[63]

Jensen feels that accountants should use sensitivity analysis for the following reasons:

> One reason why an accountant may become involved in sensitivity analysis is the need to determine the amount of time and resources to consume in gathering, analyzing, and reporting accounting input data. The generation of information for mathematical decision models cannot be entirely an "open-ended" proposition; instead the accounting system must weigh costs of supplying data against benefits received in a well-defined operational setting.
>
> Another reason why accountants may in the future become more involved in sensitivity analysis of mathematical models lies in the wealth of accounting information which can be generated from such analysis. Accountants must learn how to exploit these models in order to provide management with opportunity costs and other types of information which cannot be generated efficiently by traditional accounting methods. Endeavors to develop new and more efficient sensitivity analysis techniques will hopefully receive greater attention in accounting research.[64]

In summary, sensitivity analysis can be used to determine how the results of an operation will be influenced by changes or errors in the input data. In sensitivity analysis, the objective is to determine the relative importance of any change in any of the factors that are combined in operation. And it can be utilized in connection with all of the quantitative tools of decision making described in this chapter.

Inventory Models

The problem of determining inventory policies is certainly not new. Business firms have been faced with this problem since their beginnings and only during the last decade or so have approached the problem by using the new quantitative technique of representation by means of a mathematical model, conducive to optimization. The succeeding discussion briefly centers around the management inventory controls rather than inventory valuation.

The primary objective of management inventory controls is to determine the procurement level, the procurement quantity, and the procurement source in the light of the relevant costs and the properties of demand and procurement lead time, so that the sum of all costs associated with the procurement and inventory system will be minimized. Inadequate attention to these inventory decisions may result in carrying either excess or insufficient inventory, to which a cost is associated: (1) cost of carrying excess

inventories in which consists of property taxes, storage and handling, insurance, and interest charge on capital invested in excess inventory, and (2) cost of carrying insufficient inventories such as lost sales, loss of goodwill, additional administrative costs of rush orders, and increased labor costs due to overtime work on rush orders.[65]

The mathematical models used for optimizing the inventory policies can be classified as (1) deterministic models, and (2) probabilistic models.[66]

A deterministic inventory model implies that the demand is known with certainty. Such models are usually referred to as Economic Lot Size Models. The required assumptions make this model unrealistic in a great many cases but provide a good starting point. The assumptions which are made for this model are:

(1) Demand, or usage, are constant.

(2) There are no shortage costs: only holding and ordering costs.

(3) Lead time is certain so that the moment inventory reaches zero the order is received or production run is completed.

The probabilistic inventory models usually incorporate various levels of demand, the concept of lead time,

provision for carrying a buffer or safety stock, and so forth. In this model, the demand is not known with certainty and it is described by a known probability distribution. The probabilistic inventory model under certain assumptions will provide the optimum size order quantity, as well as reorder point.

However, in business practice some of the sophisticated quantitative disciplines such as dynamic programming,[67] Markov chains and simulations,[68] and Monte Carlo technique[69] with the aid of electronic digital computer are utilized to solve the mathematical inventory models to provide relevant information for decision maker concerning optimal inventory policies.

In summary, management inventory controls are concerned with the central issue of optimizing inventory balance and quantity ordered. Thus, it should have but the one aim that might be expressed in two ways: (1) to minimize total costs associated with procurement, holding and ordering inventories, or (2) to maximize profit within specified time and resource allocations.

Simulation Studies

Although various analytical models are available for planning the activities of an enterprise, not all planning problems are amenable to solution by currently available quantitative methods. The system to be observed

and studied may be so complex that it cannot be adequately described by means of mathematical equations that yield an analytical solution sufficiently reliable for predictive purposes. Furthermore, even if a mathematical model of a system can be developed, it may not be capable of analytic solution and, therefore, also incapable of predictions concerning the future behavior of the system or elements of the system. The only recourse for solving planning problems of this nature is simulation of the system that is being studied. The succeeding discussion concentrates on definition of simulation, characteristics of simulation, advantages and limitations of simulation, and the applications of simulation in business.

Simulation Defined

One of the characteristics of the field of simulation, which is often typical of an emergent field, is the lack of uniform terminology. The terms simulation, Monte Carlo, gaming, model sampling, and various combinations thereof have been used interchangeably at times, whereas at other times they have been given specific meanings.[70] According to Morgenthaler to stimulate is to "duplicate the essence of the system or activity without actually attaining reality itself."[71] Thus, simulation consists basically of synthesizing or duplicating reality (that is, the

environment or system of interest) in a simplified form. This simplified version of reality is then subjected to intensive study and experimentation in an attempt to understand better the physical environment represented by the simulation model.

Thierauf and Grosse include all of the fundamental characteristics of simulation, namely, the use of mathematical models, computers, statistics or stochastic processes, facts, assumptions, and alternative course of action in the definition. They define simulation as:

> A quantitative technique used for evaluating alternative courses of action based upon facts and assumptions with a computerized mathematical model in order to represent actual decision making under conditions of uncertainty.[72]

Characteristics of Simulation Studies

Since simulation studies cover a broad and diverse range of applications; the objectives, as well as the characteristics, of simulation studies are similarly broad in scope and diverse in nature. Although not all simulation studies exhibit the same characteristics, many include at least several of the more common characteristics described below.[73]

1. Simulation studies tend to require a broad perspective of the problems of the system. Therefore, managers are forced to examine and understand all aspects of the problems, not just within the context of their own immediate interests. This

broad scope of analysis contributes toward the transformation of the myopic specialist by developing in him the more comprehensive viewpoint of the generalist.

2. Simulation studies are conducive to synthesizing the subsystems to compose an otherwise complex system. This subdivision of the major components of the system facilitates analysis because each subsystem can be developed by the individual(s) best qualified to do so.
3. The involvement inherent in designing a computer simulation model may more beneficial than the actual simulation itself. The insight gained about the problem as a result of developing the simulation model may suggest improvements that would otherwise have gone undetected in the structure and policies of the system being simulated.
4. Computer simulation is capable of analyzing and evaluating the large number of complex interactions among variables that typically exists in a system, regardless of whether the system is an industry, a company, or some smaller enterprise.
5. The actual simulation experiments permit a thorough observation of the system performance under a wide range of environmental conditions. This evaluation of system behavior by means of simulation

may expose relationships among variables that could not be identified by any other method. Furthermore, in a complex system, simulation may identify which variables in the system are more dominant and which relationships among variables are most significant in determining the system performance.

6. Simulation enables managers to evaluate the influence of structural changes on the operating characteristics of the system. By observing the performance of the system after structural modifications have been made, the manager can determine the effects of these structural modifications on the behavior of the system.
7. Simulation studies can be used as a pilot run--prior to exposing the actual system to the risk of experimentation--to test and evaluate proposed policies and proposed decision rules for operating the system.
8. Simulation studies can serve as a suitable medium for teaching, illustrating, and reinforcing some of the basic concepts and skills involved in (a) statistical analysis and (b) the decision making required to control operating systems.

While these represent some of the more common characteristics observed in simulation studies, they are not the only ones.

