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MANAGEMENT SCIENCE UPDATE COLUMN

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“MULTICOMMODITY DISTRIBUTION SYSTEM DESIGN BY BENDERS DECOMPOSITION”

A. M. GEOFFRION AND G. W. GRAVES—PART I

TIMS President-Elect Arthur Geoffrion sent in a bundle of update material on the article he coauthored in the January 1974 issue of *Management Science*. As the Hollywood promoters might say, this is a story so big it takes two issues to hold it. Therefore, this edition of *Update* covers a public sector application, and the next edition covers a private sector application.

When the article first appeared in print, Geoffrion and Graves already had one successful application under their belts, as their abstract reported: “A commonly occurring problem in distribution system design is the optimal location of intermediate distribution facilities between plants and customers. A multicommodity capacitated single-period version of this problem is formulated as a mixed integer linear program. A solution technique based on Benders Decomposition is developed, implemented, and successfully applied to a real problem for a major food firm with 17 commodity classes, 14 plants, 45 possible distribution center sites, and 121 customer zones. An essentially optimal solution was found and proven with a surprisingly small number of Benders cuts. Some discussion is given concerning why this problem class appears to be so amenable to solution by Benders’ method, and also concerning what we feel to be the proper professional use of the present computational technique.”

The following description is shortened and paraphrased from a case study prepared by Insight, a consulting firm that handles applications of the Geoffrion-Graves approach.

The Department of Defense distributes over 3.5 million separate items to 50,000 customers/units throughout the world. To do this DOD uses a network of wholesale distribution centers in the continental United States and Hawaii. In 1975 there were 34 such distribution centers belonging to the Army, Navy, Air Force, Marine Corps, and Defense Logistics Agency. Each service/agency ran its own distribution network separately for the most part.

U.S. disengagement from Southeast Asia reduced the need for an enlarged support structure. Rationalizing the DOD distribution system thus became a number one priority of the Joint Logistics Commanders in 1975.

The study group’s mandate translated into the following specific questions to be answered: How many wholesale depots should there be, where should they be located, what products should each carry, and which customers should each serve to minimize total costs without degrading response times? How well does this least cost system hold up under numerous alternative future environmental and policy scenarios, especially mobilization requirements? Exclusions from the study were fresh food products, petroleum and ammunition, all of which have entirely different distribution channels and requirements.

In the project design, the 3.7 million separate stock items were aggregated into 69 product groups, using aggregation criteria of functional and physical homogeneity. The 50,000 DOD customers were aggregated into 205 demand zones based on three digit zip codes, demand densities and the need to maintain separate service identity in many cases. The 19,000 vendor sources were aggregated into 142 procurement zones, again based on three digit zip codes and

densities of supply sources in various regions. In addition, since large volumes of repairable material flow back via the distribution system to repair facilities, each customer was also treated as a supply source for repairable coded product groups. Stocking criteria were established for different depot locations based on the availability at each location of certain facilities.

Depot costs were developed through intensive analysis of accounting reports and regression analysis. Freight costs were developed using a regression-based freight rate generator which took account of freight class mix, size, and mode of shipment.

It was discovered that certain depots were located so close to each other that no reliable economic distinction could be made among them. A clustering technique resulted in an analysis of fifteen cluster locations rather than the 34 discrete depot locations.

As was suspected, the DOD distribution system had excess capacity, even taking into account liberal estimates of mobilization requirements. The excess capacity was quantified and locations identified where reductions should be made.

Repositioning stocks to depots nearer major consumers and continental U.S. ports of embarkation could result in significant transportation savings as well as pipeline inventory reductions.

Depots located on large multi-mission installations (with operational bases, repair facilities, etc.) incur lower overhead support costs per unit of throughput than stand-alone supply depots.

Realigning the DOD distribution system to reduce excess capacity, make greater use of multi-mission installations and position stocks closer to consumption points could yield system-wide productivity improvement of 10% and at the same time improve customer service by 15%.

Two years have passed since the Department of Defense Study was completed. During that time, the results have become a blueprint for actual changes in the DOD distribution system. Several depots have been or are being phased out, and mission realignments have occurred among those remaining.

We'll be back in two months with more adventures of the Geoffrion-Graves approach and a mysterious (i.e., unnamed) Midwestern manufacturer of replacement parts.