# Creative and Innovative Approaches to the Science of Management

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The IC² Management and Management Science Series, Number 5
*W. Cooper and George Kozmetsky, Series Editors*

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**Quorum Books**
Westport, Connecticut • London

# Creative and Innovative Approaches to the Science of Management

To William W. Cooper

Our mentor and a founding father
of the Science of Management

# Preface

This collection explores creative and innovative approaches to the science of management. All of the authors believe that research in management should be based on scientific grounds, in the sense of being general. However, such research must also exhibit a strong orientation toward applications with accompanying theoretical or methodological developments. All these chapters are creative in their own right, but, more importantly, they provide a rigorous foundation for further creativity and innovation in management practice and in management science. The following synopses make it clear that all of the chapters apply this approach to. a broad range of topics that are of interest to management.

The book is divided into seven parts. The first section, Accounting and Control, deals with creative and innovative approaches to accounting and control. The chapter by Ijiri, "Variance Analysis and Triple-Entry Bookkeeping," extends the conventional double-entry bookkeeping framework logically to a triple-entry systems. In the single-entry bookkeeping era, merchants could prepare balance sheets, but not income statements, in an integrated manner. Double-entry bookkeeping changed this state of affairs by requiring that every change in net assets resulting from operations be accounted for by income accounts, thereby linking "what happened," as reflected in changes on the balance sheet, with "explanations" in an income statement as to "why they occurred." This chapter focuses on an extension of double-entry bookkeeping to triple-entry bookkeeping by providing a systematic basis for the analysis of changes

between two income statements, thus "explaining" why the changes occurred. The way in which this is accomplished can be regarded as a generalization of customary variance analyses in present-day cost accounting to the entire set of income statement accounts. These extensions to a triple-entry system are aided by introducing a new system of accounting concepts, which can be called "momentum accounting," in which all transactions are recorded not in dollar units, but in dollars per month. In this way the record keeping associated with momentum accounting can be said to deal with creation and dissipation of income momentum.

In the second chapter, "Accounting for Productivity Gains," Banker makes the. distinction between sustainable productivity gains due to process improvements and temporary efficiency fluctuations due to environmental variations. He accomplishes this by developing parametric and nonparametric models to separate sustainable productivity gains and temporary efficiency fluctuations. An interpretation is presented by means of accounting variances. The concepts in the chapter are demonstrated in terms of an actual application, using production data collected from a plant that employs a mature technology. The methodology developed by Banker, as reported in this chapter, contributes to the serious need of management to identify productivity gains for strategic, operational, and control decisions in such a way that gains are measured objectively with an accompanying theoretical and analytical basis, which makes the resulting measurements managerially meaningful.

In the third chapter, "On Assessing Internal Controls," Stephens provides an in-depth survey of accounting literature—academic as well as practitioner and official as well as unofficial—that is concerned with assessing the effectiveness of internal controls. Results from this survey are then compared to actions taken by the Securities and Exchange Commission with respect to requirements for public disclosures, which now take the form of a management report incorporated in the annual corporate report in order to disclose the results of such management assessments and the involvement of independent accountants with such assessments. Stephens documents the need for carefully developed criteria that management can use to assess internal control and goes on to evaluate the role of independent accountants and the benefits of such disclosures to users of the corporate reports. This is an important issue of public policy that is often debated—sometimes with confusion and generally without a proper theoretical foundation such as this chapter provides.

Part II of this book, Computers and Decision Support, starts with a chapter by Bailey, Kiang, Kuipers, and Whinston, entitled "Qualitative and Causal Reasoning in Auditing." This chapter explores the use of qualitative and causal reasoning in physical systems and provides a new way for

auditors to strengthen their decisions in the analytical review portion of audit planning. The potential of this new technique, based on qualitative and causal approaches to predicting the dynamic behavior of physical systems, is illustrated in this chapter by means of a qualitative simulation model (QSIM) coupled with causal reasoning. The chapter compares this approach with currently popular "expert system" approaches to auditing and highlights the greater potential of this new technique.