Advantages and Limitations of Simulation Studies

Advantages offset disadvantages only when simulation is used to solve the right kind of problem. The major advantages of a simulation model can be summarized as follows:

1. Simulation model permits one to feel a cause and effect relationship which can be result in suggestions for improvement in the system and its related subsystems.
2. Simulation model aids in judging what information is really important in making decisions and obtaining management control.
3. Simulation model familiarizes one with data needed and available to him in making his decisions, thereby demonstrating economic and management principles in practice.
4. Simulation model permits the individual participate to test alternative course of action before making a final decision. Since most business games make use of computers, they provide the participants with some familiarity with electronic data processing.
5. Simulation model permits the participants to quickly

ascertain their capabilities and their weaknesses. This kind of simulation creates a high degree of self-motivation and self-learning because feedback provides a basis for self-evaluation and self-correction.[74]

The limitations of simulation models include the costly resources needed to conduct the simulation and the likelihood of misinterpretation of the results. First, data and information on the system must be sufficient to give realism to the model and make a successful simulation possible. Also, a method must be available for testing the model and/or the results of the simulation so that both are within a degree of acceptability to reality. Simulation today implies the use of computers. The high cost of such equipment and skilled personnel can be a disadvantage unless the benefits or profit gains can offset such costs.[75]

Applications of Simulation Studies

There are many business applications of simulation studies. From the review of literature, the following applications of simulation studies come to light.[76]

1. Layout of plant facilities: to evaluate the effectiveness of either existing or proposed layouts of a typically complex production system.

2. Solution of queueing problems: the objective of queueing problem is to minimize the total cost of (1) waiting for service and (2) idle time of the service facilities.

3. Assembly-line balancing: to provide maximum flexibility in designing the assembly line, thus minimizing (1) the idle time of the line, (2) the cost and effort arising from the line-balancing procedure, and (3) the time lag between ordering a production rate change and effecting it.

4. Inventory-control systems: the objective is to minimize total costs that typically include the following elements: acquisition or reordering cost, holding costs, stockout or shortage costs, and transportation costs.

5. Job-shop simulation: this subset of the more general scheduling problem is basically a queueing model with two or more sequential servers (that is, production facilities).

6. Network analysis: to pinpoint the trouble spots and to estimate the time required to finish the project.

7. Location analysis: e.g., to determine optimal locations for plants and warehouses.

8. Marketing analysis: (for example, to determine pricing policies, marketing strategies, and advertising expenditures).

9. Management training (that is, management business games).

10. Budgeting: Mattessich[77] has developed an approach to total firm simulation using a budget model of the firm that uses the conventional accounting structure of a firm as its framework, and the output is in the form of various period-by-period budgets and projected financial statements.

In summary, simulation studies, of course, are not a substitute for competent and efficient management; they merely provide an extension of the resources available to permit more effective exercise of management perogatives. Mathematical models--and thus simulation models--provide quantitative information that can be used by the executive in decision making. They neither eliminate nor reduce the need for decision making and do not substitute for the skill or judgment of the decision maker.

Summary

In this report, the managerial considerations of the following quantitative tools of decision making were discussed briefly: flexible budgeting, present value concept, statistical techniques (statistical sampling and Bayesian statistics), statistical forecasting techniques (moving average, exponential smoothing, and regression or correlation analysis), network analysis (PERT and CPM), linear programming, sensitivity analysis, inventory models, and simulation studies. One major discussion was centered on their characteristics, limitations and assessment of applicability in today's dynamic business operations and in particular in accounting. In addition, this chapter provided information concerning the quantitative tools of decision making to be used by today's versatile decision maker and accountant whose expanding horizons require an understanding of these tools. The complexity and future

promise of quantitative tools of decision making demand an understanding by both accountant and decision maker. Quantitative tools of decision making provide another means of structuring and analyzing information. However, quantitative tools of decision making provide more than a means for structuring and analyzing information. Quantification of information facilitates objectivity (non-biasing) in decision making, and, in effect, tends to decrease value judgments and increase the factual content of decision making.

One way to conclude this appendix is to quote Professor Summers' view on quantitative decision models:

> Quantitative decision models exist for many situations. To make these models operate at fullest efficiency, information system managers (most of whom are accountants) need to know their information requirements. Decision models do not differentiate between valid and invalid information; it is the accountant who does that.[78] / The underscoring is that of the researcher. /

Appendix B Footnotes

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APPENDIX C

SUPPORTING TABLES

TABLE C-1. THE FREQUENCY OF USE OF QUANTITATIVE TOOLS OF DECISION MAKING BY CONTROLLERS (43 Firms with Size of Less Than $399.50 Million Sales)

RARELY			OCCASIONALLY			PERIODICALLY			ROUTINELY		
TOOL 1	5	11.63	TOOL 1	3	6.98	TOOL 1	1	2.33	TOOL 1	30	69.77
TOOL 2	2	4.65	TOOL 2	7	16.28	TOOL 2	17	39.53	TOOL 2	16	37.21
TOOL 3	6	13.95	TOOL 3	12	27.91	TOOL 3	7	16.28	TOOL 3	6	13.95
TOOL 4	9	20.93	TOOL 4	12	27.91	TOOL 4	8	18.60	TOOL 4	2	4.65
TOOL 5	3	6.98	TOOL 5	8	18.60	TOOL 5	12	27.91	TOOL 5	12	27.91
TOOL 6	5	11.63	TOOL 6	12	27.91	TOOL 6	10	23.26	TOOL 6	7	16.28
TOOL 7	10	23.26	TOOL 7	10	23.26	TOOL 7	10	23.26	TOOL 7	5	11.63
TOOL 8	8	18.60	TOOL 8	12	27.91	TOOL 8	7	16.28	TOOL 8	3	6.98
TOOL 9	4	9.30	TOOL 9	11	25.58	TOOL 9	5	11.63	TOOL 9	13	30.23

TABLE C-2. THE FREQUENCY OF USE OF QUANTITATIVE TOOLS OF DECISION MAKING BY CONTROLLERS (40 Firms with Size of $400-699.50 Million Sales)

TOOL 1	2	5.00	TOOL 1	2	5.00	TOOL 1	5	12.50	TOOL 1	28	70.00
TOOL 2	0	0.00	TOOL 2	3	7.50	TOOL 2	12	30.00	TOOL 2	24	60.00
TOOL 3	4	10.00	TOOL 3	16	40.00	TOOL 3	10	25.00	TOOL 3	3	7.50
TOOL 4	10	25.00	TOOL 4	6	15.00	TOOL 4	8	20.00	TOOL 4	14	35.00
TOOL 5	5	12.50	TOOL 5	8	20.00	TOOL 5	6	15.00	TOOL 5	18	45.00
TOOL 6	4	10.00	TOOL 6	11	27.50	TOOL 6	13	32.50	TOOL 6	9	22.50
TOOL 7	8	20.00	TOOL 7	10	25.00	TOOL 7	6	15.00	TOOL 7	9	22.50
TOOL 8	10	25.00	TOOL 8	6	15.00	TOOL 8	7	17.50	TOOL 8	10	25.00
TOOL 9	11	27.50	TOOL 9	6	15.00	TOOL 9	7	17.50	TOOL 9	13	32.50

TABLE C-3. THE FREQUENCY OF USE OF QUANTITATIVE TOOLS OF DECISION MAKING BY CONTROLLERS (24 Firms with Size of $700-999.50 Million Sales)

