



Operations Research

Publication details, including instructions for authors and subscription information:
<http://pubsonline.informs.org>

The Analysts' Bookshelf

To cite this article:

(1956) The Analysts' Bookshelf. Operations Research 4(3):402-411. <https://doi.org/10.1287/opre.4.3.402>

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The Analysts' Bookshelf

PUBLICATIONS OF THE RAND CORPORATION*

READERS OF OPERATIONS RESEARCH may be interested in The Rand Corporation's unclassified research output, most of which is readily available to the public. The purpose of this note is to indicate the general nature of this research and to point out where it can be examined.

The Rand Corporation, a private, non-profit organization, is engaged primarily in research for the United States Air Force. It also conducts some research under contract for the Atomic Energy Commission and engages in private research using its own funds. A major part of Rand's research for the Air Force involves the comparison of alternative weapon systems. These comparisons, intended to help the nation get the most out of its resources, are often called 'systems analyses'. In some respects, they are closely related to 'operations research,' though they are usually designed to assist in development and procurement decisions rather than in operations decisions. And for that reason, these analyses are extremely complex, in comparison with the operations research of World War II, for it is necessary to look further into the future, to recognize still greater uncertainties, and to consider vastly expanded numbers of variables and of possible courses of action. As a consequence, Rand has to work on a host of component problems and, of course, to tap a wide range of skills.

Some of this 'component research' and many of the by-products are relevant to non-military problems of choice—those which are the concern of businessmen, management consultants, officials and analysts in non-military branches of the government, and operations researchers in general. Brief descriptions of the major research categories, and mention of a few specific by-products, may guide readers to Rand outputs that would be useful to them.

The research is performed by six major divisions—economics, engineering, mathematics, physics, social science, and systems development—but the materials which are available can perhaps be put under four headings: (1) basic information, (2) methodology of systems analysis, (3) special techniques, (4) component analyses. The items mentioned below under each heading are supposed to be indicative of Rand's activities without, of course, being exhaustive.

Basic Information. Some unclassified papers result from inquiries into physical relationships—that is, into such subjects as aerodynamics, propulsion, atmospheric properties, and structural fatigue. There are also studies of human behavior, e.g., the doctrines, attitudes, and capabilities of other nations, or the effects of emotional stress.

Methodology of Systems Analysis. The difficulties of *designing* good analyses are common to all forms of systems or operations research, whether for the use of

* This note was prepared at the request of the Editor by L. J. HENDERSON, JR., and his staff at the Washington office of The Rand Corporation.

business firms or of government. A few Rand papers deal with such matters as the treatment of uncertainty and time-flows, criteria for the replacement of equipment, and the dangers in general of adopting erroneous criteria.* (Unless such matters are handled with care, analyses may find the best way to do the wrong job, and, in those circumstances, the most admirable analytical techniques will not yield helpful results.)

Special Techniques Rand has contributed to the development of new mathematical and other special techniques and to their application in concrete problems. Some of this work is on topics that are frequently discussed in OPERATIONS RESEARCH and in other publications, e.g., the theory of queues, linear and dynamic programming, game theory, and the use of Monte Carlo models.† Part is on topics that are perhaps less well publicized, such as special computational methods, approximations for electronic computers, and the use of 'interprocess' instead of 'interindustry' relationships. With interprocess relationships, the possibility of producing the same commodity by means of alternate processes (i.e., different raw material and equipment requirements) could be taken into account.

Component Analyses A few studies of particular problems of choice bear no military classification and may be useful to some readers of OPERATIONS RESEARCH. Examples include comparisons of alternative petroleum blends, alternative routes through a large number of designated points (the 'traveling-salesman' problem‡), alternative organizations and equipment for data-processing, and alternative means of training persons to perform a particular operation. Also there have been studies of electronic reliability, of possible future transport aircraft, and of certain applications of radar. In addition, the non-contract research Rand has financed, within the terms of the Corporation's charter, is unclassified. This research makes use of methodology and experience developed in the course of contract work and is intended to contribute to national security. By and large, these studies fall under three headings: (1) foreign policy formation, especially background information and appraisal, (2) economic efficiency of (civil) government, (3) technical studies, such as the comparison of various ways to increase water supplies.