In Chapter 5, "Implementation of Decision Support Systems: An Empirical Study of Japanese Production Control Systems," Matsuda, Oota, and Sueyoshi report the results of a survey of twenty-one Japanese manufacturing firms regarding the impact of implementing decision support systems in fifty-seven mainframe computer systems for production control. Specifically, the survey examined this impact on eight subsystems: (1) information, (2) responsibility, (3) goal-setting, (4) measurement, (5) evaluation, (6) incentive, (7) standard-setting, and (8) education. Two types of information systems (schedule control systems and man-hour control systems) were found to have influence over decision making for administrative control activities that was sufficient to affect the performance of subordinates.

In Chapter 6, "Model Representation in Information Resources Management," Hsu and Wallace work from a perspective in which formal models are regarded as an integral part of enterprise information resources and argue that these model resources should be represented and managed together with data resources and knowledge resources. This means that model structures should be defined at the same levels as data and knowledge and should include the interrelationships of these three types of resources. This leads to the development of a "metadatabase" as an organizationwide repository of all information resources. A representation of such a metadata structure, the global information resources dictionary (GIRD) model, is illustrated in the chapter.

Part III, Resource Management, examines resource management from human, economic, and financial perspectives. Chapter 7, "Integrated Modeling Systems for Corporate Human Resource Decisions," highlights the need for integrated modeling systems for human resource decisions in corporations and government agencies and Niehaus's experience with both civilian and military manpower planning for the U. S. Navy to demonstrate what can be accomplished by such an integrated modeling approach. The chapter also provides examples of integrated human resources modeling systems, such as the models developed at Mare Island Naval Shipyard. It then discusses the importance of the evolution of the information systems needed to carry out such integrated human resource modeling systems and emphasizes that with the development of microcomputer systems,

integrated models for human resource management can be largely based at desktop workstation.

To properly manage any kind of resources, managers must have methods for evaluating efficiency and effectiveness, and Chapter 8, "Tradeoffs between Efficiency and Effectiveness in Management of Public Services," addresses this issue. In some studies, efficiency and effectiveness in the management of public services have been regarded as being negatively correlated. Schinnar provides a model that shows how this can occur, but at the same time he also shows situations where efficiency and effectiveness can be positively correlated. This provides not only insight for researchers, but also guidance for practitioners. Here efficiency is defined as a ratio of service activities to resources utilized, and effectiveness is defined in terms of outcomes relative to service activities. A simple model is formulated to show how, under quite reasonable conditions, the highest level of service effectiveness can be attained at moderate levels of efficiency. Beyond this level, efficiency and effectiveness are competitive, while below this level, the two are complementary.

Next is Ahn and Seiford's. "Sensitivity of DEA to Models and Variable Sets in a Hypothesis Test Setting: The Efficiency of University Operations," which focuses on issues of efficiency and effectiveness in comparing the performance of private and public universities. Conventional econometric approaches to estimating production functions involve a priori specification of a hypothesized parametric form, after which a set of parameter values is estimated. This choice of a functional form colors the analyses. Data envelopment analysis (DEA) offers a better alternative for studying these criteria because it does not require explicit specification of particular functional relationships between the inputs and the outputs. However, DEA could be modeled in several different ways—that is, ratio, additive, and multiplicative models—and this choice might affect the resulting evaluations along with the choice of alternate criteria. Using data from 153 universities, however, this study reports that the results are not sensitive to the choice of model—and thus are not affected by these choices—but the results are sensitive to the choice of variable set and hence to the criteria used. Of particular significance is the finding that public universities are more efficient than private universities when more highly visible output variables, which can be easily monitored, are used.

Part IV, Organization Design, opens with Levy and Thompson's "The Optimal Size of a Law Firm and the Contingency Fee Decision," which deals with the size decision for a law firm where a balance must be struck between unbilled hours, which result from having excess human resources, and lost billings, which could result from not having enough human resources. Using a simple form of statistical-probability distribution to

represent the arrival of new clients or cases, Levy and Thompson first present a simple optimization case. They then complicate the situation in order to consider income from referral fees, which a firm may earn by referring excess demand to other firms. Finally, they cover conditions under which a law firm may be willing to accept a new client on a contingency fee basis. A general approach is thus provided for all of these possibilities, which evidently can bear on the issue of optimal size under varying policy constraints and possibilities.