TOOL 1	0	0.00	TOOL 1	2	8.33	TOOL 1	7	29.17	TOOL 1	15	62.50
TOOL 2	1	4.17	TOOL 2	2	8.33	TOOL 2	9	37.50	TOOL 2	11	45.83
TOOL 3	2	8.33	TOOL 3	9	37.50	TOOL 3	5	20.83	TOOL 3	6	25.00
TOOL 4	4	16.67	TOOL 4	5	20.83	TOOL 4	8	33.33	TOOL 4	4	16.67
TOOL 5	0	0.00	TOOL 5	6	25.00	TOOL 5	8	33.33	TOOL 5	8	33.33
TOOL 6	2	8.33	TOOL 6	9	37.50	TOOL 6	8	33.33	TOOL 6	3	12.50
TOOL 7	3	12.50	TOOL 7	7	29.17	TOOL 7	6	25.00	TOOL 7	5	20.83
TOOL 8	4	16.67	TOOL 8	6	25.00	TOOL 8	4	16.67	TOOL 8	5	20.83
TOOL 9	3	12.50	TOOL 9	8	33.33	TOOL 9	7	29.17	TOOL 9	5	20.83

TABLE C-4. THE FREQUENCY OF USE OF QUANTITATIVE TOOLS OF DECISION MAKING BY CONTROLLERS (69 Firms with Size Over $1 Billion Sales)

TOOL 1	6	8.70	TOOL 1	4	5.80	TOOL 1	9	13.04	TOOL 1	47	68.12
TOOL 2	1	1.45	TOOL 2	2	2.90	TOOL 2	18	26.09	TOOL 2	48	69.57
TOOL 3	10	14.49	TOOL 3	20	28.99	TOOL 3	22	31.88	TOOL 3	12	17.39
TOOL 4	12	17.39	TOOL 4	17	24.64	TOOL 4	15	21.74	TOOL 4	18	26.09
TOOL 5	5	7.25	TOOL 5	19	27.54	TOOL 5	16	23.19	TOOL 5	24	34.78
TOOL 6	12	17.39	TOOL 6	21	30.43	TOOL 6	18	26.09	TOOL 6	14	20.29
TOOL 7	9	13.04	TOOL 7	23	33.33	TOOL 7	16	23.19	TOOL 7	15	21.74
TOOL 8	9	13.04	TOOL 8	24	34.78	TOOL 8	15	21.74	TOOL 8	14	20.29
TOOL 9	5	7.25	TOOL 9	10	14.49	TOOL 9	15	21.74	TOOL 9	25	36.23

TABLE C-5. THE FREQUENCY OF USE OF QUANTITATIVE TOOLS OF DECISION MAKING BY CONTROLLERS (83 Durable Manufacturing Firms)

TOOL 1	6	7.23	TOOL 1	7	8.43	TOOL 1	11	13.25	TOOL 1	59	71.08
TOOL 2	3	3.61	TOOL 2	8	9.64	TOOL 2	20	24.10	TOOL 2	50	60.24
TOOL 3	14	16.87	TOOL 3	30	36.14	TOOL 3	18	21.69	TOOL 3	8	9.64
TOOL 4	18	21.69	TOOL 4	25	30.12	TOOL 4	13	15.66	TOOL 4	18	21.69
TOOL 5	9	10.84	TOOL 5	14	16.87	TOOL 5	18	21.69	TOOL 5	36	43.37
TOOL 6	12	14.46	TOOL 6	21	25.30	TOOL 6	23	27.71	TOOL 6	20	24.10
TOOL 7	10	12.05	TOOL 7	26	31.33	TOOL 7	15	18.07	TOOL 7	17	20.48
TOOL 8	15	18.07	TOOL 8	19	22.89	TOOL 8	21	25.30	TOOL 8	13	15.66

TABLE C-6. THE FREQUENCY OF USE OF QUANTITATIVE TOOLS OF DECISION MAKING BY CONTROLLERS (65 Non-durable Manufacturing Firms)

TOOL 1	5	7.69	TOOL 1	3	4.62	TOOL 1	7	10.77	TOOL 1	40	61.54
TOOL 2	1	1.54	TOOL 2	5	7.69	TOOL 2	20	30.77	TOOL 2	38	58.46
TOOL 3	7	10.77	TOOL 3	18	27.69	TOOL 3	16	24.62	TOOL 3	14	21.54
TOOL 4	12	18.46	TOOL 4	5	13.85	TOOL 4	18	27.69	TOOL 4	13	20.00
TOOL 5	3	4.62	TOOL 5	16	24.62	TOOL 5	17	26.15	TOOL 5	20	30.77
TOOL 6	7	10.77	TOOL 6	23	35.38	TOOL 6	16	24.62	TOOL 6	10	15.38
TOOL 7	15	23.08	TOOL 7	16	24.62	TOOL 7	14	21.54	TOOL 7	14	21.54
TOOL 8	11	16.92	TOOL 8	23	35.38	TOOL 8	7	10.77	TOOL 8	11	16.92

TABLE C-7. THE FREQUENCY OF USE OF QUANTITATIVE TOOLS OF DECISION MAKING BY CONTROLLERS (28 Unclassified Firms)

TOOL 1	2	7.14	TOOL 1	1	3.57	TOOL 1	4	14.29	TOOL 1	21	75.00
TOOL 2	0	0.00	TOOL 2	1	3.57	TOOL 2	16	57.14	TOOL 2	11	39.29
TOOL 3	1	3.57	TOOL 3	9	32.14	TOOL 3	10	35.71	TOOL 3	5	17.86
TOOL 4	5	17.86	TOOL 4	6	21.43	TOOL 4	8	28.57	TOOL 4	7	25.00
TOOL 5	1	3.57	TOOL 5	11	39.29	TOOL 5	7	25.00	TOOL 5	6	21.43
TOOL 6	4	14.29	TOOL 6	9	32.14	TOOL 6	10	35.71	TOOL 6	3	10.71
TOOL 7	5	17.86	TOOL 7	8	28.57	TOOL 7	9	32.14	TOOL 7	3	10.71
TOOL 8	5	17.86	TOOL 8	6	21.43	TOOL 8	5	17.86	TOOL 8	8	28.57
TOOL 9	3	10.71	TOOL 9	7	25.00	TOOL 9	9	32.14	TOOL 9	6	21.43

FOR EDUCATION 1

TABLE C-8. THE FREQUENCY OF USE OF QUANTITATIVE TOOLS OF DECISION MAKING BY CONTROLLERS (Bachelor's Degree)

TOOL 1	6	5.41	TOOL 1	6	5.41	TOOL 1	16	14.41	TOOL 1	78	70.27
TOOL 2	1	0.90	TOOL 2	11	9.91	TOOL 2	37	33.33	TOOL 2	59	53.15
TOOL 3	11	9.91	TOOL 3	32	28.83	TOOL 3	28	25.23	TOOL 3	18	16.22
TOOL 4	22	19.82	TOOL 4	23	20.72	TOOL 4	25	22.52	TOOL 4	21	18.92
TOOL 5	7	6.31	TOOL 5	28	25.23	TOOL 5	20	18.02	TOOL 5	42	37.84
TOOL 6	13	11.71	TOOL 6	33	29.73	TOOL 6	34	30.63	TOOL 6	18	16.22
TOOL 7	20	18.02	TOOL 7	31	27.93	TOOL 7	23	20.72	TOOL 7	24	21.62
TOOL 8	19	17.12	TOOL 8	29	26.13	TOOL 8	15	13.51	TOOL 8	23	20.72
TOOL 9	15	13.51	TOOL 9	12	10.81	TOOL 9	23	20.72	TOOL 9	39	35.14