In most instances, since the work is done under government contract, the distribution of Rand research publications is limited to military agencies and government contractors working on similar problems. However, the United States Air Force and the Atomic Energy Commission have encouraged Rand to make unclassified publications available to individual scientists in industry and universities whenever it is clearly in the interests of the progress of science to do so. The only limit has been holding the costs of such distribution to a reasonable level. Several years ago the Air Force approved a proposal to place Rand unclassified research publications in 40 strategically located American libraries. These deposits include

* C. J. HITCH, "Sub-optimization in Operations Problems," *Operations Research* 1, 87, May 1953.

† H. KAHN AND A. W. MARSHALL, "Methods of Reducing Sample Size in Monte Carlo Computations," *Operations Research* 1, 263, November 1953.

‡ G. DANTZIG, R. FULKERSON, AND S. JOHNSON, "Solution of a Large-Scale Traveling-Salesman Problem," *Operations Research* 2, 393, November 1954.

nearly 600 publications, and the collection continues to grow as military publications are declassified and new unclassified publications appear

Under the library deposit system, publications are available to patrons of any public or private library on inter-library loan. To acquaint a broader audience with the contents of the deposits, some 300 copies of the *Rand Index of Publications* have been placed in reference rooms of American college and university libraries. This *Index* will prove a useful guide to the publications described above.

If the local library does not have a copy of the *Rand Index*, it can obtain one by writing to The Rand Corporation, Santa Monica, California. The library deposit system has enabled a larger number of people to use Rand's publications than would have been possible if limited editions had been distributed on a first-come-first-serve basis. Under Rand's agreement with the deposit libraries, publications may be reproduced for research purposes.

PARKINSON'S LAW

A PENETRATING ANALYSIS that appeared in *The Economist* of London on November 19, 1955 bids fair to add a new term to the lingo of business administration. This article, which was reprinted in full in the March 1956 *Fortune*, demonstrates that the sizes of administrative staffs increase exponentially, irrespective of variations in the amount of work to be done.

Parkinson's law states that even though work load may be constant or decreasing, the number of personnel in an administrative department increases by a fixed average annual percentage. In the case of the British civil service, this annual increase lies between 5.17 and 6.56 per cent.

Parkinson's law is a combination of the *law of multiplication of subordinates* (an official wants to multiply subordinates, not rivals), and the *law of multiplication of work* (officials make work for each other).

These laws operate as follows:

A fancies himself overworked (he really wants a grade promotion) so he recommends the appointment of two subordinates *C* and *D* (subordinates must number two or more, each being kept in order by fear of the other's promotion). With no change (or even a decrease) in over-all work load, the three make so much work for each other that soon *C* and *D* are demanding assistance, and each eventually acquires two subordinates—*E*, *F*, *G*, and *H* are added to the staff. (The promotion of *A* is now practically certain.) Seven officials are now doing what one did before. These seven make so much work for each other that all are fully occupied and *A* is actually working harder than ever. An incoming document may well come before each of them in turn. Official *E* decides that it falls within the province of *F*, who places a draft reply before *C*, who amends it drastically before consulting *D*, who asks *G* to deal with it. But *G* goes on leave at this point, handing the file over to *H*, who drafts a minute, which is signed by *D* and returned to *C*, who revises his draft accordingly and lays the new version before *A*.

What does *A* do? He would have every excuse for signing the thing unread, for he has many other matters on his mind. Knowing now that he is to succeed *W* next year he has to decide whether *C* or *D* should succeed to his own office. He had to agree to *G* going on leave, although not yet strictly

entitled to it. He is worried whether *H* should not have gone instead, for reasons of health. He has looked pale recently—partly but not solely because of his domestic troubles. Then there is the business of *F*'s special increment of salary for the period of the conference, and *E*'s application for transfer to the Ministry of Pensions. *A* had heard that *D* is in love with a married typist and that *G* and *F* are no longer on speaking terms—no one seems to know why. So *A* might be tempted to sign *C*'s draft and have done with it.

