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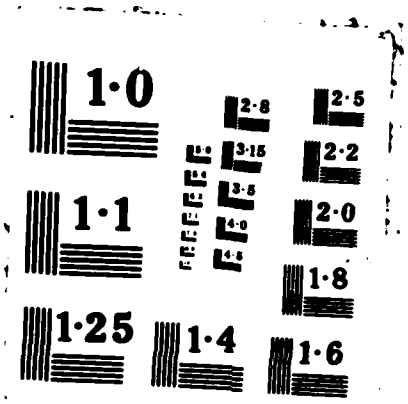
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Dr. Neal Glassman
Office of Naval Research
Room 607
800 North Quincy Street
Arlington, VA 22217

Dear Dr. Glassman,

Enclosed is the final report on ONR Contract N00014-87-K-0389, entitled "Temporal Planning and Management Decision Under Risk and Uncertainty."

Sincerely yours,

A. Charnes

A. Charnes

University Professor across The University of Texas System
John P. Harbin U.T. Regents' Chair
Director, Center for Cybernetic Studies

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Encl.

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FINAL REPORT

"TEMPORAL PLANNING AND MANAGEMENT DECISION UNDER RISK AND UNCERTAINTY"

Contract No. N00014-87-K-0389

Submitted to the Office of Naval Research

by

A. Charnes

University Professor across The University of Texas System
John P. Harbin Centennial Chair
Director, Center for Cybernetic Studies

December 2, 1987

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FINAL REPORT

TEMPORAL PLANNING AND MANAGEMENT DECISION UNDER RISK AND UNCERTAINTY

ONR Contract Number N00014-87-K-0389

Introduction

The Principal Investigator was Dr. A. Charnes, who is a University Professor across The University of Texas System and the John P. Harbin Centennial Chair. As such, he is Professor in the Department of Mathematics, the Department of Computer Sciences, the Department of General Business, the Graduate School of Biomedical Sciences, and the Biomathematics Research Group of the M.D. Anderson Cancer Center in Houston, Texas.

The theoretical research accomplished heretofore will continue to arise from concrete analytical problems of direct relevance to operations research of a military nature. Many of these are identical or closely similar in form to situations in industry, engineering, and other sciences to the extent that progress in one area implies progress in the other. Mathematically, the fields covered involve linear and non-linear optimization, integer and chance-constrained programming, mathematical statistics, game theory, multicriteria or [illegible]-extremal optimization, algorithmic and computational methods.

To be especially noted is that the project work has corresponded to directions indicated for accelerated research initiatives by the Mathematics Division of ONR.

Significant Accomplishments and Intended Directions of Effort

The major areas of significant research contributions were linear programming solution theory, convex duality and chance-constrained programming, stochastic and inverse problems, minimum discrimination information theory, data envelopment analysis,

and computational methods. As may be noted, it is intended to continue in these directions of endeavor following the lead of openings suggested by these accomplishments.

Re the call in the Accelerated Initiative that "methods for moving from points interior to the polytope to nearby basic solutions must be discovered," these were already invented by the Principal Investigator and K. Kortanek and W. Raike in 1963 on ONR supported research, have been currently used in published research papers with R. Armstrong and C. Haksever (Ph.D. student of Charnes) in "Implementation of Successive Linear Programming Algorithms for Non-convex Ratio Goals Problems," (CCS Research Report 515) with accepted publication in Computers and Operations Research Journal.

The finding that, contrary to statements of its progenitors, Karmarkar's algorithm movements tend to cling to polytope boundaries was shown in CCS 517, "Karmarkar's Projective Algorithm: A Null Space Variant for Multi-Commodity Generalized Networks," published in Acta Mathematicae Applicatae Sinica of China. In this paper the precise position of each point at each step of the algorithm is analytically given for almost the simplest possible polytope. This shows that having to keep in the interior can be influenced as greatly by local boundaries as are extreme point methods, i.e., instead of creeping along edges in the latter, one may be creeping along just under the surface boundary.

The character of the Karmarkar algorithm as a "barrier" method of the type developed by Fiacco (Ph.D. student of Charnes) and McCormick was first pointed out in CCS 501, "An Explicit Solution Sequence and Convergence of Karmarkar's Algorithm." The idea of using (differential) extrapolation to improve the convergence path of solution presented as new by Karmarkar in a recent TIMS/ORSA meeting was anticipated and published by Fiacco and McCormick 25 years ago in connection with their SUMT algorithm, the first rigorously convergent "barrier" algorithm.