Näslund's chapter, "A Fractal Analysis of Capital Structure," provides new insights into hierarchical organization structures. In this chapter, a firm is assumed to have a hierarchical financial structure. The relationship between a unit at level n and its subdivisions at level n + 1 is assumed to be the same for all n. Then, borrowing ideas from fractal geometry, the probability of bankruptcy for the firm as a whole is derived from the probability of bankruptcy at lower hierarchy levels of firms or subdivisions of a firm. This approach, via fractal geometry, also yields a precise value for the optimal debt ratio, which depends on (1) the risk and return of the individual projects of the firm and (2) the form of the hierarchical structure of the firm.

The chapter by Lewin, "Applying the Audit Risk Model to the Organization Design of the Firm," emphasizes the need for coordinating audit risk with the design of the organization to be audited. Using an actual case of improper accounting practices at a large corporation, the chapter identifies the audit risk associated with a given form of organization and discusses ways to improve organization design by considering it from the audit standpoint from the beginning of the design process. The chapter also proposes a new research agenda in light of the observed deficiency in the coordination between organization design and audit risk.

Part V, Industry and Economy, opens with a chapter by Ruefli, Adaniya, Gallegos, and Limb, entitled "Longitudinal Analysis of Industries: An Ordinal Time Series Approach." The chapter uses rank-order statistics for 101 industries over a twenty-year period. The rank-order statistics used are assets, employees, equity, net income, revenues, return on assets, return on equity, return on sales, and research and development (R&D). The aim is to study changes in ranks that can occur from period to period and to identify underlying patterns. For this purpose, the entropy statistic is used to identify (and quantify) the uncertainty levels associated with the year-to-year rank transitions. Using this statistic, R&D expenditures were found to have the lowest level of uncertainty, which means that the R&D rank of any industry remained highly stable over time. Intraindustry rank statistics were studied for two of the industries covered. It was noted that the intraindustry rank analysis resulted in patterns quite different from those observed in the

interindustry rank analysis. This suggests that intraindustry behavior and interindustry behavior are governed by different mechanisms.

The title of the chapter by Bowlin, "An Analysis of the Financial Competitiveness of Defense Industry Firms," describes the topic that he addresses. Over twenty laws enacted since 1982 have impacted on the procurement policies and procedures of the Department of Defense. The widely held belief that this has adversely impacted on defense industry firms has been buttressed by certain defense-industry-sponsored studies, which have found this to be the case. Using data envelopment analysis Bowlin compares the financial performance of aerospace defense firms with the firms included in the Standard & Poor's (S&P 500) stock market index. The results of this DEA study fail to corroborate the defense industry's findings. The supposed adverse impact on defense industry firms during the period covered was found to be no worse than the deterioration found in other firms represented in the S&P 500 index.

In the next chapter, "A Multiregional Model for India, 2000 A.D.," Dhar, Goel, and Rao present their results from a multiregional and multisectional optimizing model that they constructed for the Indian economy. This study differs from earlier attempts to study this problem because this model deals with the availability of basic needs satisfactions in all regions simultaneously in order to reduce the existing inequalities among regions in terms of per capita aggregate household consumption levels. An appropriate consumption target is selected, and gross domestic product (GDP) or value added is maximized to achieve a more equitable distribution of income across the regions. Trading and transport implications of the results are also analyzed. The empirical analyses carried out in this study show, among many other things, that it is possible to reduce the regional disparity in income and consumption substantially while, at the same time, sustaining a growth rate in GDP of 5 5 to 6 percent a year.