But *A* is a conscientious man. Beset as he is with problems created by his colleagues for themselves and for him—created by the mere fact of these officials' existence—he is not the man to shirk his duty. He reads through the draft with care, deletes the fussy paragraphs added by *C* and *H* and restores the thing back to the form preferred in the first instance by the able (if quarrelsome) *F*. He corrects the English—none of these young men can write grammatically—and finally produces the same reply he would have written if officials *C* to *H* had never been born. Far more people have taken far longer to produce the same result. No one has been idle. All have done their best. And it is late in the evening before *A* finally quits his office and begins the return journey to Ealing. The last of the office lights are being turned off in the gathering dusk which marks the end of another day's administrative toil. Among the last to leave, *A* reflects, with bowed shoulders and a wry smile, that late hours, like gray hairs, are among the penalties of success.

The validity of Parkinson's law is tested in two incontrovertible cases. (a) Between 1914 and 1928, the number of officers and men in the Royal Navy decreased from 146,000 to 100,000, the number of capital ships decreased from 62 to 20, yet the number of officials in the British Admiralty in Whitehall increased over this period at the average annual rate of 5.6 per cent—from 2,000 to 3,569. (b) British colonial territories shrank drastically in the period between 1935 and 1954, yet Colonial-Office officials grew from 372 in 1935 to 450 in 1939, 817 in 1943, 1,139 in 1947, and 1,661 in 1954—a steady increase at the average annual rate of 5.9 per cent.¹

G S

**ORDNANCE CORPS, U. S. ARMY, *Tables of the Cumulative Binomial Probabilities*, distributed as PB 111389, Office of Technical Service,
U. S. Dept. of Commerce, Washington, 1952, 577 pp., \$6.00**

THIS PAPER-COVERED VOLUME, prepared by DR. F. E. GRUBBS and the Computation Laboratory of the Ballistic Research Laboratories, Aberdeen Proving Ground, contains a tabulation, accurate to seven decimal places, of the probabilities

$$\sum_{k=c}^n \binom{n}{k} p^k (1-p)^{n-k}$$

of at least c successes in n trials when the probability of success in a single trial is p , for the following ranges: $c=1(1)n$, $n=1(1)150$, and $p=0.01(0.01)0.50$. The main tabulation is preceded by a brief introduction giving three simple examples on how to use the tables.

It is indicated in the foreword that the purpose of these tables is to provide at

low cost a reference on the cumulative binomial distribution whose use would not entail the amount of page-turning necessary if one were to obtain the distribution from KARL PEARSON's *Tables of the Incomplete Beta Function Ratio* (1934), which essentially goes up to $n = 100$. It is somewhat regrettable that such a table had not appeared several decades earlier since some of this purpose is blunted by the present-day availability of high-speed computers or of computing services using them for large-scale problems. Furthermore, in 1955 the Annals of the Computation Laboratory of Harvard University released a competitive hard-covered volume for \$8.00 containing 6-place tables of the cumulative binomial for the ranges $c = 0(1)n$, $n = 1(1)50(2)100(10)200(20)500(50)1000$, $p = 0.01(0.01)0.5$, $p = \frac{1}{2}j$ ($j = 1, 2, 3, 5, 6, 7$) and $p = \frac{1}{6}j$ ($j = 1, 2, 3, 5, 6, 7$) and a table of $\log n!$ for $n = 0(1)1199$, all preceded by an excellent introduction by FREDERICK MOSTELLER discussing the preparation and uses of the tables in applications as well as some useful related items.

Until the day when the electronic high-speed computer eliminates, if it ever will, the need for such large tables, these tables of the cumulative binomial will continue to find extensive use by statisticians, quality controllers, operations and systems analysts, cost analysts, logistics analysts, geneticists, gamblers, and armchair gamblers, some of whom will have some regrets that because of size limitations or for other reasons it was not possible to include alongside each entry in the tables the values of the tails of the first moment, i.e.,

$$\sum_{k=c}^n k \binom{n}{k} p^k (1-p)^{n-k}$$

Prospective purchasers of tables of the cumulative binomial distribution, who feel they can live without the additional decimal place in the Ordnance Corps' compilation or without those entries for n between $n = 50$ and $n = 150$ not included in volume XXXV of the Annals of the Computation Laboratory of Harvard University, will find the latter a better buy.