Re ability to handle problems of larger and larger size, cited as a major reason for meaninglessness of the "computational complexity" criterion, the rigorous analysis and

development of requisite data structures for the class of network and general network problems (which are involved in approximately seventy percent of real applications) shows that Karmarkar's scheme cannot compete and becomes impossible for sizes which can be handled by the special extreme point algorithms as developed and employed over the past three decades.

Work is especially active in various directions of Data Envelopment Analysis. As shown in the Charnes, Cooper, Golany, Seiford, Stutz published paper, all the so-called "efficiency measure models" are simply the Charnes-Cooper test for vector (Pareto) or multi-objective optimality. These are employed to develop a generalization of the empirical distribution function process of mathematical statistics in the form of an empirical "production" function. I.e., as with other mathematical statistics estimations, they involve a class of inverse problems----here in multi-objective programming. The study of such stability (and sensitivity analysis of DEA) continues with Dr. L. Neralic, formerly Visiting Professor from the University of Zagreb (See CCS 531, 536, 542, 543, 544, and 545) and Dr. S. Zlobec of McGill University (CCS 560). In particular, the relations between it and multi-objective programming have been pushed forward in work generalizing the CCR ratio model to a semi-infinite programming structure with Visiting Professor Wei of the People's University of China and Ph.D. student Z. Huang (CCS 551). A further extension to normed linear spaces (CCS 575) has just been made by Charnes, Huang and Wei. Besides releasing one from confinement to polyhedral production possibility sets, the new structure may enable one to formulate and develop a stochastic base for DEA theory.

Extensions of this strategy to the so-called "additive" DEA model are underway as well as for the new "extended additive" model just developed (CCS 558). They require new informatics and software developments which are taking place conjointly.

The research in constrained stochastic network analysis (CCS 514) continues with the development of models for multiple aircraft systems which pose significant new problems for complexity reduction and effective computation.

Other work in stochastic and chance-constrained programming analysis and convex duality continues with Professors A. Ben-Tal and M. Teboulle. It is expected also that new efforts, involving variously P. Brockett, M. Wolfe, M. Keane, and L. Seiford, in the area of minimum discrimination information methods in computerized tomography, which can be vital for recovery of information concerning a hostile territory from perimeter measurements, will achieve successful culminations.

Special Awards and Honors

Special letters of commendation from the U.S. Army Recruiting Command Chief of Staff, Col. Phillips, and Captain Kelly of the United States Navy for the research contained in CCS reports entitled "Data Envelopment Analysis Approaches to Policy Evaluation and Management of Army Recruiting Activities I: The Tradeoffs between Joint Services and Army Advertising" and "Critique of Draft Final Report of the Ad-Mix Study."

A China State Dinner in the Great Hall of the People, Beijing, China was given by the Ministry of Science and Technology of China in honor of Professor Charnes in connection with his invited lecture tour of China for The State Science and Technology Commission (Ministry); Guangzhou, Guilin, Xian, Tsinghua, Beijing Universities.

Chair, Optimization and Expert Systems session, annual Optimizaton Days meeting, Montreal, Quebec, May 12 - 15, 1987.

Professor Charnes is an International Advisory Committee Member for the Thirteenth International Symposium on Mathematical Programming, August 29 - September 2, 1988, Tokyo, Japan and has been made chairman and organizer of two sessions there: (1) Applied Game Theory, and (2) Data Envelopment Analysis.

Invited paper for the Gerhard Tintner Memorial Volume.

Two invited papers for the Karl Fox Seventieth Birthday Festschrift.

Distinguished Lecture, International Symposium on Simulation and Expert Systems, Federal University of Brazil, Rio de Janeiro, August 5 - 6, 1987.

A 70th birthday Festschrift and meeting in honor of Charnes is slated for 14 - 16 of October 1987 in Austin. The only invited participants are students and lineal academic descendants of students of Charnes. Other 70th birthday events are scheduled for Guadalajara, Mexico at the annual meeting of Academia Nacional de Ingenieria de Mexico, September 22-24, 1987, also at Belgrade/Dubrovnik by Yugoslav Academy of Sciences and Yugoslav Operations Research Society October 6 - 9, 1987, also at International Conference on Combinatorial Optimization and Statistics, Srinagar, India August 17 - 19, 1987.