FOR EDUCATION 2

TABLE C-9. THE FREQUENCY OF USE OF QUANTITATIVE TOOLS OF DECISION MAKING BY CONTROLLERS (Master's Degree)

TOOL 1	7	10.77	TOOL 1	5	7.69	TOOL 1	6	9.23	TOOL 1	42	64.62
TOOL 2	3	4.62	TOOL 2	3	4.62	TOOL 2	19	29.23	TOOL 2	40	61.54
TOOL 3	11	16.92	TOOL 3	25	38.46	TOOL 3	16	24.62	TOOL 3	9	13.85
TOOL 4	13	20.00	TOOL 4	17	26.15	TOOL 4	14	21.54	TOOL 4	17	26.15
TOOL 5	6	9.23	TOOL 5	13	20.00	TOOL 5	22	33.85	TOOL 5	20	30.77
TOOL 6	10	15.38	TOOL 6	20	30.77	TOOL 6	15	23.08	TOOL 6	15	23.08
TOOL 7	10	15.38	TOOL 7	19	29.23	TOOL 7	15	23.08	TOOL 7	10	15.38
TOOL 8	12	18.46	TOOL 8	19	29.23	TOOL 8	18	27.69	TOOL 8	9	13.85
TOOL 9	8	12.31	TOOL 9	23	35.38	TOOL 9	11	16.92	TOOL 9	17	26.15

TABLE C-10. THE NUMBER OF CONTROLLERS' OPINION CONCERNING THE OVERALL RESULTS ACHIEVED FROM USING QUANTITATIVE TOOLS OF DECISION MAKING (43 Firms with Sales of Less Than $399.50 Million)
FOR SIZE 1

	POOR		FAIR		GOOD		VERY GOOD	
TOOL 1	0	0.00	8	18.60	12	27.91	18	41.86
TOOL 2	0	0.00	1	2.33	26	60.47	14	32.56
TOOL 3	2	4.65	9	20.93	12	27.91	5	11.63
TOOL 4	2	4.65	16	37.21	8	18.60	2	4.65
TOOL 5	2	4.65	11	25.58	12	27.91	10	23.26
TOOL 6	3	6.98	8	18.60	14	32.56	7	16.28
TOOL 7	3	6.98	12	27.91	10	23.26	7	16.28
TOOL 8	3	6.98	8	18.60	16	37.21	3	6.98
TOOL 9	4	9.30	10	23.26	12	27.91	6	13.95

TABLE C-11. THE NUMBER OF CONTROLLERS' OPINION CONCERNING THE OVERALL RESULTS ACHIEVED FROM USING QUANTITATIVE TOOLS OF DECISION MAKING (40 Firms with Sales of $400-699.50 Million)
FOR SIZE 2

TOOL 1	1	2.50	5	12.50	16	40.00	14	35.00
TOOL 2	0	0.00	7	17.50	17	42.50	15	37.50
TOOL 3	1	2.50	12	30.00	14	35.00	6	15.00
TOOL 4	1	2.50	14	35.00	10	25.00	10	25.00
TOOL 5	2	5.00	7	17.50	21	52.50	7	17.50
TOOL 6	2	5.00	10	25.00	19	47.50	6	15.00
TOOL 7	1	2.50	14	35.00	12	30.00	6	15.00
TOOL 8	0	0.00	14	35.00	9	22.50	9	22.50
TOOL 9	2	5.00	10	25.00	15	37.50	7	17.50

TABLE C-12. THE NUMBER OF CONTROLLERS' OPINION CONCERNING THE OVERALL RESULTS ACHIEVED FROM USING QUANTITATIVE TOOLS OF DECISION MAKING (24 Firms with Sales of $700-999.50 Million)

FOR SIZE 3

TOOL 1	0	0.00	TOOL 1	2	8.33	TOOL 1	14	58.33	TOOL 1	8	33.33
TOOL 2	0	0.00	TOOL 2	4	16.67	TOOL 2	10	41.67	TOOL 2	8	33.33
TOOL 3	1	4.17	TOOL 3	11	45.83	TOOL 3	6	25.00	TOOL 3	3	12.50
TOOL 4	3	12.50	TOOL 4	10	41.67	TOOL 4	7	29.17	TOOL 4	1	4.17
TOOL 5	1	4.17	TOOL 5	8	33.33	TOOL 5	11	45.83	TOOL 5	1	4.17
TOOL 6	1	4.17	TOOL 6	10	41.67	TOOL 6	8	33.33	TOOL 6	1	4.17
TOOL 7	3	12.50	TOOL 7	6	25.00	TOOL 7	11	45.83	TOOL 7	1	4.17
TOOL 8	1	4.17	TOOL 8	12	50.00	TOOL 8	5	20.83	TOOL 8	1	4.17
TOOL 9	1	4.17	TOOL 9	13	54.17	TOOL 9	6	25.00	TOOL 9	1	4.17

TABLE C-13. THE NUMBER OF CONTROLLERS' OPINION CONCERNING THE OVERALL RESULTS ACHIEVED FROM USING QUANTITATIVE TOOLS OF DECISION MAKING (69 Firms with Sales of over $1 Billion)

FOR SIZE 4

TOOL 1	0	0.00	TOOL 1	12	17.39	TOOL 1	26	37.68	TOOL 1	27	39.13
TOOL 2	0	0.00	TOOL 2	6	8.70	TOOL 2	32	46.38	TOOL 2	31	44.93
TOOL 3	4	5.80	TOOL 3	27	39.13	TOOL 3	22	31.88	TOOL 3	9	13.04
TOOL 4	10	14.49	TOOL 4	22	31.88	TOOL 4	20	28.99	TOOL 4	9	13.04
TOOL 5	6	8.70	TOOL 5	18	26.09	TOOL 5	27	39.13	TOOL 5	13	18.84
TOOL 6	9	13.04	TOOL 6	26	37.68	TOOL 6	23	33.33	TOOL 6	7	10.14
TOOL 7	5	7.25	TOOL 7	20	28.99	TOOL 7	25	36.23	TOOL 7	12	17.39
TOOL 8	6	8.70	TOOL 8	19	27.54	TOOL 8	32	46.38	TOOL 8	5	7.25
TOOL 9	3	4.35	TOOL 9	16	23.19	TOOL 9	20	28.99	TOOL 9	16	23.19

TABLE C-14. THE NUMBER OF CONTROLLERS' OPINION CONCERNING THE OVERALL RESULTS ACHIEVED FROM USING QUANTITATIVE TOOLS OF DECISION MAKING (83 Durable Manufacturing Firms) FOR GROUP 1