No attempt is made in this review to discuss the usefulness of such tables in operations research. For those who are not acquainted with this usefulness, no brief discussion will suffice, and for those who are, no discussion is necessary.

M. L. JUNCOSA
The Rand Corporation

RICHARD G. CANNING, *Electronic Data Processing for Business and Industry*, John Wiley and Sons, Inc., New York, 1956, 332 pp., \$7.00

THIS BOOK is a sober, careful, enlightening description of the process of estimating the value of an electronic data processor to a company. It offers valuable guidance in choosing the data processing system.

Naturally, a book that discusses systems is subject to obsolescence. For example, although the author mentions the Raycom, now the Datamatic 1000, he is unaware of its built-in file maintenance and sorting and its large magnetic-tape capacity and speed.

Although the author recognizes some of the difficulties of using 'random access' he leaves the impression that as soon as a few engineering details are worked out, random-access machines will make present machines virtually obsolete. It is more

likely that random-access equipment will become optional standard auxiliary equipment on all general-purpose machines, to be used on a small fraction of all applications.

The culmination of this book is a discussion of how to prepare a report to management. A report to management prepared as recommended will be a good report. However, it would be a better report if more attention had been given to two important considerations:

1. Experience has shown that general-purpose data processors can be used profitably in many more ways than the systems engineer is able to visualize. After installation, as company staff becomes trained on a broad front to understand them, new applications are brought to the machine and it becomes overloaded. It is therefore desirable to plan for a machine with considerable spare capacity provided it can pay for itself out of known applications.
2. Preparing to use an electronic data processor effectively costs many man-years of effort. These man-years will be paid for out of savings, but it will not be unusual for this cost to exceed the cost of the data-processing system. This factor carefully evaluated will frequently demonstrate the wisdom of providing the needed spare capacity in the original machine rather than by later conversion to a larger machine.

With these minor reservations, the reviewer recommends that this book be required reading for systems analysts.

R. F. CLIPPINGER
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MANAGEMENT SCIENCE

THE JANUARY 1956 ISSUE OF *Management Science* (vol. 2, No. 2) has the following table of contents:

- JOHN S. COLEMAN—*Computers as Tools for Management*
 ADAM ABRUZZI—*Formulating a Theory of Work Measurement*
 GEORGE DANTZIG—*Recent Advances in Linear Programming*
 M. BECKMAN AND R. MUTH—*An Inventory Policy for a Case of Lagged Delivery*
 L. WHEATON SMITH, JR.—*Current Status of the Industrial Use of Linear Programming*
 C. C. HOLT, F. MODIGLIANI, J. F. MUTH—*Derivation of a Linear Decision Rule for Production and Employment*
 MERRILL M. FLOOD—*The Objective of TIMS (Presidential Address)*
 C. WEST CHURCHMAN—*Management Science—Fact or Theory?*
Report of the Second National Meeting, TIMS

NAVAL RESEARCH LOGISTICS QUARTERLY

THREE ISSUES of the *Naval Research Logistics Quarterly* have recently appeared. Tables of contents and summaries are reproduced below.

Vol. 2, Nos. 1 and 2—March-June 1955 (Bound together)

R. E. MCSHANE, *Science and Logistics*

The report of the panel on "Science and Logistics" of the Fifth Annual Logistics Research Conference is summarized by its chairman.

HENRY E. EICLFS, *Some Command Problems and Decisions*

This paper presents illustrations of some consequences of command decisions that are made without adequate regard to their logistic consequences. It was written as part of two compilations "Principles of Logistics" and "Notes on Logistic Aspects of Command" prepared for the Naval War College in 1954.

D. C. MACKENZIE, *Contractor Performance*

This revised version of a speech presented at the Bureau of Supplies and Accounts Field Conference of November, 1954, discusses the reasons for delinquent performance under a contract and possible solutions to this problem.

J. G. BRYAN, G. P. WADSWORTH, AND T. M. WHITIN, *A Multi-Stage Inventory Model*

An inventory control problem, in which inventory may be maintained on raw materials or on work after each stage of a three-stage process, is solved.