CCS RESEARCH REPORTS

"TEMPORAL PLANNING AND MANAGEMENT DECISION UNDER RISK AND UNCERTAINTY"

Number	Title	Authors
463	Cost-Volume-Utility Analysis with Partial Stochastic Information	P. Brockett A. Charnes W.W. Cooper
502	Successive Linear Programming for Ratio Goal Problems	R. Armstrong A. Charnes C. Haksever
508	Decision Models and Methods for Emergency Government Interventions: Case Study of Natural Cash Shortages	A. Charnes W.W. Cooper W.L. Gorr C. Hsu B. Von Rabenau
514	On N-Person Game Solutions and Convex Programs with Essentially Unconstrained Duals	A. Ben-Tal A. Charnes B. Golany
515	Implementation of Successive Linear Programming Algorithms for Non-Convex Ratio Goals Problems	R. Armstrong A. Charnes C. Haksever
524	Hydrocarbon Production Scheduling in Oilfield Development	A. Al-Saffar J. Al-Zayer A. Charnes S. Duffuaa
525	Characterization of Classes in CCT Efficiency Analysis	A. Charnes W.W. Cooper R. M. Thrall
526	Extremal Principle Solutions of Games in Characteristic Form: The Core, Chebychev, and Shapley Value Generalizations	A. Charnes B. Golany M. Keane J. Rousseau
527	Expected Utility, Penalty Functions, and Duality in Stochastic Non-Linear Programming	A. Ben-Tal M. Teboulle
531	Sensitivity Analysis in DEA	A. Charnes L. Neralic
532	Data Envelopment Analysis Approaches to Policy Evaluation and Management of Army Recruiting Activities I: The Tradeoffs between Joint Services and Army Advertising	A. Charnes W.W. Cooper B. Golany R. Halek G. Klopp E. Schmitz D. Thomas

534	A Data Envelopment Analysis of High Turnover Consumer Products in Competitive Markets	A. Charnes W.W. Cooper B. Golany F. Phillips D. Learner
535	A Goal Interval Approach for Some Tanker Distributional Policy Analyses	A. Charnes J. Gomez
536	Sensitivity Analysis in DEA - Part II	A. Charnes L. Neralic
537	A Comparison of DEA to Existing and Proposed Systems for Measuring Efficiency of Regulated Companies	A. Charnes W.W. Cooper D. Divine T. Ruefli D. Thomas
539	Optimal Hiring Decisions for Entry-Level Auditors in a CPA Firm. A Computerized Model for the Improvement of Hiring Practices	A. Charnes W.W. Cooper J. Deitrich W. Hank Moody H.-C. Shin
540	GTGEN: A Generator for Generalized Transportation Problems	M. Chang
541	On N-Person Game Solutions and Convex Programs with Essentially Unconstrained Duals	A. Ben-Tal A. Charnes B. Golany
542	Sensitivity in DEA - Part III	A. Charnes L. Neralic
543	Sensitivity in DEA - Part IV	A. Charnes
544	Sensitivity in DEA - Part V	A. Charnes L. Neralic
545	Sensitivity in DEA - Part VI	[illegible] ... Neralic
546	Critique of Draft Final Report of the Ad-Mix Study	A. Charnes W.W. Cooper B. Brockett B. Golany
547	An Extension of the Fibonacci Series Applied to a Replinishment Problem	I. Ali
549	Toward Resource Value Transfer Economics	A. Charnes S. Littlechild J. Rousseau
550	On Errors in the Evans and Heckman Bell System Breakup Studies	A. Charnes W.W. Cooper T. Sueyoshi

551	Data Envelopment Analysis with Infinitely Many Decision Making Units via Multiobjective Pareto Efficiency	A. Charnes W.W. Cooper Q.L. Wei
552	An Improved Primal Simplex Variant for Pure Processing Networks	M. Chang C.H. Chen M. Engquist
553	Two-Phase DEA and Its Use for Evaluations and Management of Recruiting Activities in the U.S. Army	A. Charnes W.W. Cooper B. Golany R. Halek G. Klopp E. Schmitz D. Thomas
554	Chance-Constrained Infrastructure and Zero-Order Stochastic Decision Rules	A. Charnes W.W. Cooper M. Kress
556	Optimized Certainty Equivalents for Decisions Under Uncertainty	A. Ben-Tal A. Ben-Israel
558	Data Envelopment Analysis & Axiomatic Notions of Efficiency and Reference Sets	A. Charnes W.W. Cooper J. Rousseau J. Semple
559	Cone Ratio Data Envelopment Analysis & Multiobjective Programming	A. Charnes W.W. Cooper Q.L. Wei Z.M. Huang
560	Efficiency Evaluations in Data Envelopment Analysis Are Stable	A. Charnes S. Zlobec
561	A Computational Method for Solving DEA Problems with Infinitely Many DMU's	A. Charnes K. Tone
563	Optimal Design Modification by Geometric Programming and Constrained Stochastic Network Models	A. Charnes W.W. Cooper B. Golany J. Masters
565	Using Data Envelopment Analysis to Measure the Efficiency of Not-for-Profit Organizations: A Critical Evaluation-Comment	T. Ahn A. Charnes W.W. Cooper
568	Entropic Means	A. Ben-Tal A. Charnes M. Teboulle
569	A Valid Statistical Method for River Routing Studies	A. Charnes J. Heaney S. Dufuaa R. Dickenson