TOOL 1	1	1.20	TOOL 1	15	18.07	TOOL 1	31	37.35	TOOL 1	36	43.37
TOOL 2	0	0.00	TOOL 2	9	10.84	TOOL 2	37	44.58	TOOL 2	34	40.96
TOOL 3	4	4.82	TOOL 3	29	34.94	TOOL 3	23	27.71	TOOL 3	9	10.84
TOOL 4	6	7.23	TOOL 4	32	38.55	TOOL 4	18	21.69	TOOL 4	12	14.46
TOOL 5	9	10.84	TOOL 5	17	20.48	TOOL 5	35	42.17	TOOL 5	16	19.28
TOOL 6	7	8.43	TOOL 6	21	25.30	TOOL 6	31	37.35	TOOL 6	15	18.07
TOOL 7	3	3.61	TOOL 7	27	32.53	TOOL 7	23	27.71	TOOL 7	13	15.66
TOOL 8	3	3.61	TOOL 8	17	20.48	TOOL 8	37	44.58	TOOL 8	9	10.84
TOOL 9	7	8.43	TOOL 9	19	22.89	TOOL 9	22	26.51	TOOL 9	20	24.10

TABLE C-15. THE NUMBER OF CONTROLLERS' OPINION CONCERNING THE OVERALL RESULTS ACHIEVED FROM USING QUANTITATIVE TOOLS OF DECISION MAKING (65 Nondurable Manufacturing Firms) FOR GROUP 2

TOOL 1	0	0.00	TOOL 1	10	15.38	TOOL 1	25	38.46	TOOL 1	19	29.23
TOOL 2	0	0.00	TOOL 2	8	12.31	TOOL 2	32	49.23	TOOL 2	24	36.92
TOOL 3	3	4.62	TOOL 3	21	32.31	TOOL 3	20	30.77	TOOL 3	11	16.92
TOOL 4	5	7.69	TOOL 4	21	32.31	TOOL 4	19	29.23	TOOL 4	6	9.23
TOOL 5	2	3.08	TOOL 5	20	30.77	TOOL 5	20	30.77	TOOL 5	13	20.00
TOOL 6	4	6.15	TOOL 6	26	40.00	TOOL 6	21	32.31	TOOL 6	5	7.69
TOOL 7	7	10.77	TOOL 7	19	29.23	TOOL 7	23	35.38	TOOL 7	9	13.85
TOOL 8	4	6.15	TOOL 8	24	36.92	TOOL 8	18	27.69	TOOL 8	5	7.69
TOOL 9	3	4.62	TOOL 9	19	29.23	TOOL 9	19	29.23	TOOL 9	8	12.31

TABLE C-16. THE NUMBER OF CONTROLLERS' OPINION CONCERNING THE OVERALL RESULTS ACHIEVED FROM USING QUANTITATIVE TOOLS OF DECISION MAKING (28 Unclassified Firms) FOR GROUP 3

TOOL 1	0	0.00	TOOL 1	2	7.14	TOOL 1	12	42.86	TOOL 1	12	42.86
TOOL 2	0	0.00	TOOL 2	1	3.57	TOOL 2	16	57.14	TOOL 2	10	35.71
TOOL 3	1	3.57	TOOL 3	9	32.14	TOOL 3	11	39.29	TOOL 3	3	10.71
TOOL 4	5	17.86	TOOL 4	9	32.14	TOOL 4	8	28.57	TOOL 4	4	14.29
TOOL 5	0	0.00	TOOL 5	7	25.00	TOOL 5	16	57.14	TOOL 5	2	7.14
TOOL 6	4	14.29	TOOL 6	7	25.00	TOOL 6	12	42.86	TOOL 6	1	3.57
TOOL 7	2	7.14	TOOL 7	6	21.43	TOOL 7	12	42.86	TOOL 7	4	14.29
TOOL 8	3	10.71	TOOL 8	12	42.86	TOOL 8	7	25.00	TOOL 8	4	14.29
TOOL 9	0	0.00	TOOL 9	11	39.29	TOOL 9	12	42.86	TOOL 9	2	7.14

TABLE C-17. THE NUMBER OF CONTROLLERS' OPINION CONCERNING THE OVERALL RESULTS ACHIEVED FROM USING QUANTITATIVE TOOLS OF DECISION MAKING (111 Bachelor's Degree)

TOOL 1	0	0.00	TOOL 1	16	14.41	TOOL 1	43	38.74	TOOL 1	45	40.54
TOOL 2	0	0.00	TOOL 2	14	12.61	TOOL 2	53	47.75	TOOL 2	40	36.04
TOOL 3	7	6.31	TOOL 3	32	28.83	TOOL 3	33	29.73	TOOL 3	15	13.51
TOOL 4	8	7.21	TOOL 4	42	37.84	TOOL 4	24	21.62	TOOL 4	14	12.61
TOOL 5	6	5.41	TOOL 5	31	27.93	TOOL 5	42	37.84	TOOL 5	18	16.22
TOOL 6	9	8.11	TOOL 6	35	31.53	TOOL 6	43	38.74	TOOL 6	11	9.91
TOOL 7	7	6.31	TOOL 7	38	34.23	TOOL 7	32	28.83	TOOL 7	19	17.12
TOOL 8	6	5.41	TOOL 8	35	31.53	TOOL 8	38	34.23	TOOL 8	8	7.21
TOOL 9	6	5.41	TOOL 9	27	24.32	TOOL 9	36	32.43	TOOL 9	18	16.22

TABLE C-18. THE NUMBER OF CONTROLLERS' OPINION CONCERNING THE OVERALL RESULTS ACHIEVED FROM USING QUANTITATIVE TOOLS OF DECISION MAKING (65 Master's Degree)

FOR EDUCATION 2

TOOL 1	1	1.54	TOOL 1	11	16.92	TOOL 1	25	38.46	TOOL 1	22	33.85
TOOL 2	0	0.00	TOOL 2	4	6.15	TOOL 2	32	49.23	TOOL 2	28	43.08
TOOL 3	1	1.54	TOOL 3	27	41.54	TOOL 3	21	32.31	TOOL 3	8	12.31
TOOL 4	8	12.31	TOOL 4	20	30.77	TOOL 4	21	32.31	TOOL 4	8	12.31
TOOL 5	5	7.69	TOOL 5	13	20.00	TOOL 5	29	44.62	TOOL 5	13	20.00
TOOL 6	6	9.23	TOOL 6	19	29.23	TOOL 6	21	32.31	TOOL 6	10	15.38
TOOL 7	5	7.69	TOOL 7	14	21.54	TOOL 7	26	40.00	TOOL 7	7	10.77
TOOL 8	4	6.15	TOOL 8	18	27.69	TOOL 8	24	36.92	TOOL 8	10	15.38
TOOL 9	4	6.15	TOOL 9	22	33.85	TOOL 9	17	26.15	TOOL 9	12	18.46

Linear Programming		Flexible Budgeting		PERT & CPM		PV Conts		Forecasting Techniques		Simu-lation		Statistical Techniques	

TABLE C-19. THE NUMBER OF CONTROLLERS WHO ARE APPLYING THE QUANTITATIVE TOOLS OF DECISION MAKING TO BUSINESS PROBLEMS (43 Firms with Size of Less than $399.50 Million Sales)