SAUL GASS AND THOMAS SAATY, *The Computational Algorithm for the Parametric Objective Function*

If a linear-programming problem involves two objective functions, it is desirable to learn all solutions depending on the relative weight attached to the two functions. This paper presents details of an algorithm which finds these solutions systematically.

RUFUS ISAACS, *The Problem of Aiming and Evasion*

The general problem of a marksman versus a mobile target, with a time lag in the gunner's information as to the target's position, appears in many guises in many situations. It is a classic military problem. Formulated in terms of game theory, the desiderata are: How should the target best maneuver to confound prediction of his position? How and when should the marksman make this prediction? What hit probability is to be expected when both participants behave optimally?

RUFUS ISAACS, *The Problem of Aiming and Evasion (Continued)*

This paper discusses this general class of problems and then settles on one which seems to be the simplest possible example that is not trivial. Nevertheless it is difficult. In two previous papers devoted to it, the evader's best strategy and value of the game were given. Here the emphasis is on the marksman. He has no optimal strategy, but does have an *ideal* strategy with the property that every near optimal strategy is close to it. He also has a class of *passive* ϵ -strategies such that if and only if he obeys their dictates will he either come within ϵ or the best hit probability or else always remain in a position where it is possible to do so.

J. W. PETERSEN AND M. A. GEISLER, *The Costs of Alternative Air Base Stocking and Requisitioning Policies*

This is a mathematical and statistical study of the supply operations at a typical Air Force base. The objective of the study is to determine the effect upon support cost of different logistics policies, involving changes in safety level and requisitioning frequency. This effect is found to vary according to the price and demand rate of the item being considered, and the study indicates that large

monetary savings can be realized by adopting different stocking and requisitioning policies dependent upon item demand and price. Thus, the study indicates that it is more economical to have items costing under \$10 requisitioned from the depot every three or six months, rather than every month, even if obsolescence charges on base stocks are as high as 50 per cent per year. The study has also indicated that stand-by stockage of cheap (under \$10), low demand items is desirable because the cost of such stockage tends to be less than the costs incurred by premium supply action when a demand for such an item arises.

H. W. KUHN, *The Hungarian Method for the Assignment Problem*

Assuming that numerical scores are available for the performance of each of n persons on each of n jobs, the 'assignment problem' is the quest for an assignment of persons to jobs so that the sum of the n scores so obtained is as large as possible. It is shown that ideas latent in the work of two Hungarian mathematicians may be exploited to yield a new method of solving this problem.

J. M. DANSKIN, *Mathematical Treatment of a Stockpiling Problem*

If money is spent too fast while stockpiling for a contingency, production may be highly inefficient. If it is spent too slowly, there may be too little stockpile when the contingency comes. The problem of finding an optimum spending rate in one of these situations is discussed.

HAROLD DAVIS, *A Mathematical Evaluation of a Work Sampling Technique*

A study of cargo handling methods required a re-evaluation of a standard work sampling technique. The most interesting conclusion can be qualitatively summarized as follows: if there is evidence that the process lacks any prominent periodic component, then it is better to sample at fixed periods than at random.

Vol. 2, No. 3—September 1955

IRA N. CURTIS, *Logistics Without Storage*

This paper discusses ways and means for reducing storage requirements in the logistic pipeline.

OSKAR MORGENSTERN, *Note on the Formulation of the Theory of Logistics*

As a preliminary step to the erection of a 'theory' of logistics, the author proposes definitions of some important concepts and identifies several types of logistical situations and problems.

H. D. MILLS, *Organized Decision Making*

Some aspects of the phenomena associated with decision making by an organization are discussed. Their interplay is illustrated by a simple example.

J. R. SIMPSON, *A Formula for Decisions on Retention or Disposal of Excess Stock*

The author proposes a formula for use in deciding whether to retain or sell to the highest bidder large stocks of items of material that appear to exceed demands in the immediate future. Estimates of expected demand, storage cost, percentage return from disposal sales, probability of obsolescence, and interest charges are the basic factors employed in the formula. Given these data for an item, and

that certain assumptions used in the derivation of the formula are satisfied, one may determine the optimum level of stock to retain.