572	A Two-Person Zero-Sum Semi-Infinite Game Model for DEA with Infinitely Many Decision Manking Units	A. Charnes W.W. Cooper Q.L. Wei
574	Portfolio Theory for the Optimized-Certainty-Equivalent Maximizing Investor	A. Ben-Tal M. Teboulle
575	Fundamental Theorems of Nondominated Solutions Associated with Cones in Normed Linear Spaces	A. Charnes Z.M. Huang Q.L. Wei

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UNDER RISK AND UNCERTAINTY"

A. Charnes, W.W. Cooper, A. Lewin, R. Morey, and J. Rousseau, "Sensitivity and Stability Analysis in DEA," Annals of Operations Research, Vol. 2, 1985, pp. 139-156. (CCS 434)

A. Charnes, C.T. Clark, W.W. Cooper, and B. Golany, "A Developmental Study of Data Envelopment Analysis in Measuring the Efficiency of Maintenance Units in the U.S. Air Forces," Annals of Operations Research, Vol. 2, 1985, pp. 95-112. (CCS 460)

A. Charnes, W.W. Cooper, J. J. Rousseau, A. Schinnar, N.E. Terleckyj, and D. Levy, "A Goal-Focusing Approach to Analysis of Intergenerational Transfers of Income," International Journal of Systems Sciences, Vol. 17, No. 3, 1986, pp. 443-446. (CCS 466)

I. Ali, A. Charnes, and T. Song, "A Two-Segment Approximation Algorithm for Separable Convex Programming with Linear Constraints," Mathematische Operationsforschung und Statistik - Series Optimization, Vol. 17, No. 2, 1986, pp. 147-159. (CCS 476)

I. Ali, A. Charnes, and T. Song, "Design and Implementation of Data Structure for Generalized Networks," Journal of Information and Optimization Sciences, Vol. 7, No.2, May 1986, pp. 81-104. (CCS 483)

A. Charnes, W.W. Cooper, and R. Thrall, "Classifying and Characterizing Efficiencies in Data Envelopment Analysis," OR Letters, Vol. 5, No. 3, August 1986, pp. 105-110. (CCS 487)

A. Charnes, W.W. Cooper, and T. Sueyoshi, "Least Squares/Ridge Regressions and Goal Programming/Constrained Regression Alternatives," European Journal of Operations Research, Special Issue on Operations Research/Statistics Interface edited by S. Zanakis, Vol. 27, No. 2, 1986, pp. 146-157. (CCS 490)

P. Brockett, A. Charnes, K. Paick, "Computation of Minimum Cross Entropy Estimates: An Unconstrained Dual Convex Programming Method," IEEE Transactions on Information Theory, Vol. IT-32, No. 2, March 1986, pp. 236-242. (CCS 491)

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A. Charnes, W.F. Bowlin, W.W. Cooper, and A. Maindiratta, "Data Envelopment Analysis and Regression Approaches to Efficiency Estimation and Evaluation," Annals of Operations Research, Vol. 2, 1985, pp. 113-138. (CCS 503)

A. Charnes, W.W. Cooper, B. Golany, L. Seiford, and J. Stutz, "Foundations of Data Envelopment Analysis for Pareto Optimal Empirical Production Functions," special issue of Journal of Econometrics, Vol. 30, 1985, pp. 91-107. (CCS 504)

I. Ali, A. Charnes, and T. Song, "Karmarkar's Projective Algorithm: A Null Space Variant for Multi-Commodity Generalized Networks," ACTA Mathematicae Applicatae Sinica (English Series), Vol. 2, No. 2, 1986, pp. 178-190. (CCS 517)

A. Charnes and J. Gomez, "A Goal Interval Approach for Some Tanker Distributional Policy Analysis, Proceedings, XII Congreso de la Academia Nacional de Ingenieria, Saltillo, Mexico, September 23-26, 1986. (CCS 535)

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MARCH, 1988

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