FOR SIZE 1

1	19	44.19	11	25.58	8	18.60	8	18.60	13	30.23	10	23.26	8	18.60
2	6	13.95	10	23.26	1	2.33	25	58.14	3	6.98	2	4.65	0	0.00
3	14	32.56	5	11.63	2	4.65	2	4.65	7	16.28	5	11.63	0	0.00
4	6	13.93	3	6.98	2	4.65	3	6.98	1	2.33	3	6.98	1	2.33
5	11	25.58	8	18.60	0	0.00	0	0.00	1	2.33	2	4.65	0	0.00
6	10	23.26	4	9.30	3	6.98	4	9.30	3	6.98	4	9.30	0	0.00
7	8	18.60	7	16.28	1	2.33	8	18.60	1	2.33	1	2.33	4	9.30
8	1	2.33	2	4.65	2	4.65	20	46.51	1	2.33	1	2.33	1	2.33
9	3	6.98	2	4.65	9	20.93	30	69.77	9	20.93	2	4.65	1	2.33
10	8	18.60	5	11.63	2	4.65	0	0.00	1	2.33	2	4.65	1	2.33
11	0	0.00	5	11.63	17	39.53	0	0.00	5	11.63	0	0.00	6	13.95
12	1	2.33	7	16.28	3	6.98	4	9.30	21	48.84	8	18.60	10	23.26
13	2	4.65	13	30.23	3	6.98	4	9.30	21	48.84	4	9.30	8	18.60
14	1	2.33	3	6.98	4	9.30	8	18.60	2	4.65	10	23.26	3	6.98
15	1	2.33	13	30.23	11	25.58	1	2.33	3	6.98	2	4.65	5	11.63
16	10	23.26	5	11.63	1	2.33	1	2.33	3	6.98	1	2.33	1	2.33
17	4	9.30	3	6.98	3	6.98	3	6.98	9	20.93	5	11.63	13	30.23
18	4	9.30	6	13.95	7	16.28	8	18.60	6	13.95	6	13.95	10	23.26
19	5	11.63	2	4.65	0	0.00	1	2.33	0	0.00	0	0.00	16	37.21
20	10	23.26	8	18.60	3	6.98	2	4.65	4	9.30	3	6.98	2	4.65
21	2	4.65	16	37.21	9	20.93	1	2.33	5	11.63	1	2.33	2	4.65
22	9	20.93	15	34.88	2	4.65	2	4.65	3	6.98	2	4.65	2	4.65
23	7	16.28	10	23.26	2	4.65	5	11.63	2	4.65	1	2.33	1	2.33
24	1	2.33	17	39.53	3	6.98	1	2.33	2	4.65	1	2.33	0	0.00
25	12	27.91	7	16.28	4	9.30	13	30.23	8	18.60	5	11.63	4	9.30

TABLE C-20. THE NUMBER OF CONTROLLERS WHO ARE APPLYING THE QUANTITATIVE TOOLS OF DECISION MAKING TO BUSINESS PROBLEMS (40 Firms with Size of $400-699.50 Million Sales)

FOR SIZE 2

1	19	47.50	20	50.00	6	15.00	5	12.50	15	37.50	12	30.00	5	12.50
2	8	20.00	5	12.50	1	2.50	22	55.00	7	17.50	6	15.00	4	10.00
3	11	27.50	9	22.50	2	5.00	4	10.00	7	17.50	8	20.00	3	7.50
4	11	27.50	2	5.00	0	0.00	0	0.00	2	5.00	3	7.50	0	0.00
5	14	35.00	0	0.00	1	2.50	5	12.50	5	12.50	7	17.50	4	10.00
6	7	17.50	3	7.50	5	12.50	7	17.50	4	10.00	3	7.50	6	15.00
7	5	22.50	8	20.00	0	0.00	2	5.00	1	2.50	3	7.50	3	7.50
8	2	5.00	3	7.50	5	12.50	17	42.50	4	10.00	1	2.50	2	5.00
9	1	2.50	3	7.50	7	17.50	31	77.50	4	10.00	3	7.50	5	12.50
10	8	20.00	3	7.50	0	0.00	2	5.00	1	2.50	2	5.00	2	5.00
11	1	2.50	3	7.50	7	17.50	1	2.50	3	7.50	3	7.50	11	27.50
12	1	2.50	9	22.50	1	2.50	4	10.00	18	45.00	8	20.00	4	10.00
13	2	5.00	18	45.00	1	2.50	11	27.50	13	32.50	13	32.50	10	25.00
14	0	0.00	4	10.00	4	10.00	11	27.50	3	7.50	6	15.00	5	12.50
15	1	2.50	10	25.00	9	22.50	0	0.00	2	5.00	3	7.50	3	7.50
16	10	25.00	3	7.50	1	2.50	1	2.50	3	7.50	3	7.50	2	5.00
17	4	10.00	3	7.50	0	0.00	3	7.50	6	15.00	8	20.00	14	35.00
18	1	2.50	6	15.00	18	45.00	5	12.50	3	7.50	5	12.50	4	10.00
19	4	10.00	0	0.00	5	12.50	0	0.00	2	5.00	0	0.00	19	47.50
20	10	25.00	5	12.50	3	7.50	7	17.50	5	12.50	7	17.50	3	7.50
21	0	0.00	19	47.50	7	17.50	3	7.50	6	15.00	6	15.00	5	12.50
22	5	12.50	13	32.50	3	7.50	3	7.50	2	5.00	2	5.00	2	5.00
23	3	7.50	9	22.50	3	7.50	5	12.50	2	5.00	2	5.00	2	5.00
24	3	7.50	19	47.50	1	2.50	0	0.00	4	10.00	0	0.00	0	0.00
25	14	35.00	5	12.50	6	15.00	12	30.00	5	12.50	10	25.00	4	10.00

TABLE C-21. THE NUMBER OF CONTROLLERS WHO ARE APPLYING THE QUANTITATIVE TOOLS OF DECISION MAKING TO BUSINESS PROBLEMS (24 Firms with Sales of $700-999.50 Million)

FOR SIZE 3

1	11	45.83	5	20.83	0	0.00	5	20.83	8	33.33	9	37.50	4	16.67
2	2	8.33	5	20.83	0	0.00	21	87.50	2	8.33	4	16.67	2	8.33
3	7	29.17	5	20.83	1	4.17	1	4.17	8	33.33	3	12.50	0	0.00
4	7	29.17	2	8.33	0	0.00	0	0.00	3	12.50	2	8.33	1	4.17
5	9	37.50	4	16.67	2	8.33	2	8.33	4	16.67	7	29.17	2	8.33
6	6	25.00	5	20.83	2	8.33	5	20.83	3	12.50	6	25.00	2	8.33
7	3	12.50	9	37.50	0	0.00	3	12.50	1	4.17	1	4.17	2	8.33
8	0	0.00	8	33.33	0	0.00	7	29.17	1	4.17	0	0.00	3	12.50
9	0	0.00	4	16.67	8	33.33	17	70.83	3	12.50	2	8.33	2	8.33
10	4	16.67	7	29.17	1	4.17	4	16.67	2	8.33	1	4.17	3	12.50
11	0	0.00	4	16.67	7	29.17	1	4.17	1	4.17	2	8.33	3	12.50
12	2	8.33	2	8.33	1	4.17	4	16.67	11	45.83	5	20.83	9	37.50
13	0	0.00	9	37.50	0	0.00	6	25.00	11	45.83	6	25.00	8	33.33
14	1	4.17	3	12.50	0	0.00	7	29.17	3	12.50	7	29.17	3	12.50
15	1	4.17	8	33.33	6	25.00	1	4.17	2	8.33	1	4.17	1	4.17
16	3	12.50	6	25.00	0	0.00	0	0.00	5	20.83	1	4.17	1	4.17
17	1	4.17	5	20.83	3	12.50	2	8.33	6	25.00	1	4.17	3	12.50
18	4	16.67	1	4.17	7	29.17	5	20.83	4	16.67	1	4.17	2	8.33
19	2	8.33	2	8.33	0	0.00	1	4.17	1	4.17	4	16.67	8	33.33
20	6	25.00	1	4.17	3	12.50	2	8.33	3	12.50	3	12.50	3	12.50
21	1	4.17	8	33.33	6	25.00	2	8.33	1	4.17	1	4.17	1	4.17
22	2	8.33	8	33.33	0	0.00	2	8.33	1	4.17	2	8.33	1	4.17
23	2	8.33	7	29.17	4	16.67	2	8.33	3	12.50	0	0.00	2	8.33
24	2	8.33	15	62.50	0	0.00	0	0.00	0	0.00	0	0.00	1	4.17
25	1	25.00	6	25.00	4	16.67	8	33.33	4	16.67	4	16.67	1	4.17