T. M. WHITIN AND J. W. T. YOUNGS, *A Method for Calculating Optimal Inventory Levels and Delivery Time*

This paper is concerned with establishing an inventory-control policy for items with extremely low demand. In the event that the expected savings in ordering cost that would result from buying in lots is less than the concomitant increase in carrying charges, it is uneconomical to use a lot-size formula. In this event, it is appropriate to use a system consisting of placing orders as units are demanded.

J. E. KELLEY, JR., *A Dynamic Transportation Model*

H. A. ANTONIEWICZ, *Analytic Study of War Games*

The author describes the results of a study of the mathematical aspects of a proposed war-game model.

Vol. 2, No. 4—December 1955

HARRY A. SAVHAKLIAN, *Risk and Hazard in Logistics Planning*

This paper discusses the significance of the concepts of risk and hazard in areas of military decision.

J. C. BUSBY, *Comments on the Morgenstern Model*

The author presents some ideas, stimulated by a recent article in this *Quarterly*, on management of an operating supply system.

EDWARD ZABTEL, *On the Meaning and Use of a Capacity Concept*

The author surveys and interprets previous attempts to define and measure capacity and analyzes the use of the capacity concept in economic models.

JOSEPH ALBERT GREENWOOD, *Issue Priority: Last in First Out (LIFO) vs First in First Out (FIFO) as a Method of Issuing Items from Supply Storage*

Items may be issued from storage by the principle of 'first in, first out' or 'last in, first out'. This paper gives comparisons of the two methods by various criteria.

E. M. L. BEALE, *Cycling in the Dual Simplex Algorithm*

This note describes the construction of an example in which the usual iterative method for linear programming may fail unless special techniques for overcoming degeneracy are used.

D. R. FULKERSON AND G. B. DANTZIG, *Computation of Maximal Flows in Networks*

A simple computational method, based on the simplex algorithm of linear programming, is proposed for the following problem: "Consider a network (e.g., rail, road, communication network) connecting two given points by way of a number of intermediate points, where each link of the network has a number assigned to it representing its capacity. Assuming a steady state condition, find a maximal flow from one given point to the other."

SAMUEL KARLIN, *The Structure of Dynamic Programming Models*

This paper discusses the structure and formulation of dynamic-programming models. R. Bellman's "Principle of Optimality" is re-examined for deterministic models. A formulation of the general stochastic dynamic-programming model is given and applied to an inventory problem.

JOSEPH O. HARRISON, JR.
Operations Research Office

BOOKS RECEIVED

NORBERT LLOYD ENRICH, *Modern Methods Controls in the Management of Production, Quality, Waste and Maintenance*, Modern Textiles Magazine and Rayon Publishing Corporation, 303 Fifth Avenue, New York, 1955, 28 pp., \$2.00

ALAN S. MANNE, *Scheduling of Petroleum Refinery Operations*, Harvard University Press, Cambridge, Massachusetts, 1956, 185 pp., \$5.00

JAMES W. PERRY, ALLEN KENT, AND MADELINE M. BERRY, *Machine Literature Searching*, Interscience Publishers, Inc., New York, 1956, 162 pp., \$4.00

S. VAJDA, *The Theory of Games and Linear Programming*, John Wiley & Sons, Inc., New York, 1956, 106 pp., \$1.75

Proceedings of the Second Annual Computer Applications Symposium, October 24-25, 1955, Armour Research Foundation, Chicago, 108 pp., \$3.00

The Structural Interdependence of the Economy, Proceedings of an International Conference on Input-Output Analysis, Varenna, Italy, June 27-July 10, 1954, edited by Tibor Barnas, John Wiley and Sons, Inc., New York, 1956, 429 pp., \$7.50

HOWARD S. LEVIN, *Office Work and Automation*, John Wiley and Sons, Inc., New York, 1956, 203 pp., \$4.50

HEINZ GARTMANN, *The Men Behind the Space Rockets*, David McKay Co., Inc., New York, 1956, 185 pp., \$3.95

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