Part VI moves more toward a focus on methodological contributions to a science of management, which we have grouped under the title Programming Models. It starts with a chapter by Glover entitled "Improved Linear and Integer Programming Models for Discriminant Analysis." In a departure from the common methodology of statistics, a series of research efforts have begun to appear that try to capture the goals of statistical discriminant analysis in a collection of linear programming (LP) formulations in order to make such analyses applicable to many types of problems. Glover demonstrates that the full power of the LP discriminant analysis models has not been achieved because a previously undetected distortion had attenuated the quality of the solutions generated. Glover also shows how to eliminate the distortion and develops special properties of the resulting models that provide links between continuous and discrete

solutions. A postoptimizing procedure is introduced to exploit these properties for use with an integer programming objective directed to minimizing the number of misclassifications. These results open a door to new possibilities for model manipulation and simplifications, which include the use of a successive goal method to establish a series of conditional objectives for improved discrimination.

The next chapter, "Chance-Constrained Programming with Stochastic Processes as Parameters," also covers programming models and methods. Jagannathan extends the usual chance-constrained linear programming models in which the parameters are usually assumed to be random variables with known distributions. In this chapter, the right-side parameters of the model are allowed to be more general stochastic processes. The properties and solution methods of the chance-constrained programs are discussed first for the case of the finite index set and then for the case of the continuous index set. While Jagannathan's study is restricted to static model (zero-order) rules of chance-constrained programming, it is possible to generalize the results to the case of random left-side parameters along with more general multistage chance-constrained programming models.

Szwarc's chapter, "Single Machine Total Tardiness Problem Revisited," deals with the well-known single machine total tardiness model in which the problem is to schedule jobs for a single machine that can process only one job at a time. The objective is to minimize total overdue days—that is, the sum of overdue days associated with each job. It has been shown that the problem can be decomposed into smaller subproblems thereby reducing computational complexity. This chapter presents a theory of the total tardiness problem based on a precedence relation concept that determines the ordering between adjacent jobs. It then discusses the decomposability of the problem, which is shown to depend on the adjacent precedence relation matrix. The use of this theory demonstrates that further improvement is possible and that the decomposition result obtained in this chapter can be improved even further by reducing the number of possible partitions.

Part VII, Methodological Issues, opens with Zionts's "Multiple Criteria Decision Making and Negotiating: Some Observations." This chapter explores similarities and differences between two types of problems: one is the problem of making decisions subject to multiple conflicting objectives (which is known as the multiple criteria decision-making problem), and the other problem involves negotiations among parties with disparate objectives. Both problems involve multiple objectives: in the former they all reside in a single decision-making unit, while in the latter they are spread among multiple decision-making units. In particular, Zionts explores the relationship between concepts of nondominated solutions and Pareto-

optimal outcomes, as well as the desirability of both, and also considers ways in which Pareto-optimal solutions can be achieved in negotiations.

In the next chapter, "Bootstrapping: Implications for Decision Making," Kimes shows how bootstrapping, a relatively new nonparametric, computer-intensive, statistical method, can be used to obtain information about sample distributions, error terms, and model validity. Advantages over traditional statistical methods are examined. The term "bootstrap" originated when one sample was used to give birth to many samples. It is a distribution-free method that depends on computer uses, rather than on the mathematically closed-form solutions that are characteristic of classical (precomputer) statistical approaches. This chapter examines three types of applications: (1) the determination of the true error of the estimate, (2) the determination of the true probability distribution underlying the data, and (3) whether information can be gleaned from a small sample. Cost and time requirements for bootstrapping are examined, as are tradeoffs between the cost and the value gained from bootstrapping.

This section concludes with Gupta and Govindarajan's "Methodological Issues in Testing Contingency Theories: An Assessment of Alternative Approaches." The contingency perspectives that have been widely adopted in organizational research generally make results conditional upon some environmental contingencies, or lack of them. Various approaches have been employed for testing contingency hypotheses that are bivariate in nature—namely, one context variable and one design variable have a predicted interactive impact on some performance variable. This chapter undertakes an assessment of such approaches in the form of (1) the split-sample approach, (2) the residual misfit approach, and (3) the multiplicative interaction approach. The chapter concludes that the multiplicative approach is significantly superior to the other approaches. The authors also note that with this approach the problem of multicollinearity is really a nonissue, at least for the interval-scaled data that are commonly employed in organization theory research.

This book concludes with a bibliographical essay to provide guidance to readers who are interested in background or additional reading materials to gain further insight into the problems and issues presented in this book.

# Acknowledgments

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