TABLE C-22. THE NUMBER OF CONTROLLERS WHO ARE APPLYING THE QUANTITATIVE TOOLS OF DECISION MAKING TO BUSINESS PROBLEMS (69 Firms with Sales Over $1 Billion)

FOR SIZE 4

1	38	55.07	22	31.88	16	23.19	16	23.19	24	34.78	27	39.13	13	18.84
2	11	15.94	10	14.49	4	5.80	37	53.62	12	17.39	5	7.25	9	13.04
3	29	42.03	12	17.39	3	4.35	5	7.25	22	31.88	13	18.84	9	13.04
4	22	31.88	5	7.25	0	0.00	1	1.45	3	4.35	8	11.59	2	2.90
5	31	44.93	8	11.59	8	11.59	4	5.80	7	10.14	21	30.43	5	7.25
6	18	26.09	11	15.94	5	7.25	5	7.25	7	10.14	14	20.29	6	8.70
7	12	17.39	21	30.43	0	0.00	4	5.80	5	7.25	8	11.59	6	8.70
8	3	4.35	9	13.04	5	7.25	29	42.03	7	10.14	7	10.14	7	10.14
9	9	13.04	10	14.49	9	13.04	49	71.01	11	15.94	16	23.19	9	13.04
10	9	13.04	15	21.74	1	1.45	4	5.80	6	8.70	8	11.59	3	4.35
11	1	1.45	5	7.25	15	21.74	4	5.80	4	5.80	4	5.80	24	34.78
12	10	14.49	8	11.59	2	2.90	7	10.14	36	52.17	14	20.29	21	30.43
13	5	7.25	29	42.03	4	5.80	14	20.29	32	46.38	23	33.33	20	28.99
14	3	4.35	7	10.14	8	11.59	19	27.54	6	8.70	12	17.39	7	10.14
15	3	4.35	16	23.19	22	31.88	1	1.45	4	5.80	6	8.70	10	14.49
16	22	31.88	7	10.14	2	2.90	0	0.00	8	11.59	9	13.04	11	15.94
17	12	17.39	11	15.94	6	8.70	3	4.35	18	26.09	16	23.19	21	30.43
18	7	10.14	11	15.94	31	44.93	16	23.19	9	13.04	10	14.49	11	15.94
19	3	4.35	1	1.45	2	2.90	1	1.45	6	8.70	8	11.59	30	43.48
20	14	20.29	9	13.04	6	8.70	7	10.14	11	15.94	14	20.29	8	11.59
21	5	7.25	28	40.58	14	20.29	7	10.14	14	20.29	5	7.25	5	7.25
22	12	17.39	24	34.78	0	0.00	4	5.80	5	7.25	8	11.59	6	8.70
23	9	13.04	19	27.54	2	2.90	9	13.04	5	7.25	6	8.70	4	5.80
24	4	5.80	28	40.58	1	1.45	2	2.90	7	10.14	2	2.90	2	2.90
25	19	27.54	10	14.49	13	18.84	21	30.43	12	17.39	20	28.99	11	15.94

TABLE C-23. THE NUMBER OF CONTROLLERS WHO ARE APPLYING THE QUANTITATIVE TOOLS OF DECISION MAKING TO BUSINESS PROBLEMS (83 Durable Manufacturing Companies)

FOR GROUP 1

1	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
2	[illegible]	[illegible]	17	20.48	2	2.41	50	60.24	14	16.87	10	12.05
3	[illegible]	[illegible]	14	[illegible]	3	3.61	8	9.64	27	32.53	14	16.87
4	[illegible]	[illegible]	[illegible]	[illegible]	1	1.20	1	1.20	3	3.61	[illegible]	[illegible]
5	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
6	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
7	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
8	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
9	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
10	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
11	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
12	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
13	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
14	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
15	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
16	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
17	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
18	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
19	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
20	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
21	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
22	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
23	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
24	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
25	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

TABLE C-24. THE NUMBER OF CONTROLLERS WHO ARE APPLYING THE QUANTITATIVE TOOLS OF DECISION MAKING TO BUSINESS PROBLEMS (65 Nondurable Manufacturing Companies)

FOR GROUP 2

1	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
2	14	21.54	9	13.85	0	0.00	37	56.92	5	7.69	3	4.62
3	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
4	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
5	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
6	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
7	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
8	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
9	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
10	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
11	0	0.00	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
12	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
13	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
14	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
15	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
16	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
17	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
18	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
19	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
20	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
21	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
22	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
23	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
24	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
25	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

TABLE C-25. THE NUMBER OF CONTROLLERS WHO ARE APPLYING THE QUANTITATIVE TOOLS OF DECISION MAKING TO BUSINESS PROBLEMS (28 Unclassified Firms)

1	21	75.00	7	25.00	7	25.00	10	35.71	6	21.43	5	17.86	2	7.14		
2	5	17.86	4	14.29	4	14.29	18	64.29	5	17.86	4	14.29	2	7.14		
3	10	35.71	5	17.86	1	3.57	1	3.57	6	21.43	5	17.86	0	0.00		
4	11	39.29	3	10.71	0	0.00	1	3.57	2	7.14	5	17.86	1	3.57		
5	16	57.14	3	10.71	1	3.57	2	7.14	1	3.57	4	14.29	1	3.57		
6	10	35.71	5	17.86	4	14.29	2	7.14	1	3.57	5	17.86	3	10.71		
7	9	32.14	6	21.43	0	0.00	5	17.86	3	10.71	2	7.14	5	17.86		
8	1	3.57	5	17.86	1	3.57	16	57.14	0	0.00	0	0.00	3	10.71		
9	0	0.00	4	14.29	5	17.86	22	78.57	1	3.57	2	7.14	3	10.71		
10	10	35.71	3	10.71	1	3.57	2	7.14	0	0.00	3	10.71	2	7.14		
11	0	0.00	6	21.43	11	39.29	0	0.00	2	7.14	3	10.71	7	25.00		
12	1	3.57	4	14.29	1	3.57	2	7.14	14	50.00	6	21.43	8	28.57		
13	2	7.14	13	46.43	2	7.14	6	21.43	14	50.00	6	21.43	8	28.57		
14	0	0.00	4	14.29	4	14.29	9	32.14	2	7.14	7	25.00	3	10.71		
15	2	7.14	9	32.14	11	39.29	1	3.57	1	3.57	3	10.71	2	7.14		
16	12	42.86	2	7.14	1	3.57	0	0.00	3	10.71	4	14.29	5	17.86		
17	2	7.14	4	14.29	3	10.71	1	3.57	6	21.43	6	21.43	10	35.71		
18	7	25.00	6	21.43	9	32.14	6	21.43	3	10.71	4	14.29	6	21.43		
19	4	14.29	1	3.57	3	10.71	0	0.00	2	7.14	3	10.71	11	39.29		
20	9	32.14	3	10.71	4	14.29	3	10.71	2	7.14	4	14.29	2	7.14		
21	2	7.14	12	42.86	8	28.57	3	10.71	3	10.71	1	3.57	3	10.71		
22	4	14.29	13	46.43	1	3.57	0	0.00	1	3.57	0	0.00	4	14.29		
23	3	10.71	11	39.29	2	7.14	1	3.57	3	10.71	2	7.14	2	7.14		
24	4	14.29	16	57.14	1	3.57	1	3.57	2	7.14	0	0.00	1	3.57		
25	10	35.71	5	17.86	4	14.29	8	28.57	3	10.71	7	25.00	2	7.14		

TABLE C-26. THE NUMBER OF CONTROLLERS WHO ARE APPLYING THE QUANTITATIVE TOOLS OF DECISION MAKING TO BUSINESS PROBLEMS (111 Bachelor's Degree)

1	49	44.14	39	34.23	17	15.32	22	19.82	38	34.23	36	32.43	17	15.32
2	20	18.02	19	17.12	3	2.70	67	60.36	15	13.51	13	11.71	9	8.11
3	34	30.63	19	17.12	3	2.70	7	6.31	26	23.42	19	17.12	7	6.31
4	34	30.63	8	7.21	1	0.90	3	2.70	6	5.41	13	11.71	1	0.90
5	32	28.83	10	9.01	9	8.11	5	4.50	13	11.71	25	22.52	8	7.21
6	22	19.82	12	10.81	9	8.11	12	10.81	12	10.81	20	18.02	9	8.11
7	20	18.02	26	23.42	0	0.00	8	7.21	4	3.60	9	8.11	10	9.01
8	4	3.60	9	8.11	7	6.31	50	45.05	8	7.21	5	4.50	6	5.41
9	9	8.11	11	9.91	18	16.22	80	72.07	12	10.81	11	9.91	10	9.01
10	18	16.22	18	16.22	1	0.90	6	5.41	5	4.50	9	8.11	3	2.70
11	1	0.90	12	10.81	27	24.32.	3	2.70	9	8.11	7	6.31	30	27.03
12	7	6.31	16	14.41	6	5.41	13	11.71	51	45.95	18	16.22	25	22.52
13	5	4.50	43	38.74	7	6.31	25	22.52	51	45.95	28	25.23	24	21.62
14	4	3.60	6	5.41	13	11.71	31	27.93	9	8.11	19	17.12	10	9.01
15	4	3.60	25	22.52	33	29.73	1	0.90	7	6.31	8	7.21	11	9.91
16	27	24.32	11	9.91	3	2.70	1	0.90	12	10.81	8	7.21	9	8.11
17	13	11.71	11	9.91	7	6.31	8	7.21	20	18.02	19	17.12	31	27.93
18	9	8.11	18	16.22	34	30.63	24	21.62	16	14.41	15	13.51	12	10.81
19	9	8.11	2	1.80	4	3.60	2	1.80	4	3.60	9	8.11	45	40.54
20	24	21.62	15	13.51	9	8.11	12	10.81	15	13.51	14	12.61	5	4.51
21	6	5.41	44	39.64	21	18.92	6	5.41	14	12.61	7	6.31	7	6.31
22	21	18.92	38	34.23	3	2.70	7	6.31	8	7.21	7	6.31	7	6.31
23	9	8.11	32	28.83	6	5.41	14	12.61	8	7.21	5	4.50	3	2.70
24	6	5.41	53	47.75	3	2.70	2	1.80	9	8.11	0	0.00	1	0.90
25	31	27.93	17	15.32	15	13.51	36	32.43	19	17.12	25	22.52	13	11.71

TABLE C-27. THE NUMBER OF CONTROLLERS WHO ARE APPLYING THE QUANTITATIVE TOOLS OF DECISION MAKING TO BUSINESS PROBLEMS (65 Master's Degree)

1	38	58.46	20	30.77	13	20.00	12	18.46	22	33.85	22	33.85	13	20.00
2	7	10.77	11	16.92	3	4.62	38	58.46	9	13.85	4	6.15	6	9.23
3	27	41.54	12	18.46	5	7.69	5	7.69	18	27.69	10	15.38	5	7.69
4	1	27.69	4	6.15	1	1.54	1	1.54	3	4.62	3	4.62	3	4.62
5	33	50.77	10	15.38	2	3.08	6	9.23	4	6.15	12	18.46	3	4.62
6	18	27.69	11	16.92	6	9.23	9	13.85	5	7.69	7	10.77	5	7.69
7	12	18.46	19	29.23	1	1.54	9	13.85	4	6.15	4	6.15	5	7.69
8	2	3.08	13	20.00	5	7.69	23	35.38	5	7.69	4	6.15	7	10.77
9	4	6.15	8	12.31	15	23.08	47	72.31	15	23.08	12	18.46	7	10.77
10	11	16.92	12	18.46	3	4.62	4	6.15	5	7.69	4	6.15	6	9.23
11	1	1.54	5	7.69	19	29.23	3	4.62	4	6.15	2	3.08	14	21.54
12	7	10.77	10	15.38	1	1.54	6	9.23	35	53.85	17	26.15	19	29.23
13	4	6.15	26	40.00	1	1.54	10	15.38	26	40.00	18	27.69	22	33.85
14	1	1.54	11	16.92	3	4.62	14	21.54	5	7.69	16	24.62	8	12.31
15	2	3.08	22	33.85	15	23.08	2	3.08	4	6.15	4	6.15	8	12.31
16	18	27.69	10	15.38	1	1.54	1	1.54	7	10.77	6	9.23	6	9.23
17	8	12.31	11	16.92	5	7.69	3	4.62	19	29.23	11	16.92	20	30.77
18	7	10.77	8	12.31	29	44.62	10	15.38	6	9.23	7	10.77	15	23.08
19	5	7.69	3	4.62	3	4.62	1	1.54	5	7.69	3	4.62	28	43.08
20	16	24.62	8	12.31	6	9.23	6	9.23	8	12.31	13	20.00	10	15.38
21	2	3.08	27	41.54	15	23.08	7	10.77	12	18.46	6	9.23	6	9.23
22	7	10.77	22	33.85	2	3.08	4	6.15	3	4.62	7	10.77	4	6.15
23	12	18.46	13	20.00	5	7.69	7	10.77	4	6.15	4	6.15	6	9.23
24	4	6.15	26	40.00	2	3.08	1	1.54	4	6.15	3	4.62	2	3.08
25	20	30.77	11	16.92	12	18.46	18	27.69	10	15.38	14	21.54	7	10.77